Appendix A: Simulation Parameters

Table A.1: Constants and parameters for simulation modeling

Constant	Value	Description
Lattice	1(bound), 2(fluid)	Type of lattice to create initial particles
Gravity	z=-9.81	Gravitational acceleration, m/s^2
Reference Density (ρ_0)	1400.0	Reference density of the fluid, kg/m^3
Density Gradient	Rho0	Initial density gradient method
HSWL	0.8 (dry), Auto (wet)	Max still water level for sound speed calc.
γ	7 (default)	Polytropic constant for water
System Speed	Auto	Max system speed for calculations
Coef. of Sound	20 (default)	Coefficient to multiply system speed
Sound Speed	Auto	Speed of sound in the simulation
Coef. h	0.15 (dry) 0.8 (wet)	Coefficient for smoothing length calculation
CFL Number	0.2	Coefficient to multiply dt

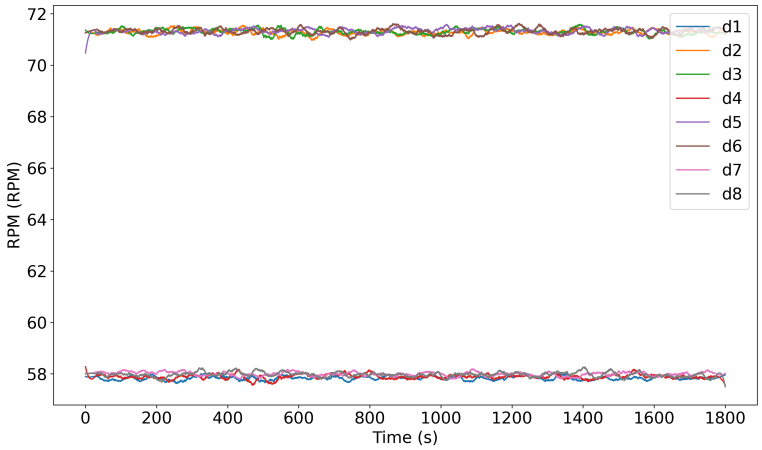
Table A.2: Simulation process parameters and settings

Parameter	Value	Description
SavePosDouble	0 (default)	Precision for saving particle position
Boundary	DBC	Boundary method used
Step Algorithm	Verlet	Step algorithm for integration
Verlet Steps	40 (default)	Steps for Eulerian equations in Verlet
Kernel	Wendland	Interaction kernel type
Visco Treatment	Artificial	Viscosity formulation
Viscosity (ν)	8.1e-6	Viscosity value m^2/s
Visco Bound Factor	0.1	Multiplier for boundary viscosity
Density Diffusion Term	Fourtakas	Method for density diffusion
DDT Value	0.1 (default)	Value for density diffusion term
Shifting	Full	Shifting mode for corrections
Shift Coef	-2 (default)	Coefficient for shifting computation
Shift TFS	2.75 (default)	Threshold to detect free surface
Rigid Algorithm	DEM	Algorithm for rigid body dynamics
DtFixed	1e-5 s	Fixed time step value, s
DtAllParticles	1	Inclusion of particles for DT calc.
TimeOut	0.01 s	Time out for data output, s
PartsOutMax	1%	Max fluid particles out of domain
RhopOutMin	700 kg/m^3	Minimum valid density
RhopOutMax	2000 kg/m^3	Maximum valid density

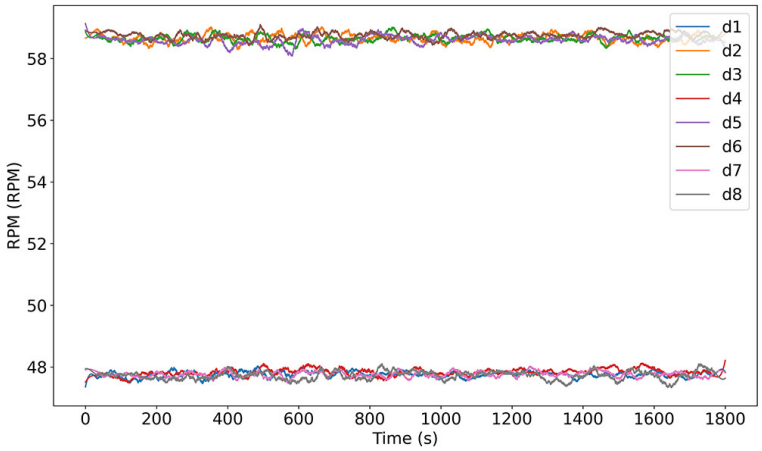
Appendix B: RPM Measurements – Dry Milling

Table B.1: RPM signal analysis results for dry measurements across various mill diameters

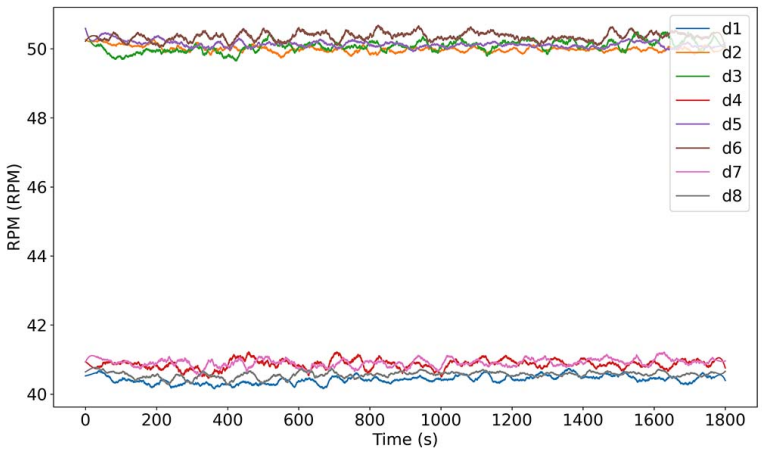
Run No.	Diameter	Mean	Std Dev	Min	Max	Range	CV	Skewness	Kurtosis	Set RPM	Mean Dev	Std Dev Dev	Within Limits
1	300	57.83	0.07	57.63	58.02	0.39	0.00	-0.1181	2.3918	55.78	2.05	0.07	1.0000
1	400	47.76	0.10	47.36	48.03	0.67	0.00	-0.2931	2.8441	46.39	1.37	0.10	1.0000
1	500	40.42	0.11	40.16	40.74	0.58	0.00	0.0815	2.5331	39.31	1.11	0.11	1.0000
2	300	71.28	0.09	70.97	71.55	0.58	0.00	-0.0972	2.9952	68.18	3.10	0.09	1.0000
2	400	58.66	0.13	58.29	59.02	0.73	0.00	0.1109	2.7048	56.70	1.96	0.13	1.0000
2	500	49.99	0.09	49.73	50.28	0.55	0.00	0.5996	3.7854	48.78	1.21	0.09	1.0000
3	300	71.30	0.10	71.00	71.58	0.58	0.00	-0.0140	2.8514	68.18	3.12	0.10	1.0000
3	400	58.65	0.11	58.29	59.02	0.73	0.00	0.0733	3.0910	56.70	1.95	0.11	1.0000
3	500	50.08	0.16	49.65	50.59	0.94	0.00	0.0213	2.8957	48.78	1.30	0.16	1.0000
4	300	57.89	0.09	57.56	58.28	0.72	0.00	-0.0875	4.1983	55.78	2.11	0.09	1.0000
4	400	47.83	0.11	47.50	48.21	0.71	0.00	-0.0273	3.0506	46.39	1.44	0.11	1.0000
4	500	40.87	0.13	40.46	41.22	0.76	0.00	-0.2887	3.2004	39.31	1.56	0.13	1.0000
5	300	71.33	0.11	70.47	71.58	1.11	0.00	-0.7739	6.6045	68.18	3.15	0.11	1.0000
5	400	58.61	0.13	58.08	59.13	1.05	0.00	-0.3861	3.9964	56.70	1.91	0.13	1.0000
5	500	50.13	0.09	49.92	50.58	0.66	0.00	0.9499	4.4320	48.78	1.35	0.09	1.0000
6	300	71.32	0.11	70.98	71.62	0.64	0.00	-0.0566	2.9453	68.18	3.14	0.11	0.9965
6	400	58.76	0.11	58.42	59.10	0.68	0.00	-0.1709	2.8902	56.70	2.06	0.11	1.0000
6	500	50.35	0.12	50.02	50.67	0.65	0.00	-0.0414	2.6658	48.78	1.57	0.12	1.0000
7	300	58.00	0.08	57.80	58.19	0.39	0.00	-0.1373	2.5373	55.78	2.22	0.08	1.0000
7	400	47.76	0.09	47.46	48.02	0.56	0.00	0.0738	2.4755	46.39	1.37	0.09	1.0000
7	500	40.91	0.11	40.52	41.22	0.70	0.00	-0.2526	3.0947	39.31	1.60	0.11	1.0000
8	300	57.98	0.09	57.50	58.26	0.76	0.00	-0.0390	3.7274	55.78	2.20	0.09	1.0000
8	400	47.72	0.14	47.33	48.10	0.77	0.00	-0.0598	2.7430	46.39	1.33	0.14	1.0000
8	500	40.56	0.09	40.27	40.77	0.50	0.00	-0.7348	3.8349	39.31	1.25	0.09	1.0000



(a) D=300 mm



(b) D=400 mm



(c) D=500 mm

Figure B.1: Pre-processed RPM signal for dry milling experiments at various mill diameters

Appendix C: Torque Measurements – Dry Milling

Table C.1: Torque signal (Nm) analysis for dry milling with 300 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Corr
1	-3.280	0.325	-4.147	-2.349	1.798	0.099	0.194	2.787	-3.138	0.295	15.64	1666.24	0.789	0.387
2	-2.104	0.372	-3.046	-0.934	2.112	0.177	0.793	3.609	-2.285	0.243	26.12	1770.00	1.351	0.595
3	-1.348	0.338	-2.143	-0.363	1.780	0.251	0.569	3.352	-1.362	0.264	14.98	1784.08	0.999	-0.049
4	-2.742	0.322	-3.566	-1.924	1.642	0.117	-0.129	2.405	-2.633	0.279	70.18	1770.00	0.709	0.177
5	-1.565	0.369	-2.849	-0.699	2.150	0.236	-0.180	3.066	-1.738	0.348	15.80	1734.72	1.039	-0.472
6	-1.083	0.316	-1.979	-0.332	1.647	0.292	0.022	2.419	-1.048	0.269	38.00	1791.68	0.716	0.500
7	-2.236	0.429	-3.352	-1.291	2.061	0.192	0.155	2.218	-2.114	0.379	18.42	1689.16	0.823	0.161
8	-3.078	0.381	-3.961	-2.143	1.818	0.124	0.009	2.344	-2.892	0.338	630.76	1770.00	0.749	-0.437

Table C.2: Torque signal (Nm) analysis for dry milling with 400 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Corr
1	-11.882	0.755	-13.804	-10.027	3.777	0.064	-0.118	2.422	-11.433	0.539	1283.54	1768.14	1.406	0.585
2	-9.832	0.769	-11.735	-7.410	4.325	0.078	0.075	3.088	-10.149	0.688	30.00	1769.92	2.739	0.568
3	-8.675	1.017	-10.905	-5.224	5.681	0.117	0.729	3.471	-8.839	0.646	30.18	1729.54	2.738	0.630
4	-9.545	0.676	-11.377	-7.111	4.266	0.071	-0.151	3.473	-9.194	0.551	1238.16	1703.54	1.413	0.705
5	-9.708	0.726	-11.058	-7.623	3.435	0.075	0.748	3.079	-9.790	0.458	19.24	1748.74	2.167	0.732
6	-6.811	0.597	-8.306	-4.676	3.630	0.088	0.211	3.281	-6.867	0.525	13.34	1720.92	2.191	0.084
7	-10.804	0.736	-12.560	-8.787	3.773	0.068	-0.399	2.484	-10.306	0.431	1305.36	1514.54	1.409	0.514
8	-12.292	0.436	-13.418	-10.770	2.648	0.035	0.309	2.589	-12.266	0.420	-	-	-	0.181

Table C.3: Torque signal (Nm) analysis for dry milling with 500 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Corr
1	-26.997	1.119	-30.821	-25.227	5.594	0.041	-1.492	4.691	-26.287	0.330	-	-	-	0.437
2	-25.006	1.352	-26.818	-18.816	8.002	0.054	2.009	7.020	-25.335	0.379	30.20	215.60	4.791	0.792
3	-22.364	1.041	-25.250	-17.148	8.102	0.047	0.036	4.178	-21.899	0.683	-	-	-	0.748
4	-21.520	1.011	-27.539	-19.858	7.681	0.047	-1.693	7.451	-21.081	0.431	-	-	-	0.210
5	-23.032	1.136	-25.336	-17.938	7.398	0.049	1.064	5.004	-23.084	0.666	30.38	175.80	3.201	0.491
6	-18.177	0.630	-19.920	-15.866	4.054	0.035	-0.145	3.019	-17.853	0.462	-	-	-	0.773
7	-21.035	0.868	-23.577	-19.057	4.520	0.041	-0.818	3.155	-20.405	0.367	-	-	-	0.799
8	-26.807	1.219	-30.905	-25.201	5.704	0.045	-1.342	4.161	-25.953	0.302	-	-	-	0.362

Appendix D: Power Intake Measurements – Dry Milling

Table D.1: Power signal (W) analysis for dry milling with 300 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Energy
1	80.185	2.447	76.431	86.069	9.638	0.031	0.666	2.557	78.261	0.924	30.00	1769.84	7.808	144333
2	94.467	4.812	82.803	100.583	17.780	0.051	-0.588	1.823	97.107	2.368	55.80	1791.14	3.476	170041
3	84.343	2.910	73.118	90.142	17.024	0.035	-0.032	2.203	86.556	1.974	30.40	1765.64	3.586	151817
4	75.228	2.043	69.799	79.270	9.471	0.027	-0.309	2.421	73.862	1.603	30.38	1769.12	5.408	135410
5	84.707	6.693	72.396	98.860	26.464	0.079	-0.171	1.544	78.872	2.985	30.00	1769.12	15.126	152472
6	85.366	2.563	78.534	91.047	12.513	0.030	-0.912	3.391	85.622	1.969	8.58	1769.32	5.425	153658
7	78.337	1.412	75.171	82.012	6.841	0.018	0.297	2.681	77.743	1.210	30.80	1767.76	4.269	141006
8	71.407	4.348	61.734	79.434	17.700	0.061	-0.118	2.017	75.148	2.193	208.80	1778.16	4.286	128534

Table D.2: Power signal (W) analysis for dry milling with 400 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Energy
1	109.747	3.140	104.221	118.162	13.941	0.029	0.761	2.815	107.745	1.524	30.78	1796.96	10.417	197545
2	118.846	2.337	109.208	123.036	13.828	0.020	-1.547	6.306	119.884	1.119	30.18	1769.72	3.152	213922
3	111.965	2.946	100.528	116.868	16.340	0.026	-1.655	6.544	112.343	1.063	30.78	1769.92	4.525	201537
4	96.778	4.065	90.852	108.044	17.192	0.042	0.624	2.724	93.308	1.386	30.60	1769.92	14.736	174200
5	126.214	4.739	109.405	132.532	23.127	0.038	-1.971	7.076	126.318	1.148	123.40	1770.00	6.214	227185
6	105.986	5.190	89.877	116.600	26.723	0.049	0.068	2.041	102.347	2.556	30.38	1770.00	14.253	190775
7	104.244	2.474	94.138	110.725	16.587	0.024	-0.160	5.828	103.190	1.139	30.98	1776.66	7.535	187640
8	117.388	4.401	106.967	129.586	22.619	0.037	1.206	4.243	115.526	1.839	36.98	1767.94	14.060	211298

Table D.3: Power signal (W) analysis for dry milling with 500 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Energy
1	193.762	12.783	165.937	217.479	51.542	0.066	0.440	2.129	184.552	4.848	39.72	1770.00	32.927	348772
2	202.167	7.560	175.324	210.412	35.088	0.037	-1.889	5.899	205.020	2.247	8.82	1769.74	5.392	363900
3	194.963	14.504	163.165	230.326	67.161	0.074	0.647	2.772	184.519	5.332	88.00	1769.54	45.807	350933
4	147.505	4.429	134.700	157.673	22.973	0.030	0.290	2.477	144.550	2.556	34.20	1787.44	13.123	265509
5	184.366	4.537	160.620	190.218	29.598	0.025	-3.244	14.731	186.193	1.169	30.98	1785.78	4.025	331858
6	154.402	6.604	135.261	170.848	35.587	0.043	0.767	3.318	150.091	2.229	68.60	1783.92	20.757	277924
7	142.173	12.129	126.738	166.675	39.937	0.085	0.418	1.811	131.601	3.492	43.18	1767.92	35.074	255911
8	177.656	7.618	153.467	196.787	43.320	0.043	0.600	3.570	173.139	2.296	38.40	1769.52	23.648	319782

Appendix E: Size Distributions of The Products – Dry Milling

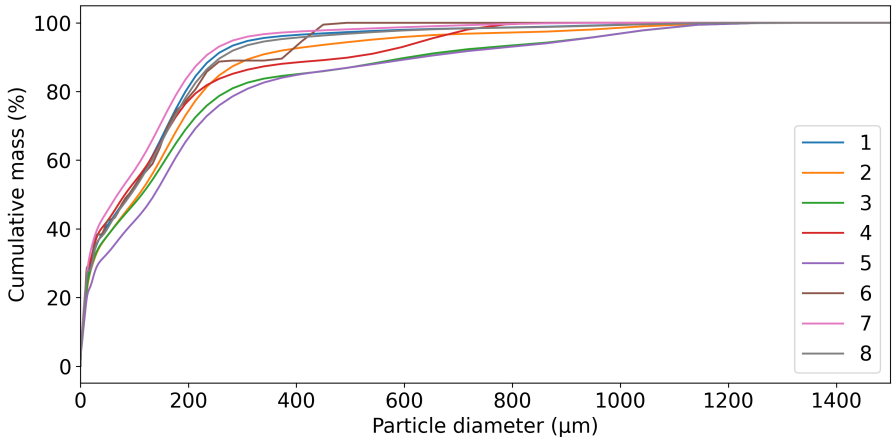


Figure E.1: Cumulative mass percentage by particle diameter from dry milling with a 300 mm drum mill

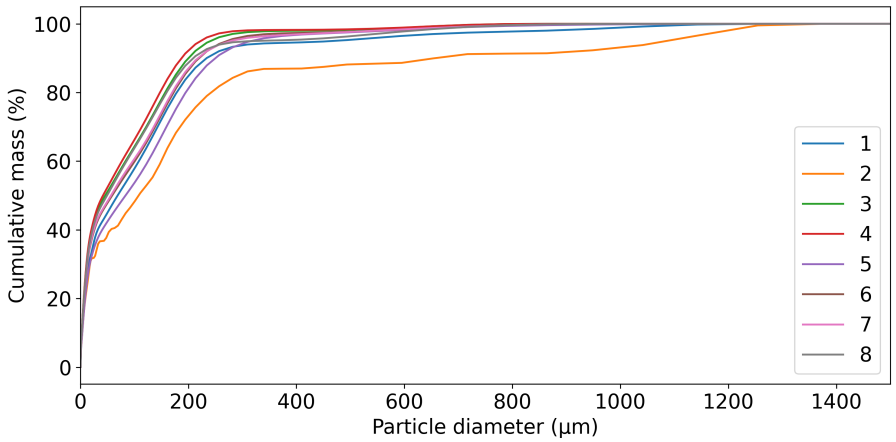


Figure E.2: Cumulative mass percentage by particle diameter from dry milling with a 400 mm drum mill

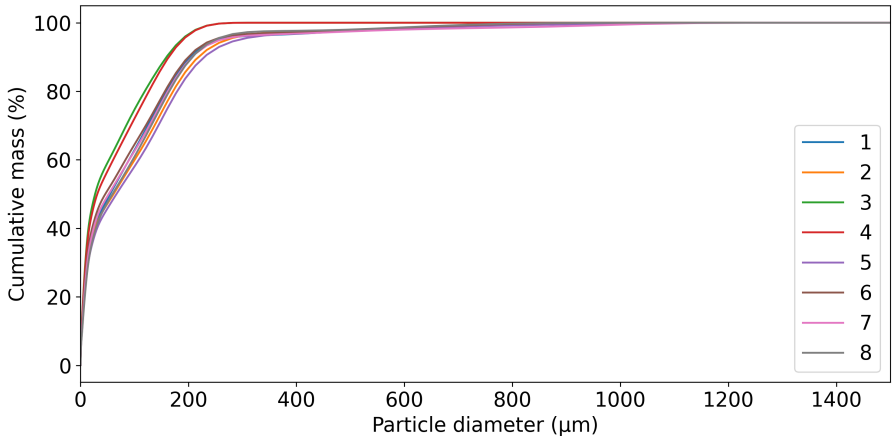
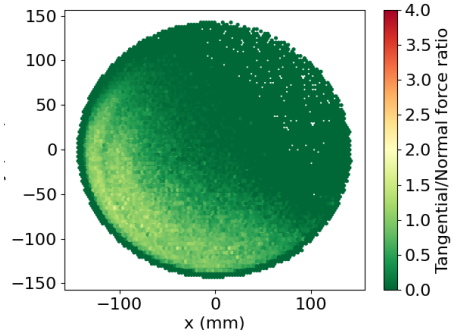


Figure E.3: Cumulative mass percentage by particle diameter from dry milling with a 500 mm drum mill

Appendix F: Charge Position – Dry Milling

Table F.1: Circulation and mass center data for various dry ball milling simulations

Run No.	Diameter (mm)	Angle CoC (°)	Angle CoM (°)	Arm CoC (m)	Arm CoM (m)
1	300	55.72	54.29	0.0587	0.0611
1	400	55.60	54.22	0.0891	0.0896
1	500	55.02	54.61	0.1146	0.1148
2	300	65.08	63.84	0.0381	0.0442
2	400	61.37	59.93	0.0776	0.0798
2	500	60.93	60.38	0.1015	0.1027
3	300	57.32	56.71	0.0648	0.0693
3	400	58.50	57.17	0.1000	0.1022
3	500	58.15	57.40	0.1325	0.1341
4	300	62.12	58.94	0.0672	0.0720
4	400	52.47	51.05	0.1134	0.1139
4	500	52.51	51.85	0.1447	0.1451
5	300	60.90	59.54	0.0387	0.0436
5	400	61.19	59.85	0.0626	0.0691
5	500	61.00	60.26	0.0873	0.0925
6	300	60.89	60.18	0.0459	0.0506
6	400	61.44	60.04	0.0775	0.0836
6	500	60.49	59.61	0.1101	0.1150
7	300	57.22	56.58	0.0596	0.0648
7	400	58.15	56.68	0.0937	0.0986
7	500	57.36	56.48	0.1279	0.1310
8	300	56.93	55.49	0.0550	0.0580
8	400	56.50	55.14	0.0849	0.0868
8	500	55.80	55.14	0.1115	0.1127



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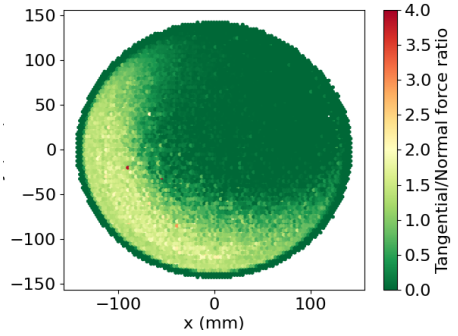

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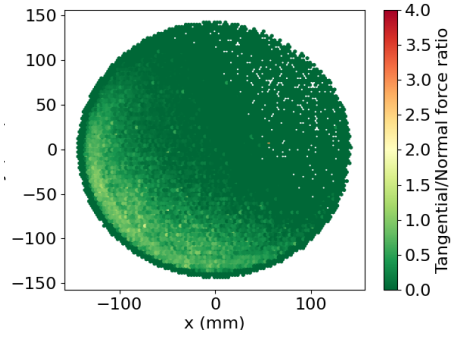

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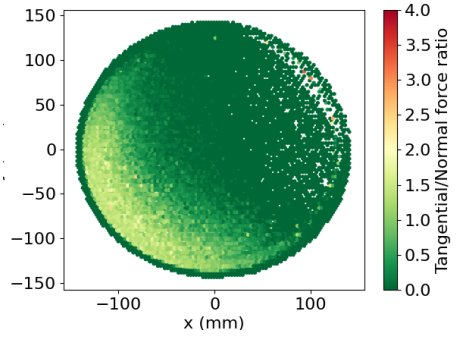

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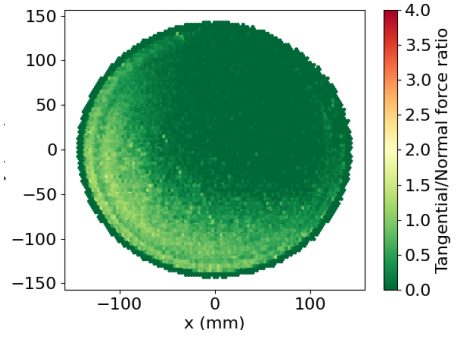

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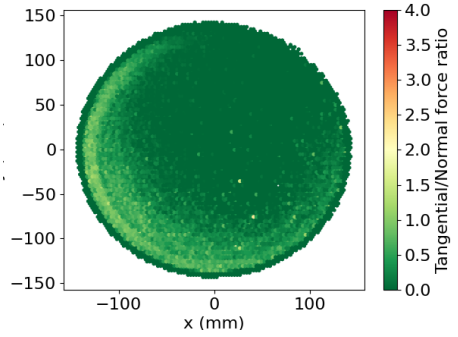

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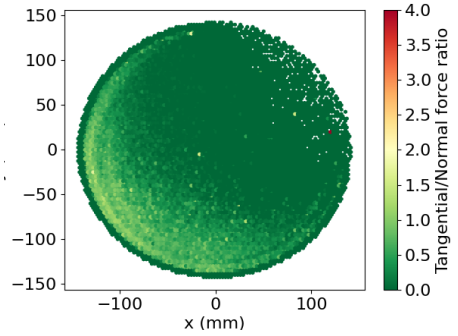
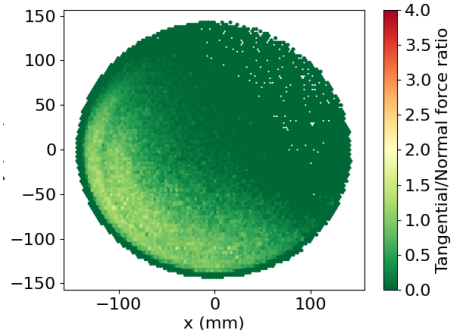
F_r=0.81, S_r=4.18, E/m=39.6kJ/kg

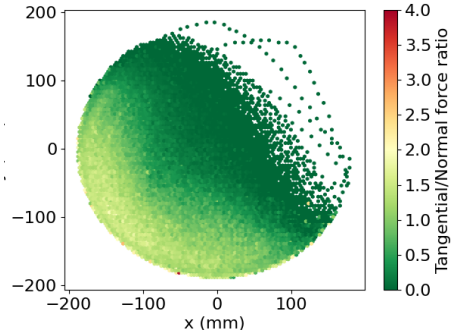


7:(ω=-1, f_d=-1, l_n=1, h_l=1)
F_r=0.85, S_r=4.84, E/m=36.3kJ/kg

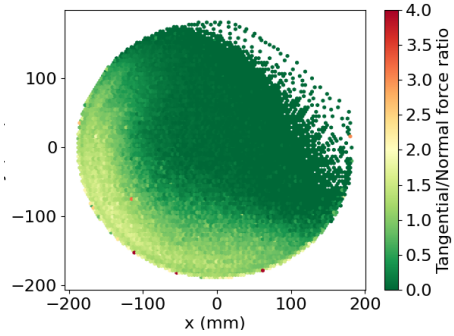


8:(ω=-1, f_d=1, l_n=-1, h_l=1)
F_r=0.92, S_r=4.33, E/m=19.9kJ/kg

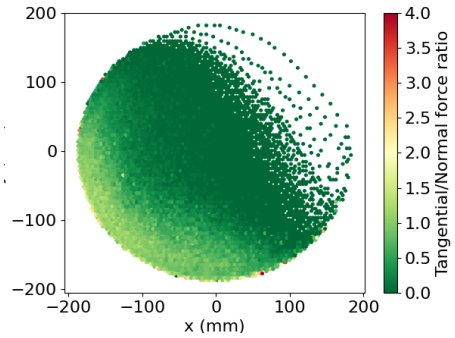
Figure F.1: Tangential to normal force ratio distribution in a 300 mm drum during dry milling



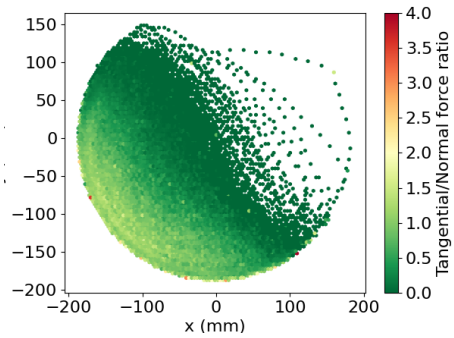
1:(ω=-1, f_d=1, l_n=1, h_l=-1)
F_r=1.3, S_r=4.91, E/m=16.9kJ/kg



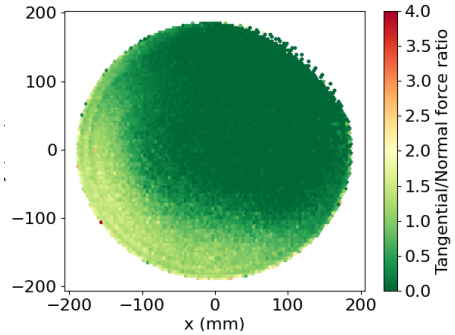
2:(ω=1, f_d=1, l_n=-1, h_l=-1)
F_r=1.3, S_r=3.62, E/m=18.4kJ/kg



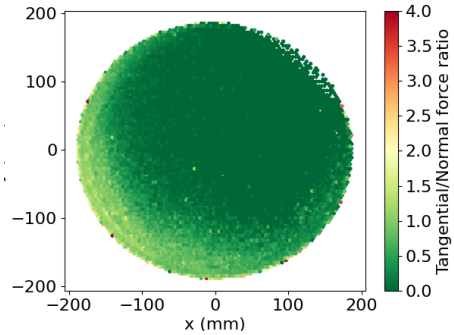
3:(ω=1, f_d=-1, l_n=1, h_l=-1)
F_r=1.2, S_r=5.58, E/m=28.8kJ/kg



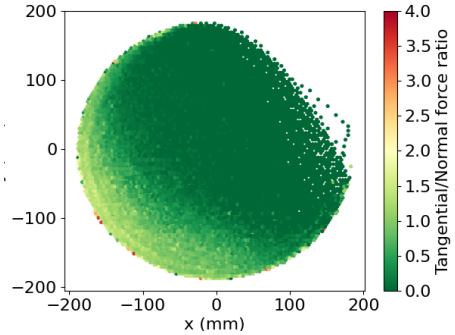
4:(ω=-1, f_d=-1, l_n=-1, h_l=-1)
F_r=1.3, S_r=5.94, E/m=24.9kJ/kg



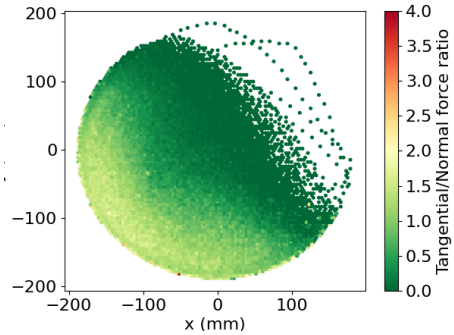
5:(ω=1, f_d=1, l_n=1, h_l=1)
F_r=1.2, S_r=4.49, E/m=19.5kJ/kg



6:(ω=1, f_d=-1, l_n=-1, h_l=1)
F_r=1.2, S_r=5.07, E/m=27.3kJ/kg

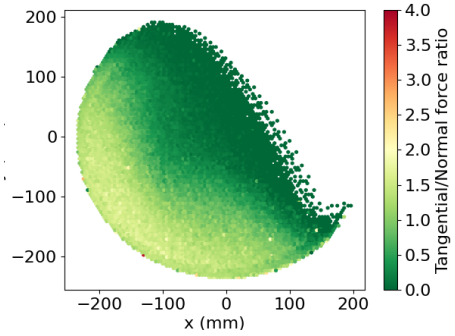


7:(ω=-1, f_d=-1, l_n=1, h_l=1)
F_r=1.2, S_r=5.15, E/m=26.8kJ/kg

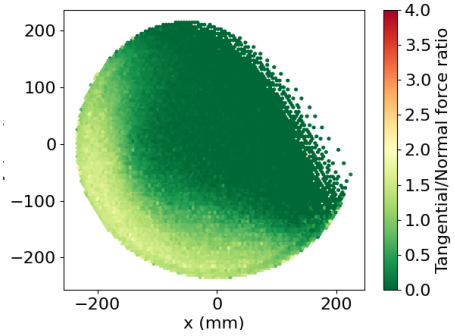


8:(ω=-1, f_d=1, l_n=-1, h_l=1)
F_r=1.3, S_r=5.49, E/m=18.1kJ/kg

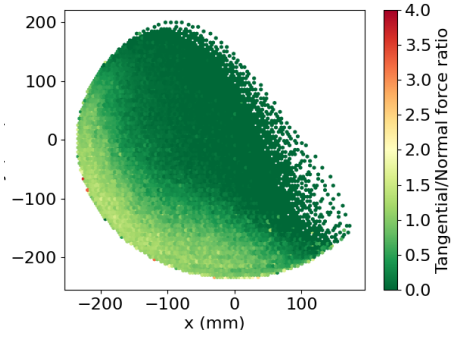
Figure F.2: Tangential to normal force ratio distribution in a 400 mm drum during dry milling



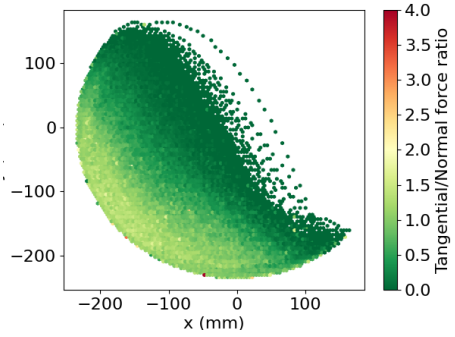
1:(ω=-1, f_d=1, l_n=1, h_l=-1)
F_r=1.2, S_r=5.52, E/m=19.0kJ/kg



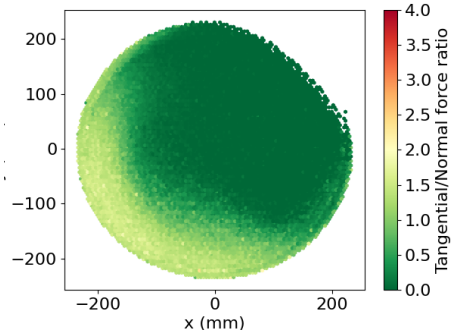
2:(ω=1, f_d=1, l_n=-1, h_l=-1)
F_r=1.2, S_r=5.10, E/m=19.8kJ/kg



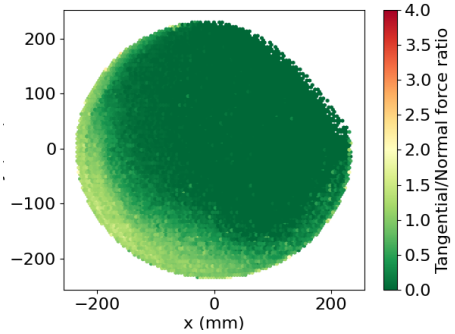
3:(ω=1, f_d=-1, l_n=1, h_l=-1)
F_r=1.1, S_r=7.34, E/m=31.8kJ/kg



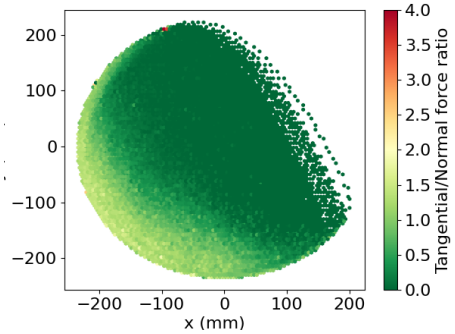
4:(ω=-1, f_d=-1, l_n=-1, h_l=-1)
F_r=1.1, S_r=6.90, E/m=24.1kJ/kg



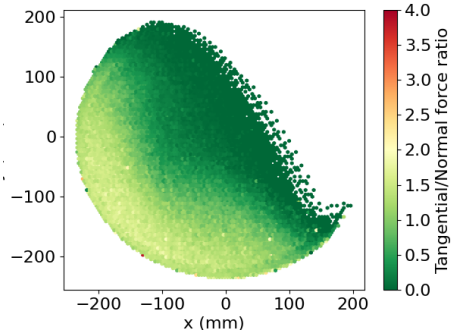
5:(ω=1, f_d=1, l_n=1, h_l=1)
F_r=1.1, S_r=4.88, E/m=18.1kJ/kg



6:(ω=1, f_d=-1, l_n=-1, h_l=1)
F_r=1.1, S_r=5.59, E/m=25.2kJ/kg



7:(ω=-1, f_d=-1, l_n=1, h_l=1)
F_r=1.1, S_r=5.40, E/m=23.2kJ/kg



8:(ω=-1, f_d=1, l_n=-1, h_l=1)
F_r=1.2, S_r=5.32, E/m=17.4kJ/kg

Figure F.3: Tangential to normal force ratio distribution in a 500 mm drum during dry milling

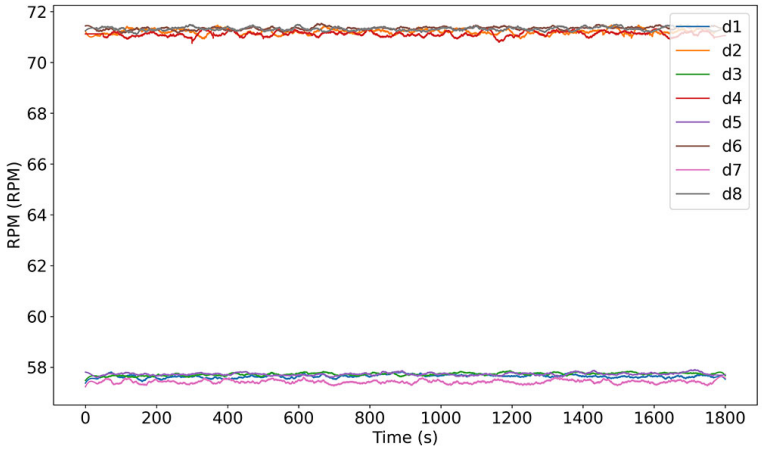
Table F.2: Analysis results of recorded dry ball milling performance including centroid coordinates, arm length, load mass, and torque

Run No.	Dia.(mm)	c_x (mm)	c_y (mm)	Angle (°)	Arm (m)	Load Mass (kg)	Mean Torque (Nm)
1	300	-37.17	3.95	96.07	0.0374	40.95	3.28
1	400	-44.08	0.94	91.22	0.0441	73.79	11.882
1	500	-53.19	-6.34	83.2	0.0536	116.24	26.997
2	300	-22.01	2.45	96.35	0.0221	40.95	2.104
2	400	-21.37	13.97	123.17	0.0255	73.79	9.832
2	500	-42.25	8.06	100.8	0.043	116.24	25.006
3	300	-13.46	5.48	112.15	0.0145	24.57	1.348
3	400	-19.81	12.26	121.75	0.0233	44.28	8.675
3	500	-42.74	-3.41	85.44	0.0429	69.75	22.364
4	300	-27.94	-4.62	80.61	0.0283	24.57	2.742
4	400	-33.74	-15.19	65.76	0.037	44.28	9.545
4	500	-37.54	-26.28	55.01	0.0458	69.75	21.52
5	300	-23.93	3.37	98.02	0.0242	40.95	1.565
5	400	-29.56	14.44	116.04	0.0329	73.79	9.708
5	500	-38.81	1.81	92.67	0.0389	116.24	23.032
6	300	-10.24	9.99	134.29	0.0143	24.57	1.083
6	400	-20.31	6.2	106.98	0.0212	44.28	6.811
6	500	-39.96	-1.65	87.64	0.04	69.75	18.177
7	300	-11.21	8.19	126.15	0.0139	24.57	2.236
7	400	-37.62	-6.22	80.61	0.0381	44.28	10.804
7	500	-43.3	-5.99	82.12	0.0437	69.75	21.035
8	300	-32.78	3	95.23	0.0329	40.95	3.078
8	400	-49.17	-6.41	82.57	0.0496	73.79	12.292
8	500	-56.16	-16.17	73.94	0.0584	116.24	26.807

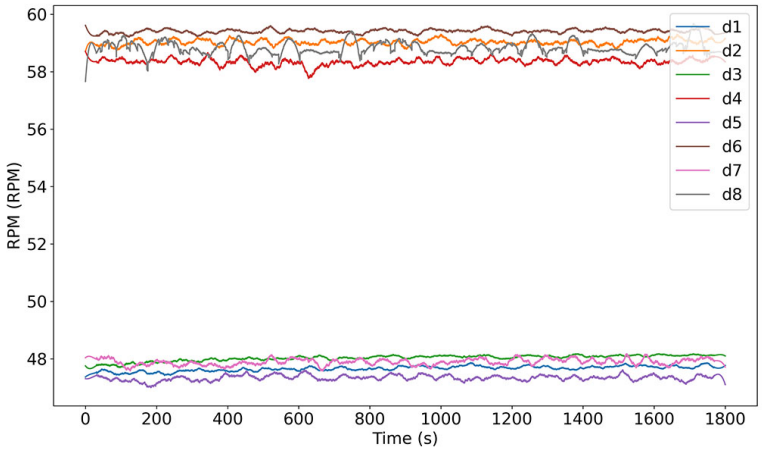
Appendix G: RPM Measurements – Wet Milling

Table G.1: RPM signal analysis results for wet measurements across various mill diameters

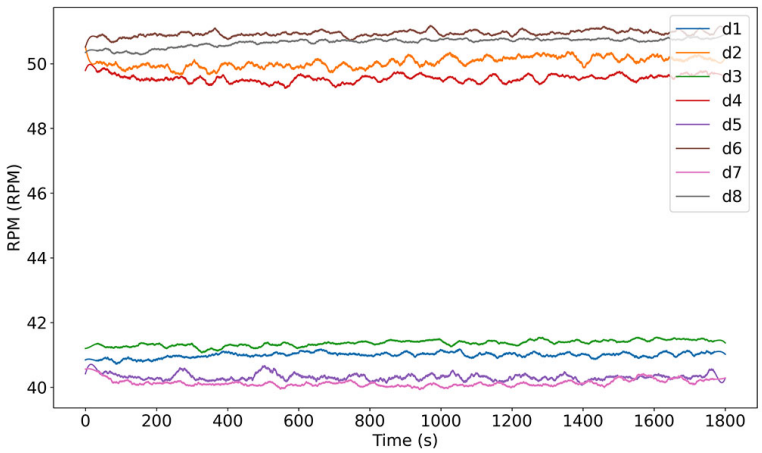
Number	Diameter	Mean	Std Dev	Min	Max	Range	CV	Skewness	Kurtosis	Set RPM	Mean Dev	Std Dev Dev	Within Limits
1	300	57.64	0.06	57.37	57.85	0.48	0.00	-0.0334	3.3888	55.78	1.86	0.06	1.0000
1	400	47.65	0.09	47.37	47.86	0.49	0.00	-0.4591	2.8839	46.39	1.26	0.09	1.0000
1	500	41.00	0.08	40.72	41.18	0.46	0.00	-0.5867	3.1721	39.31	1.69	0.08	1.0000
2	300	71.21	0.10	70.93	71.47	0.54	0.00	-0.0687	2.6448	68.18	3.03	0.10	1.0000
2	400	59.03	0.09	58.71	59.30	0.59	0.00	-0.0983	2.9380	56.70	2.33	0.09	1.0000
2	500	50.04	0.15	49.65	50.51	0.86	0.00	-0.0972	2.2934	48.78	1.26	0.15	1.0000
3	300	57.72	0.05	57.47	57.86	0.39	0.00	-0.3510	2.9393	55.78	1.94	0.05	1.0000
3	400	48.02	0.11	47.65	48.17	0.52	0.00	-1.2649	4.1486	46.39	1.63	0.11	1.0000
3	500	41.37	0.09	41.07	41.55	0.48	0.00	-0.4528	2.8384	39.31	2.06	0.09	0.1667
4	300	71.12	0.10	70.76	71.35	0.59	0.00	-0.1115	2.7453	68.18	2.94	0.10	1.0000
4	400	58.34	0.12	57.77	58.70	0.93	0.00	-0.9538	5.6647	56.70	1.64	0.12	1.0000
4	500	49.55	0.12	49.24	49.98	0.74	0.00	0.3259	3.5540	48.78	0.77	0.12	1.0000
5	300	57.73	0.05	57.59	57.91	0.32	0.00	0.4293	3.2744	55.78	1.95	0.05	1.0000
5	400	47.33	0.09	46.99	47.61	0.62	0.00	-0.2487	3.4028	46.39	0.94	0.09	1.0000
5	500	40.32	0.10	40.07	40.71	0.64	0.00	1.0621	4.6662	39.31	1.01	0.10	1.0000
6	300	71.34	0.06	71.15	71.54	0.39	0.00	-0.1305	3.0799	68.18	3.16	0.06	1.0000
6	400	59.41	0.07	59.21	59.61	0.40	0.00	-0.2345	2.8233	56.70	2.71	0.07	0.9758
6	500	50.93	0.09	50.51	51.17	0.66	0.00	-0.2673	3.7934	48.78	2.15	0.09	1.0000
7	300	57.43	0.07	57.23	57.63	0.40	0.00	0.2688	2.7774	55.78	1.65	0.07	1.0000
7	400	47.89	0.11	47.57	48.17	0.60	0.00	-0.0603	2.5079	46.39	1.50	0.11	1.0000
7	500	40.14	0.11	39.93	40.57	0.64	0.00	1.5103	6.0866	39.31	0.83	0.11	1.0000
8	300	71.33	0.07	71.10	71.50	0.40	0.00	0.1069	2.5329	68.18	3.15	0.07	1.0000
8	400	58.83	0.22	57.66	59.67	2.01	0.00	0.5883	4.5780	56.70	2.13	0.22	0.9900
8	500	50.66	0.13	50.28	50.91	0.63	0.00	-1.3262	3.8686	48.78	1.88	0.13	1.0000



(a) D=300 mm



(b) D=400 mm



(c) D=500 mm

Figure G.1: Pre-processed RPM signal for wet milling experiments at various mill diameters

Appendix H: Torque Measurements – Wet Milling

Table H.1: Torque signal (Nm) analysis for wet milling with 300 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Corr
1	-1.924	0.396	-4.336	-1.066	3.270	0.206	-1.496	8.224	-1.764	0.226	315.20	1779.04	0.698	0.410
2	-5.447	0.263	-6.560	-4.638	1.922	0.048	-0.079	3.367	-5.402	0.225	310.20	1136.56	0.764	0.173
3	-3.365	1.002	-6.969	-1.956	5.013	0.298	-1.342	3.809	-2.708	0.230	859.38	1741.94	0.752	0.964
4	-6.054	0.266	-6.814	-5.181	1.633	0.044	0.210	3.278	-6.032	0.311	1018.94	1698.74	0.851	0.199
5	-1.106	0.234	-1.896	-0.491	1.405	0.212	-0.136	3.652	-1.091	0.309	40.20	1742.54	0.600	-0.082
6	-1.614	0.522	-3.479	-0.524	2.955	0.323	-1.118	4.415	-1.315	0.264	521.16	1770.00	0.791	0.835
7	-6.774	0.307	-7.741	-5.513	2.228	0.045	-0.003	3.240	-6.760	0.294	233.60	955.74	0.855	0.267
8	-2.237	0.440	-3.786	-1.231	2.555	0.197	-0.458	3.239	-2.020	0.367	286.78	1789.14	0.789	0.587

Table H.2: Torque signal (Nm) analysis for wet milling with 400 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Corr
1	-1.960	1.758	-6.570	0.829	7.399	0.897	-0.924	2.997	-0.601	0.540	970.36	1770.00	1.159	0.960
2	-9.991	0.459	-11.203	-8.706	2.497	0.046	-0.011	2.763	-9.721	0.348	1283.74	1290.96	1.015	0.269
3	-2.965	2.719	-12.031	0.077	12.108	0.917	-1.489	4.441	-1.110	0.505	1306.96	1770.00	1.187	0.993
4	-11.885	0.366	-12.910	-10.793	2.117	0.031	-0.233	2.486	-11.753	0.333	-	-	-	0.450
5	-9.300	0.309	-10.440	-8.432	2.008	0.033	-0.565	3.662	-9.261	0.289	-	-	-	0.080
6	-0.353	0.997	-5.618	0.935	6.553	2.824	-2.749	11.179	0.122	0.324	538.56	1769.92	0.813	0.894
7	-13.760	0.326	-14.697	-13.033	1.664	0.024	-0.231	2.490	-13.743	0.312	-	-	-	-0.186
8	-0.943	1.598	-5.504	1.013	6.517	1.695	-1.261	3.702	0.157	0.429	876.58	1780.84	0.856	0.948

Table H.3: Torque signal (Nm) analysis for wet milling with 500 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Corr
1	-7.714	2.525	-17.193	-4.155	13.038	0.327	-1.427	4.326	-6.136	0.788	1330.72	1677.52	1.981	0.941
2	-24.341	0.618	-26.166	-22.581	3.585	0.025	0.087	2.987	-24.371	0.705	-	-	-	-0.126
3	-4.471	1.396	-9.377	-2.352	7.025	0.312	-0.797	3.260	-3.598	0.752	548.18	1780.30	1.246	0.882
4	-29.423	0.354	-30.297	-28.349	1.948	0.012	0.003	2.677	-29.340	0.347	-	-	-	0.139
5	-22.383	0.447	-23.669	-20.794	2.875	0.020	-0.049	2.941	-22.541	0.425	-	-	-	-0.371
6	-3.869	1.457	-10.056	-1.915	8.141	0.377	-1.916	6.976	-2.954	0.429	1109.36	1769.14	1.039	0.869
7	-31.001	0.482	-32.047	-29.659	2.388	0.016	-0.055	2.166	-30.965	0.480	-	-	-	0.084
8	-4.469	2.982	-13.944	-1.543	12.401	0.667	-1.655	4.797	-2.526	0.409	1182.14	1714.32	0.983	0.975

Appendix I: Power Intake Measurements – Wet Milling

Table I.1: Power signal (W) analysis for wet milling with 300 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Energy
1	42.052	1.223	39.506	47.541	8.035	0.029	1.401	6.496	41.778	0.706	2.90	1789.78	5.763	75693
2	96.500	3.476	88.058	101.232	13.174	0.036	-0.755	2.216	93.789	2.936	24.88	1769.72	7.443	173699
3	46.821	6.639	38.419	64.030	25.611	0.142	1.206	3.244	42.293	1.671	30.80	1770.00	21.737	84277
4	100.722	3.568	89.239	109.380	20.141	0.035	0.041	4.030	99.319	2.190	33.40	1777.42	10.061	181300
5	37.586	0.989	33.379	40.653	7.274	0.026	-0.000	3.721	38.039	0.975	30.18	1772.32	2.614	67655
6	57.167	4.056	48.258	68.446	20.188	0.071	1.341	3.646	54.759	1.225	30.18	1777.04	13.687	102901
7	80.329	1.988	72.398	85.079	12.681	0.025	-0.358	3.346	80.040	0.957	23.58	1782.58	5.039	144592
8	61.954	4.238	53.955	70.544	16.589	0.068	0.108	1.825	58.222	1.936	16.78	1769.54	12.322	111517

Table I.2: Power signal (W) analysis for wet milling with 400 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Energy
1	68.731	10.918	52.331	91.427	39.096	0.159	0.640	2.333	59.922	3.608	30.00	1764.94	31.505	123715
2	159.810	2.292	153.751	167.389	13.638	0.014	-0.861	3.664	158.794	2.568	30.00	1786.10	5.261	287659
3	69.443	16.263	52.073	113.273	61.200	0.234	1.289	3.691	57.857	3.222	30.00	1769.14	55.416	124997
4	179.051	12.800	146.346	198.897	52.551	0.071	-0.157	1.988	168.529	6.334	38.40	1757.54	30.368	322292
5	121.559	2.215	111.308	125.676	14.368	0.018	-2.348	10.606	121.779	1.382	30.00	1768.54	3.897	218806
6	69.444	6.042	58.999	91.251	32.252	0.087	2.277	7.882	66.057	1.675	30.00	1781.86	25.194	124999
7	162.841	9.208	138.512	175.654	37.142	0.057	-0.663	2.383	157.563	6.843	57.98	1770.00	18.091	293115
8	75.851	12.208	62.535	107.953	45.418	0.161	1.321	3.751	67.469	2.848	16.48	1779.56	40.484	136532

Table I.3: Power signal (W) analysis for wet milling with 500 mm diameter ball mill

No.	Mean	Std Dev	Min	Max	Range	CV	Skew	Kurt	SS Mean	SS Std Dev	Rise	Settle	Over	Energy
1	84.105	6.213	76.112	101.693	25.581	0.074	1.588	4.267	80.877	1.631	19.30	1795.26	20.816	151388
2	229.186	16.259	186.347	257.972	71.625	0.071	0.084	1.713	215.789	4.694	86.80	1773.32	42.183	412535
3	71.121	9.798	55.284	92.945	37.661	0.138	0.380	2.031	63.637	4.562	30.20	1769.32	27.543	128018
4	270.001	13.241	228.326	293.011	64.685	0.049	-0.300	2.604	262.648	7.866	10.84	1786.12	30.363	486002
5	199.639	7.454	180.443	210.488	30.045	0.037	-0.562	2.188	194.058	5.060	30.58	1770.00	16.430	359350
6	81.072	6.062	68.198	98.022	29.824	0.075	0.970	4.235	77.033	3.211	23.82	1769.94	20.989	145929
7	241.488	12.802	210.564	256.815	46.251	0.053	-0.853	2.395	234.456	12.573	67.78	1783.34	22.359	434679
8	92.482	22.592	72.180	153.447	81.267	0.244	1.425	3.688	77.453	2.845	32.20	1769.52	75.994	166468

Appendix J: Size Distributions of The Products – Wet Milling

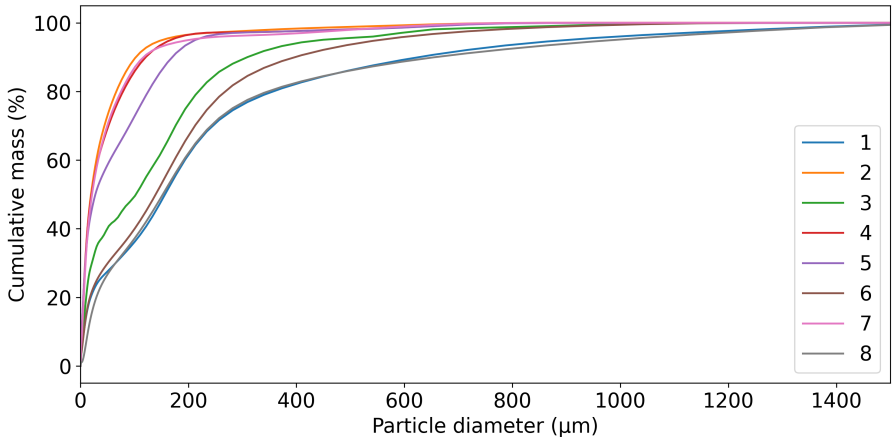


Figure J.1: Cumulative mass percentage by particle diameter from wet milling with a 300 mm drum mill

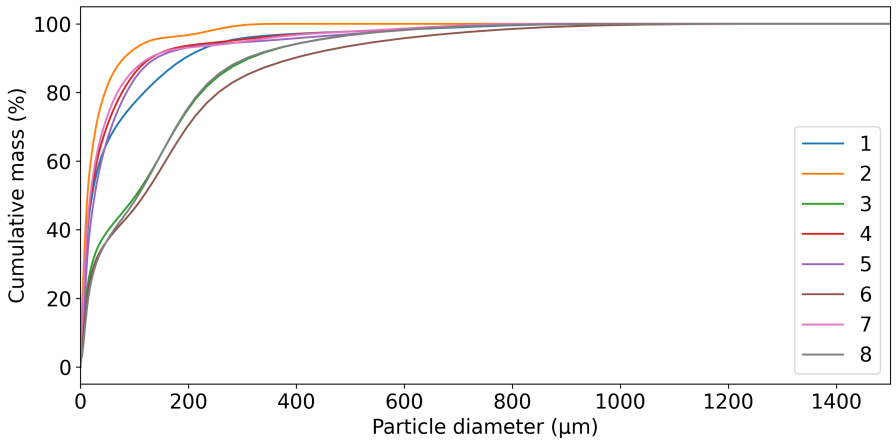


Figure J.2: Cumulative mass percentage by particle diameter from wet milling with a 400 mm drum mill

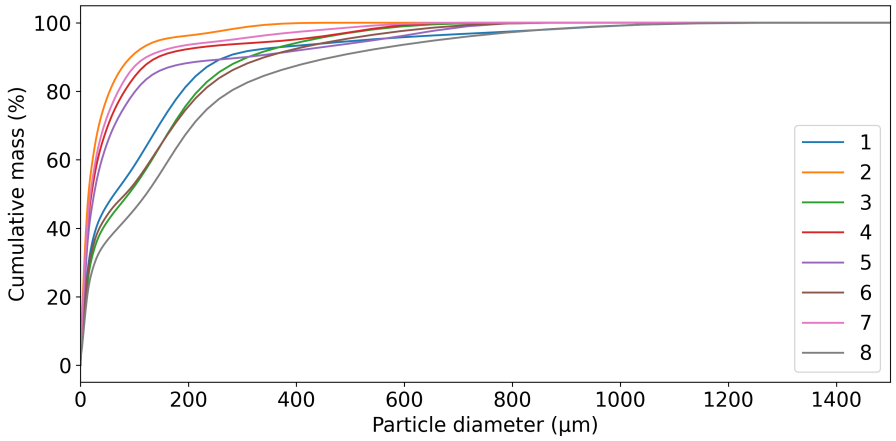
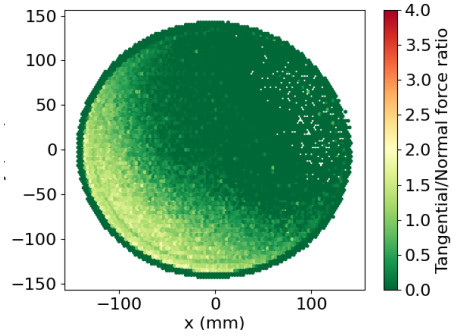


Figure J.3: Cumulative mass percentage by particle diameter from wet milling with a 500 mm drum mill

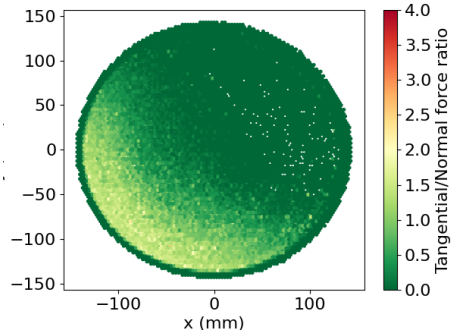
Appendix K: Charge Position – Wet Milling

Table K.1: Circulation and mass center data for various wet ball milling simulations

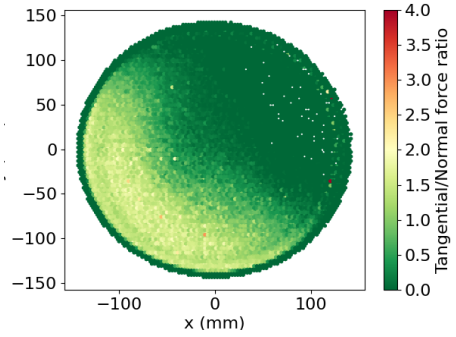
Case	Diameter (mm)	Angle CoC (°)	Angle CoM (°)	Arm CoC (m)	Arm CoM (m)
1	300	59.49	56.96	0.0594	0.0650
1	400	55.53	54.59	0.0987	0.0999
1	500	53.09	52.77	0.1308	0.1315
2	300	54.74	54.18	0.0548	0.0643
2	400	53.87	53.75	0.0942	0.0956
2	500	53.50	53.52	0.1247	0.1256
3	300	56.42	54.37	0.0517	0.0549
3	400	54.26	53.37	0.0794	0.0798
3	500	52.81	52.64	0.1018	0.1022
4	300	55.91	55.64	0.0358	0.0417
4	400	54.75	54.76	0.0644	0.0657
4	500	53.84	54.03	0.0875	0.0878
5	300	53.98	52.93	0.0556	0.0625
5	400	53.04	52.73	0.0943	0.0954
5	500	51.76	51.64	0.1264	0.1268
6	300	61.07	59.26	0.0512	0.0595
6	400	59.17	58.02	0.0901	0.0922
6	500	57.13	56.90	0.1225	0.1235
7	300	52.11	51.26	0.0479	0.0518
7	400	51.23	50.93	0.0759	0.0764
7	500	50.34	50.45	0.0976	0.0981
8	300	60.95	59.28	0.0334	0.0408
8	400	58.37	57.22	0.0607	0.0644
8	500	57.97	57.55	0.0856	0.0874



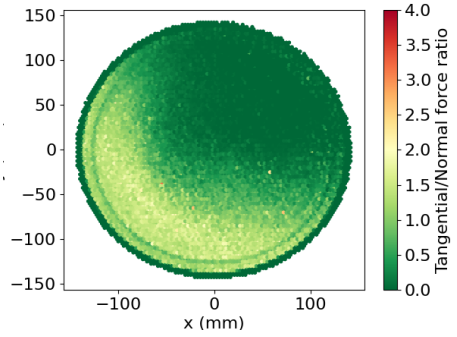
1:(ω=-1, f_d=-1, l_n=-1, h_l=1, ρ=1)
F_r=0.81, S_r=2.5, E/m=29.1kJ/kg



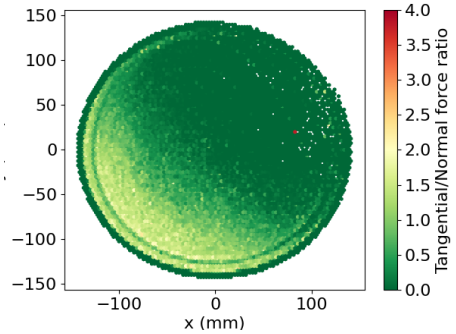
2:(ω=1, f_d=-1, l_n=-1, h_l=-1, ρ=-1)
F_r=0.84, S_r=13.1, E/m=133.6kJ/kg



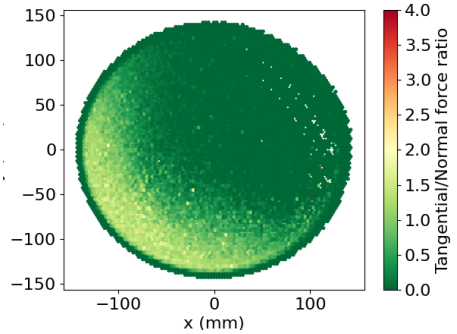
3:(ω=-1, f_d=1, l_n=-1, h_l=-1, ρ=1)
F_r=0.92, S_r=4.0, E/m=19.5kJ/kg



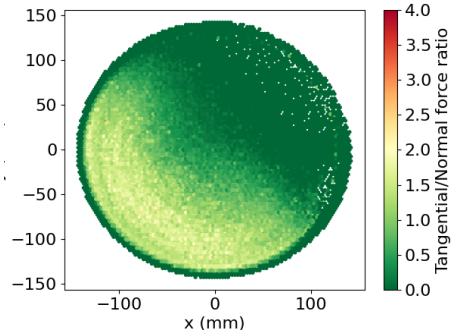
4:(ω=1, f_d=1, l_n=-1, h_l=1, ρ=-1)
F_r=0.84, S_r=11.1, E/m=83.5kJ/kg



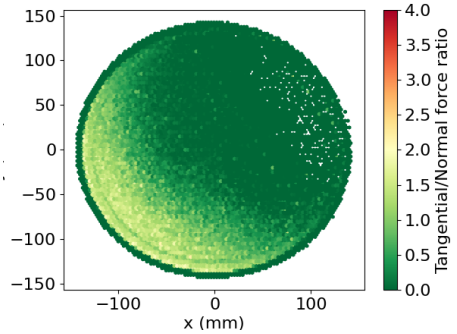
5:(ω=-1, f_d=-1, l_n=1, h_l=1, ρ=-1)
F_r=0.85, S_r=7.0, E/m=52.0kJ/kg



6:(ω=1, f_d=-1, l_n=1, h_l=-1, ρ=1)
F_r=0.79, S_r=3.3, E/m=39.6kJ/kg

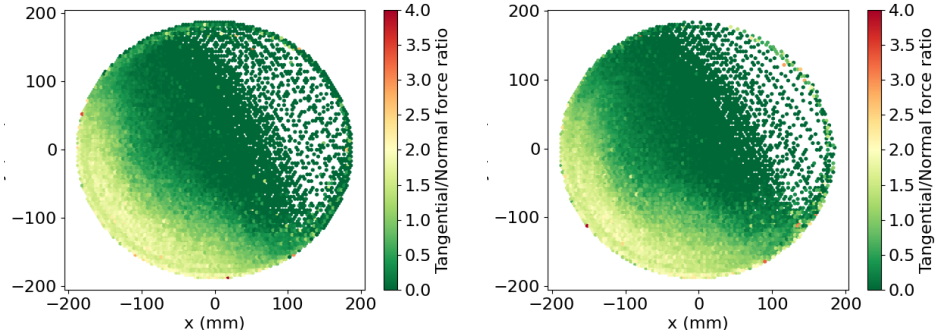


7:(ω=-1, f_d=1, l_n=1, h_l=-1, ρ=-1)
F_r=0.97, S_r=11.6, E/m=66.6kJ/kg



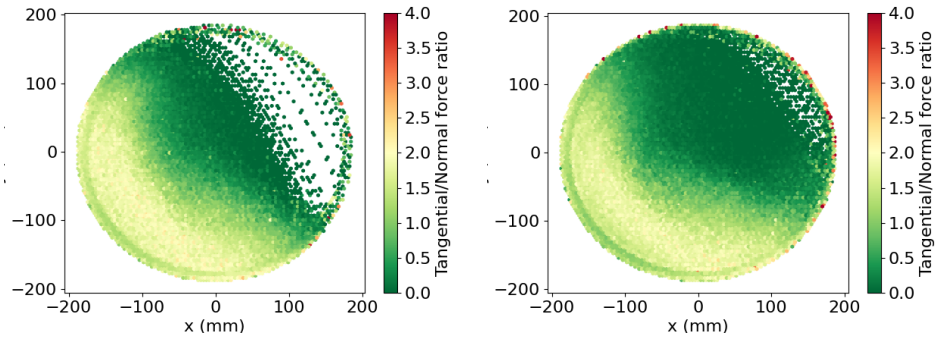
8:(ω=1, f_d=1, l_n=1, h_l=1, ρ=1)
F_r=0.80, S_r=2.5, E/m=25.8kJ/kg

Figure K.1: Tangential to normal force ratio distribution in a 300 mm drum during wet milling



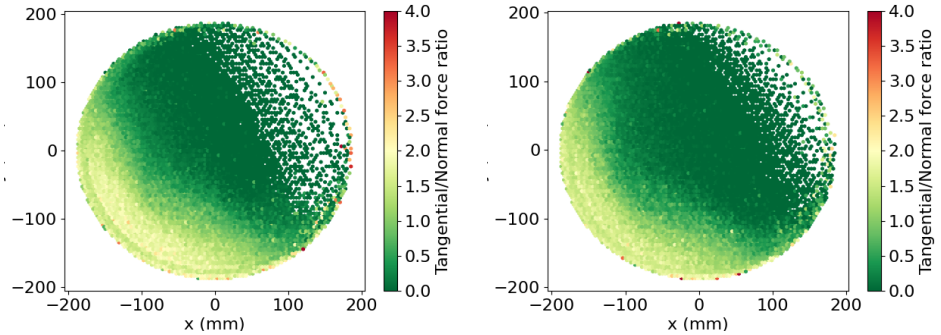
1:(ω=-1, f_d=-1, l_n=-1, h_l=1, ρ=1)
F_r=1.2, S_r=7.4, E/m=26.4kJ/kg

2:(ω=1, f_d=-1, l_n=-1, h_l=-1, ρ=-1)
F_r=1.2, S_r=19.2, E/m=122.4kJ/kg



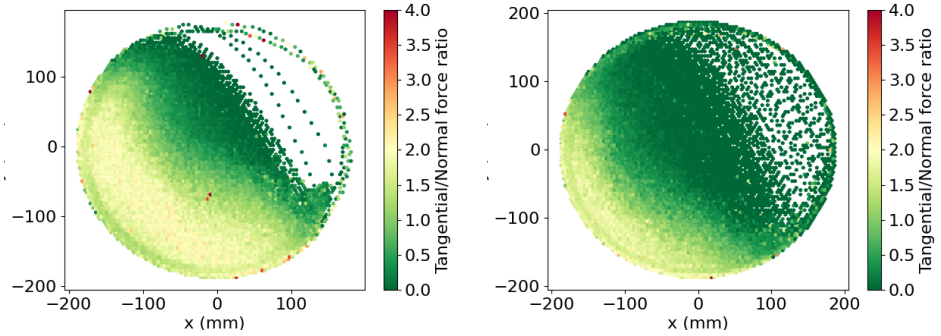
3:(ω=-1, f_d=1, l_n=-1, h_l=-1, ρ=1)
F_r=1.3, S_r=3.9, E/m=16.0kJ/kg

4:(ω=1, f_d=1, l_n=-1, h_l=1, ρ=-1)
F_r=1.2, S_r=11.4, E/m=82.2kJ/kg



5:(ω=-1, f_d=-1, l_n=1, h_l=1, ρ=-1)
F_r=1.2, S_r=10.3, E/m=93.1kJ/kg

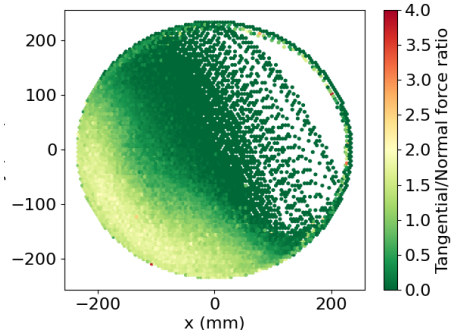
6:(ω=1, f_d=-1, l_n=1, h_l=-1, ρ=1)
F_r=1.2, S_r=3.4, E/m=26.7kJ/kg



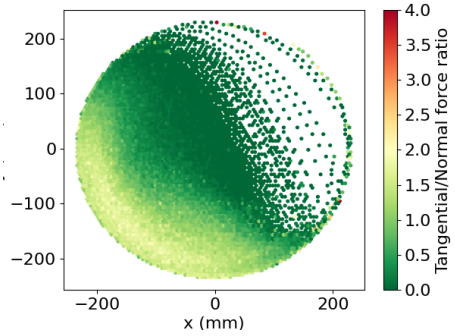
7:(ω=-1, f_d=1, l_n=1, h_l=-1, ρ=-1)
F_r=1.4, S_r=12.8, E/m=74.8kJ/kg

8:(ω=1, f_d=1, l_n=1, h_l=1, ρ=1)
F_r=1.1, S_r=4.0, E/m=17.5kJ/kg

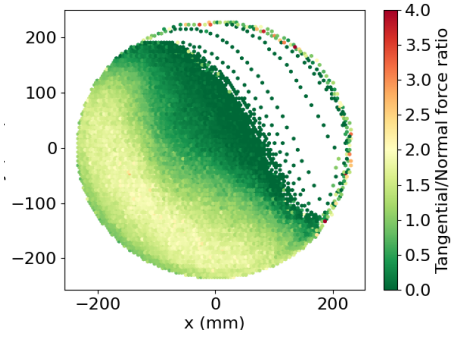
Figure K.2: Tangential to normal force ratio distribution in a 400 mm drum during wet milling



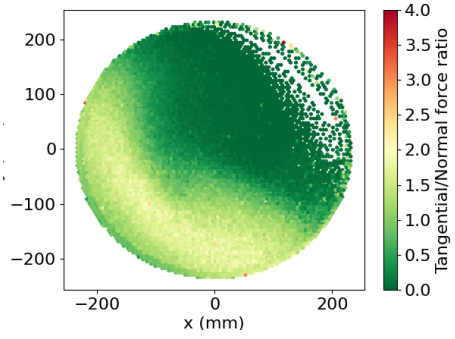
1:(ω=-1, f_d=-1, l_n=-1, h_l=1, ρ=1)
F_r=1.2, S_r=4.6, E/m=20.5kJ/kg



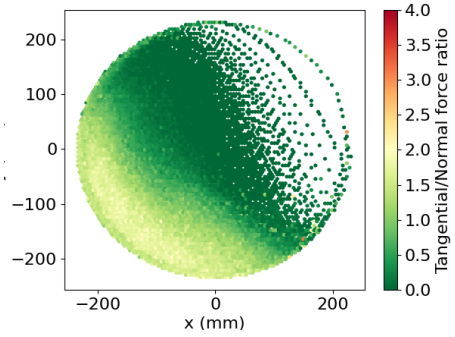
2:(ω=1, f_d=-1, l_n=-1, h_l=-1, ρ=-1)
F_r=1.2, S_r=16.1, E/m=111.5kJ/kg



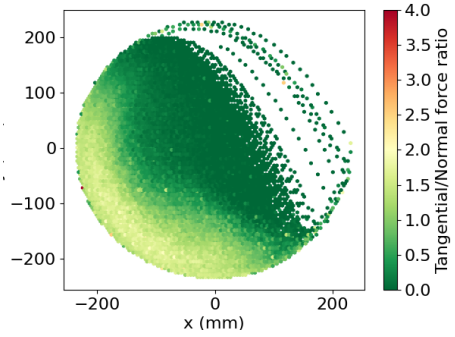
3:(ω=-1, f_d=1, l_n=-1, h_l=-1, ρ=1)
F_r=1.2, S_r=4.0, E/m=10.4kJ/kg



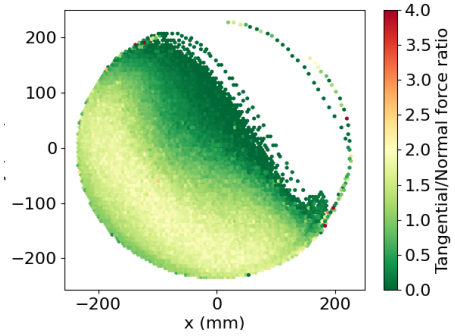
4:(ω=1, f_d=1, l_n=-1, h_l=1, ρ=-1)
F_r=1.1, S_r=10.7, E/m=78.8kJ/kg



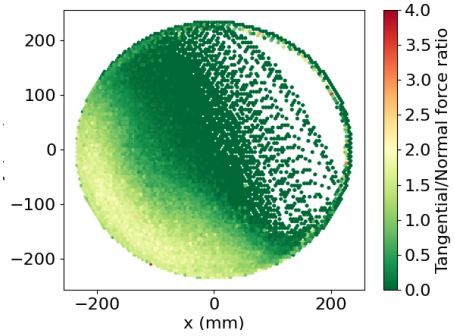
5:(ω=-1, f_d=-1, l_n=1, h_l=1, ρ=-1)
F_r=1.2, S_r=8.6, E/m=97.1kJ/kg



6:(ω=1, f_d=-1, l_n=1, h_l=-1, ρ=1)
F_r=1.1, S_r=3.9, E/m=19.8kJ/kg



7:(ω=-1, f_d=1, l_n=1, h_l=-1, ρ=-1)
F_r=1.2, S_r=12.5, E/m=70.5kJ/kg



8:(ω=1, f_d=1, l_n=1, h_l=1, ρ=1)
F_r=1.0, S_r=3.1, E/m=13.5kJ/kg

Figure K.3: Tangential to normal force ratio distribution in a 500 mm drum during wet milling

Appendix L: Correlations – Dry Milling

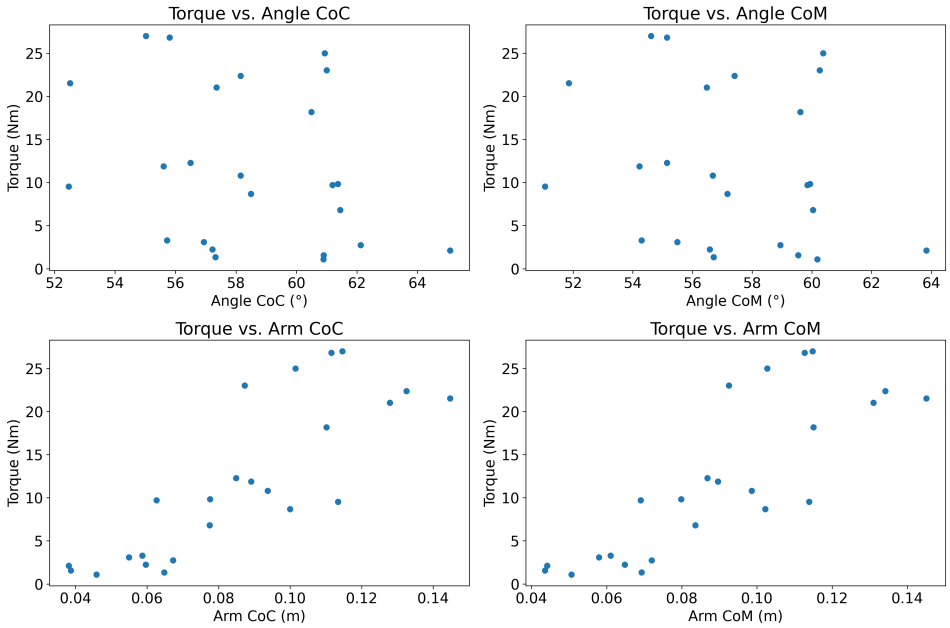


Figure L.1: Scatter plots of torque versus CoC/CoM angles and arms

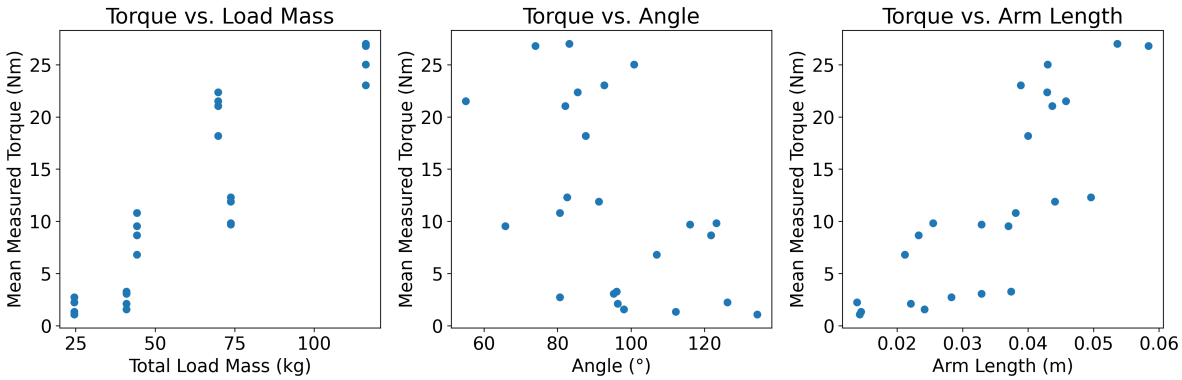


Figure L.2: Relationships between torque and load mass, angle, and arm length in milling

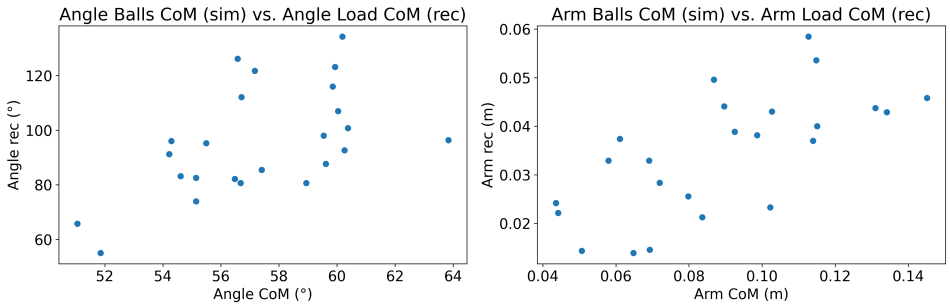


Figure L.3: Simulated versus measured CoM angles and arms comparison

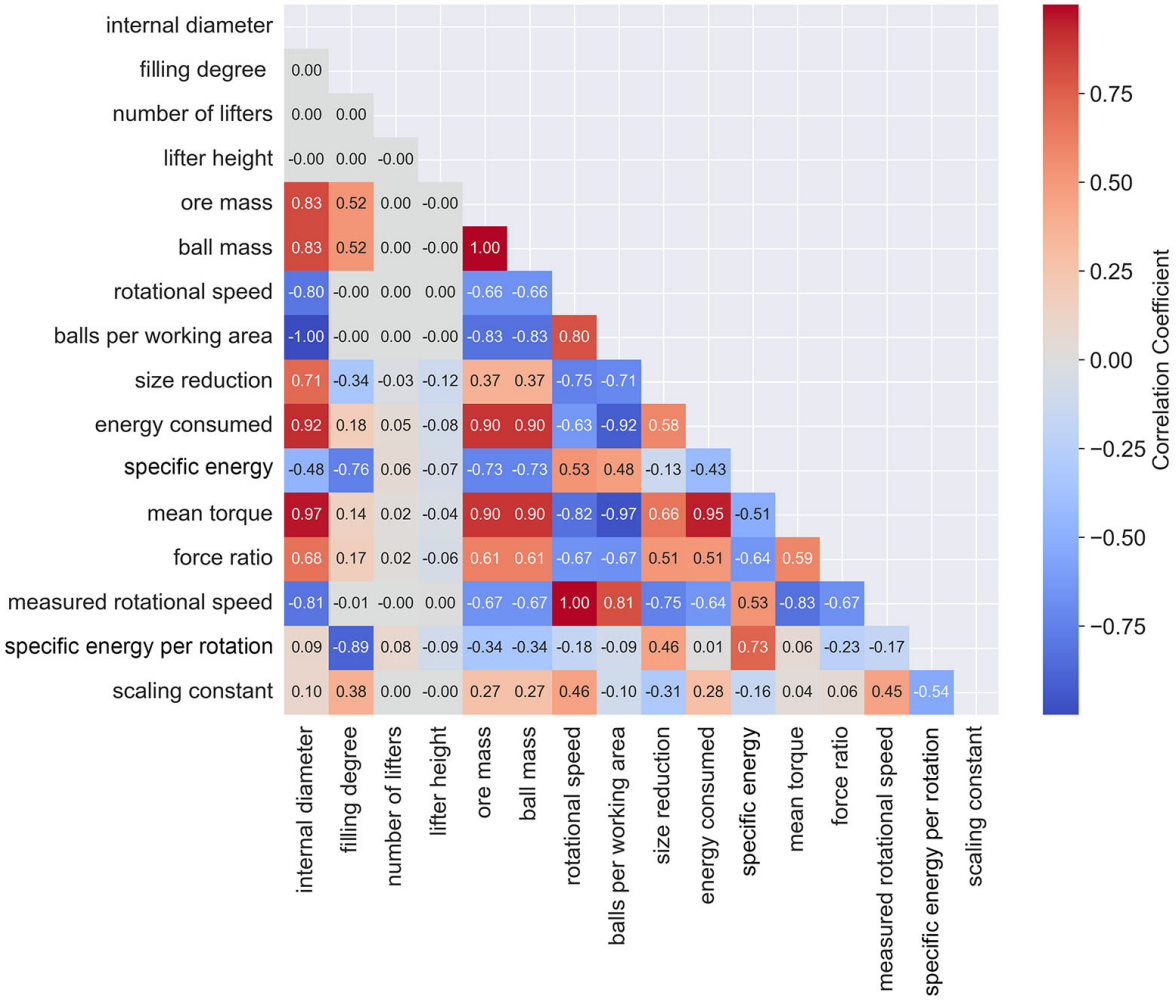


Figure L.4: Correlation matrix for milling parameters in dry milling experiments

Table L.1: Correlation coefficients and p-values for internal diameter and various dry milling parameters

	Correlation Coefficient	p-value
mean torque	0.965	0.000
energy consumed	0.919	0.000
ball mass	0.827	0.000
ore mass	0.827	0.000
size reduction	0.714	0.000
force ratio	0.676	0.000
specific energy	-0.476	0.019
rotational speed	-0.802	0.000
measured rotational speed	-0.807	0.000
balls per working area	-1.000	0.000

Table L.2: Correlation coefficients and p-values for filling degree and various dry milling parameters

	Correlation Coefficient	p-value
ore mass	0.518	0.009
ball mass	0.518	0.009
specific energy	-0.755	0.000
specific energy per rotation	-0.889	0.000

Table L.3: Correlation coefficients and p-values for ore mass and various dry milling parameters

	Correlation Coefficient	p-value
ball mass	1.000	0.000
mean torque	0.898	0.000
energy consumed	0.895	0.000
internal diameter	0.827	0.000
force ratio	0.610	0.002
filling degree	0.518	0.009
rotational speed	-0.658	0.000
measured rotational speed	-0.667	0.000
specific energy	-0.727	0.000
balls per working area	-0.828	0.000

Table L.4: Correlation coefficients and p-values for ball mass and various dry milling parameters

	Correlation Coefficient	p-value
ore mass	1.000	0.000
mean torque	0.898	0.000
energy consumed	0.895	0.000
internal diameter	0.827	0.000
force ratio	0.610	0.002
filling degree	0.518	0.009
rotational speed	-0.658	0.000
measured rotational speed	-0.667	0.000
specific energy	-0.727	0.000
balls per working area	-0.828	0.000

Table L.5: Correlation coefficients and p-values for rotational speed and various dry milling parameters

	Correlation Coefficient	p-value
measured rotational speed	1.000	0.000
balls per working area	0.802	0.000
specific energy	0.527	0.008
scaling constant	0.456	0.025
energy consumed	-0.633	0.001
ore mass	-0.658	0.000
ball mass	-0.658	0.000
force ratio	-0.667	0.000
size reduction	-0.747	0.000
internal diameter	-0.802	0.000
mean torque	-0.822	0.000

Table L.6: Correlation coefficients and p-values for measured rotational speed and various dry milling parameters

	Correlation Coefficient	p-value
rotational speed	1.000	0.000
balls per working area	0.806	0.000
specific energy	0.531	0.008
scaling constant	0.446	0.029
energy consumed	-0.641	0.001
ore mass	-0.667	0.000
ball mass	-0.667	0.000
force ratio	-0.672	0.000
size reduction	-0.748	0.000
internal diameter	-0.807	0.000
mean torque	-0.828	0.000

Table L.7: Correlation coefficients and p-values for balls per working area and various dry milling parameters

	Correlation Coefficient	p-value
measured rotational speed	0.806	0.000
rotational speed	0.802	0.000
specific energy	0.476	0.019
force ratio	-0.674	0.000
size reduction	-0.714	0.000
ore mass	-0.828	0.000
ball mass	-0.828	0.000
energy consumed	-0.920	0.000
mean torque	-0.965	0.000
internal diameter	-1.000	0.000

Table L.8: Correlation coefficients and p-values for size reduction and various dry milling parameters

	Correlation Coefficient	p-value
internal diameter	0.714	0.000
mean torque	0.664	0.000
energy consumed	0.583	0.003
force ratio	0.509	0.011
specific energy per rotation	0.458	0.024
balls per working area	-0.714	0.000
rotational speed	-0.747	0.000
measured rotational speed	-0.748	0.000

Table L.9: Correlation coefficients and p-values for energy consumed and various dry milling parameters

	Correlation Coefficient	p-value
mean torque	0.953	0.000
internal diameter	0.919	0.000
ball mass	0.895	0.000
ore mass	0.895	0.000
size reduction	0.583	0.003
force ratio	0.507	0.011
specific energy	-0.427	0.038
rotational speed	-0.633	0.001
measured rotational speed	-0.641	0.001
balls per working area	-0.920	0.000

Table L.10: Correlation coefficients and p-values for specific energy and various dry milling parameters

	Correlation Coefficient	p-value
specific energy per rotation	0.732	0.000
measured rotational speed	0.531	0.008
rotational speed	0.527	0.008
balls per working area	0.476	0.019
energy consumed	-0.427	0.038
internal diameter	-0.476	0.019
mean torque	-0.512	0.010
force ratio	-0.644	0.001
ball mass	-0.727	0.000
ore mass	-0.727	0.000
filling degree	-0.755	0.000

Table L.11: Correlation coefficients and p-values for mean torque and various dry milling parameters

	Correlation Coefficient	p-value
internal diameter	0.965	0.000
energy consumed	0.953	0.000
ball mass	0.898	0.000
ore mass	0.898	0.000
size reduction	0.664	0.000
force ratio	0.592	0.002
specific energy	-0.512	0.010
rotational speed	-0.822	0.000
measured rotational speed	-0.828	0.000
balls per working area	-0.965	0.000

Table L.12: Correlation coefficients and p-values for force ratio and various dry milling parameters

	Correlation Coefficient	p-value
internal diameter	0.676	0.000
ball mass	0.610	0.002
ore mass	0.610	0.002
mean torque	0.592	0.002
size reduction	0.509	0.011
energy consumed	0.507	0.011
specific energy	-0.644	0.001
rotational speed	-0.667	0.000
measured rotational speed	-0.672	0.000
balls per working area	-0.674	0.000

Table L.13: Correlation coefficients and p-values for specific energy per rotation and various dry milling parameters

	Correlation Coefficient	p-value
specific energy	0.732	0.000
size reduction	0.458	0.024
scaling constant	-0.538	0.007
filling degree	-0.889	0.000

Table L.14: Correlation coefficients and p-values for scaling constant and various dry milling parameters

	Correlation Coefficient	p-value
rotational speed	0.456	0.025
measured rotational speed	0.446	0.029
specific energy per rotation	-0.538	0.007

Appendix M: Correlations – Wet Milling

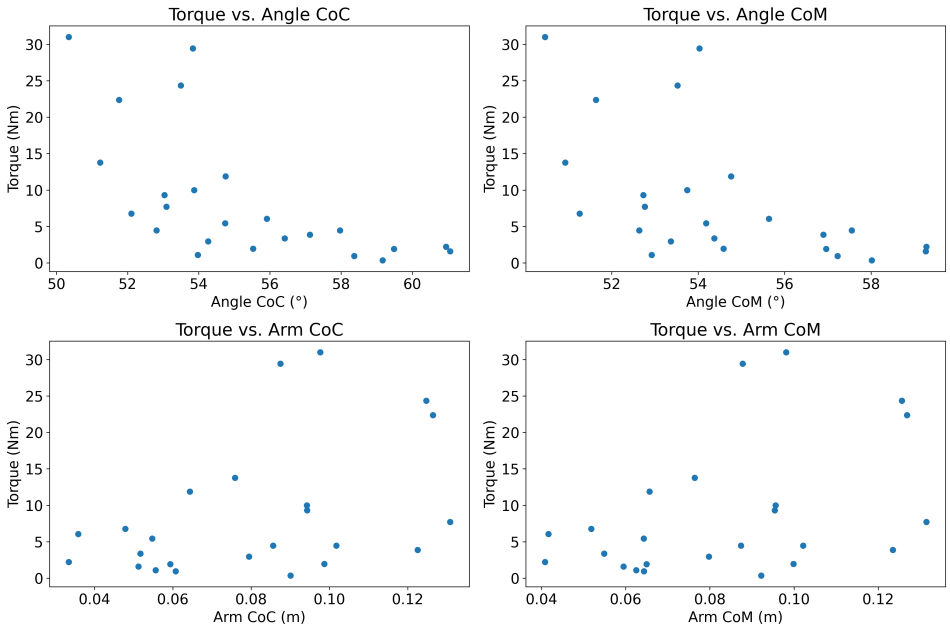


Figure M.1: Torque relationships with CoC/CoM angles and arms in wet milling

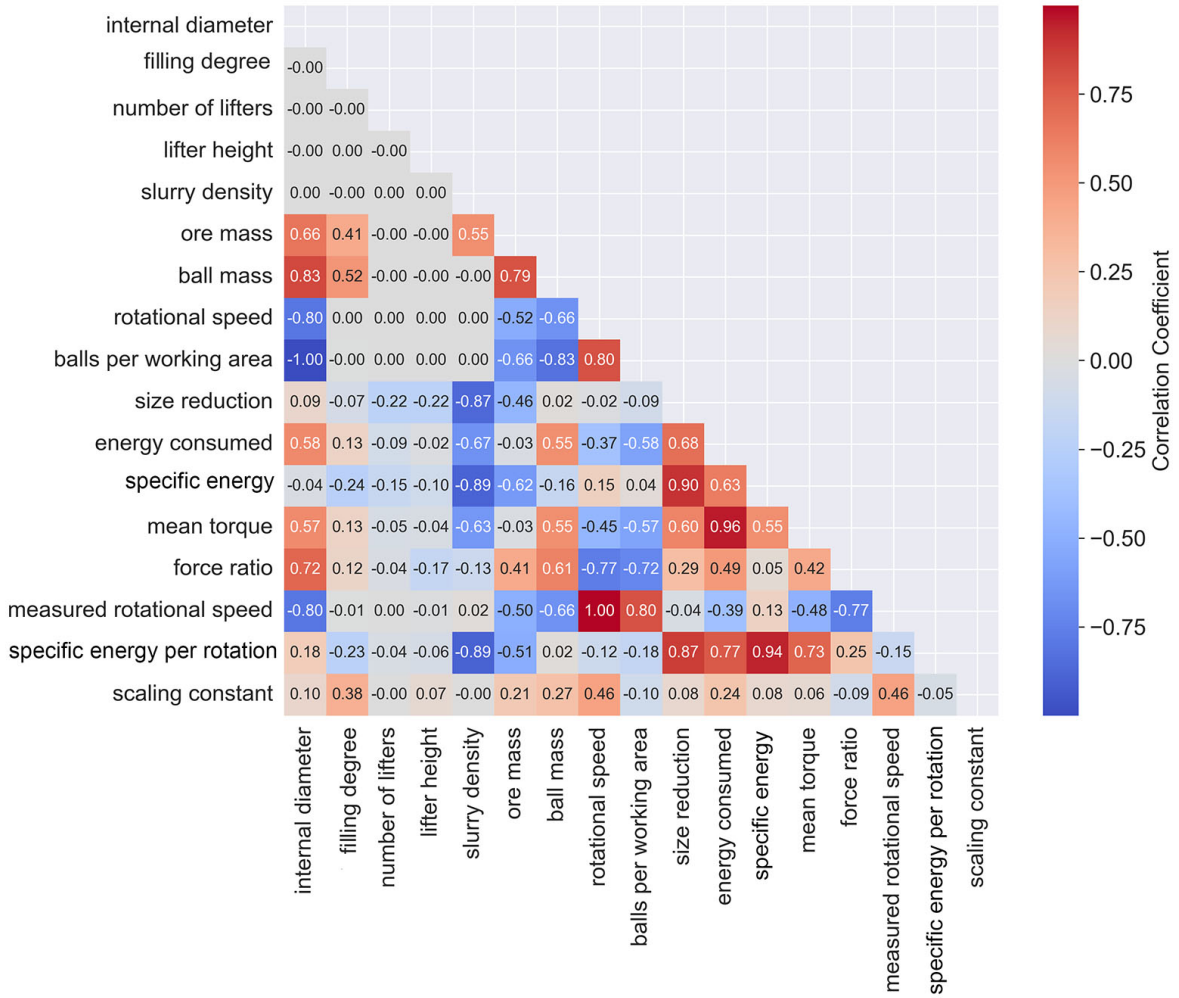


Figure M.2: Correlation matrix for milling parameters in wet milling experiments

Table M.1: Correlation coefficients and p-values for internal diameter and various wet milling parameters

	Correlation Coefficient	p-value
ball mass	0.827	0.000
force ratio	0.720	0.000
ore mass	0.658	0.000
energy consumed	0.576	0.003
mean torque	0.567	0.004
measured rotational speed	-0.797	0.000
rotational speed	-0.802	0.000
balls per working area	-1.000	0.000

Table M.2: Correlation coefficients and p-values for filling degree and various wet milling parameters

	Correlation Coefficient	p-value
ball mass	0.518	0.009
ore mass	0.412	0.046

Table M.3: Correlation coefficients and p-values for slurry density and various wet milling parameters

	Correlation Coefficient	p-value
ore mass	0.547	0.006
mean torque	-0.633	0.001
energy consumed	-0.668	0.000
size reduction	-0.866	0.000
specific energy	-0.891	0.000
specific energy per rotation	-0.893	0.000

Table M.4: Correlation coefficients and p-values for ore mass and various wet milling parameters

	Correlation Coefficient	p-value
ball mass	0.795	0.000
internal diameter	0.658	0.000
slurry density	0.547	0.006
filling degree	0.412	0.046
force ratio	0.406	0.049
size reduction	-0.460	0.024
measured rotational speed	-0.505	0.012
specific energy per rotation	-0.509	0.011
rotational speed	-0.523	0.009
specific energy	-0.619	0.001
balls per working area	-0.658	0.000

Table M.5: Correlation coefficients and p-values for ball mass and various wet milling parameters

	Correlation Coefficient	p-value
internal diameter	0.827	0.000
ore mass	0.795	0.000
force ratio	0.606	0.002
mean torque	0.550	0.005
energy consumed	0.547	0.006
filling degree	0.518	0.009
measured rotational speed	-0.658	0.000
rotational speed	-0.658	0.000
balls per working area	-0.828	0.000

Table M.6: Correlation coefficients and p-values for rotational speed and various wet milling parameters

	Correlation Coefficient	p-value
measured rotational speed	0.999	0.000
balls per working area	0.802	0.000
scaling constant	0.456	0.025
mean torque	-0.453	0.026
ore mass	-0.523	0.009
ball mass	-0.658	0.000
force ratio	-0.768	0.000
internal diameter	-0.802	0.000

Table M.7: Correlation coefficients and p-values for measured rotational speed and various wet milling parameters

	Correlation Coefficient	p-value
rotational speed	0.999	0.000
balls per working area	0.797	0.000
scaling constant	0.458	0.024
mean torque	-0.477	0.018
ore mass	-0.505	0.012
ball mass	-0.658	0.000
force ratio	-0.765	0.000
internal diameter	-0.797	0.000

Table M.8: Correlation coefficients and p-values for balls per working area and various wet milling parameters

	Correlation Coefficient	p-value
rotational speed	0.802	0.000
measured rotational speed	0.797	0.000
mean torque	-0.568	0.004
energy consumed	-0.576	0.003
ore mass	-0.658	0.000
force ratio	-0.719	0.000
ball mass	-0.828	0.000
internal diameter	-1.000	0.000

Table M.9: Correlation coefficients and p-values for size reduction and various wet milling parameters

	Correlation Coefficient	p-value
specific energy	0.899	0.000
specific energy per rotation	0.869	0.000
energy consumed	0.683	0.000
mean torque	0.600	0.002
ore mass	-0.460	0.024
slurry density	-0.866	0.000

Table M.10: Correlation coefficients and p-values for energy consumed and various wet milling parameters

	Correlation Coefficient	p-value
mean torque	0.960	0.000
specific energy per rotation	0.768	0.000
size reduction	0.683	0.000
specific energy	0.629	0.001
internal diameter	0.576	0.003
ball mass	0.547	0.006
force ratio	0.493	0.014
balls per working area	-0.576	0.003
slurry density	-0.668	0.000

Table M.11: Correlation coefficients and p-values for specific energy and various wet milling parameters

	Correlation Coefficient	p-value
specific energy per rotation	0.944	0.000
size reduction	0.899	0.000
energy consumed	0.629	0.001
mean torque	0.553	0.005
ore mass	-0.619	0.001
slurry density	-0.891	0.000

Table M.12: Correlation coefficients and p-values for mean torque and various wet milling parameters

	Correlation Coefficient	p-value
energy consumed	0.960	0.000
specific energy per rotation	0.730	0.000
size reduction	0.600	0.002
internal diameter	0.567	0.004
specific energy	0.553	0.005
ball mass	0.550	0.005
force ratio	0.417	0.043
rotational speed	-0.453	0.026
measured rotational speed	-0.477	0.018
balls per working area	-0.568	0.004
slurry density	-0.633	0.001

Table M.13: Correlation coefficients and p-values for force ratio and various wet milling parameters

	Correlation Coefficient	p-value
internal diameter	0.720	0.000
ball mass	0.606	0.002
energy consumed	0.493	0.014
mean torque	0.417	0.043
ore mass	0.406	0.049
balls per working area	-0.719	0.000
measured rotational speed	-0.765	0.000
rotational speed	-0.768	0.000

Table M.14: Correlation coefficients and p-values for specific energy per rotation and various wet milling parameters

	Correlation Coefficient	p-value
specific energy	0.944	0.000
size reduction	0.869	0.000
energy consumed	0.768	0.000
mean torque	0.730	0.000
ore mass	-0.509	0.011
slurry density	-0.893	0.000

Table M.15: Correlation coefficients and p-values for scaling constant and various wet milling parameters

	Correlation Coefficient	p-value
measured rotational speed	0.458	0.024
rotational speed	0.456	0.025

Appendix N: DoE Data

This appendix contains the statistical analysis results performed using Minitab Statistical Software. It also includes all the data from the experimental designs and their results.

Factorial Regression: size reduction versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		3,984	0,167	23,83	0,000	
rotational speed	-0,875	-0,437	0,167	-2,62	0,040	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,472872	53,29%	45,50%	16,95%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	1,530	1,5304	6,84	0,040
Linear	1	1,530	1,5304	6,84	0,040
rotational speed	1	1,530	1,5304	6,84	0,040
Error	6	1,342	0,2236		
Total	7	2,872			

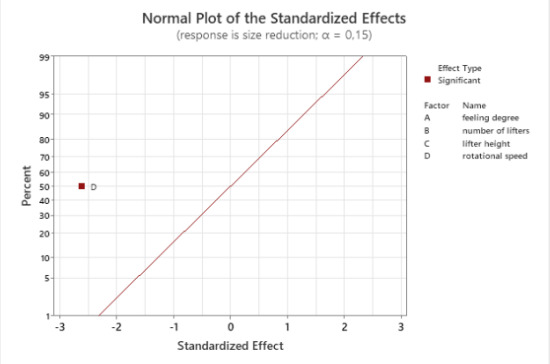
Regression Equation in Uncoded Units

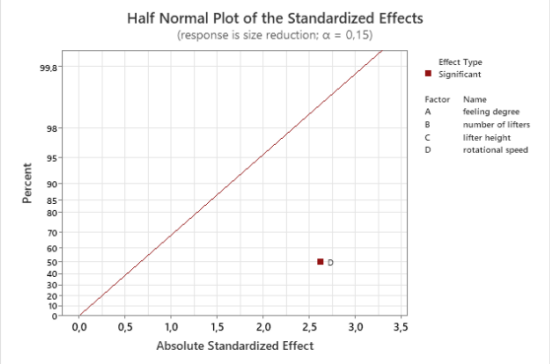
size reduction = 8,36 - 0,0705 rotational speed

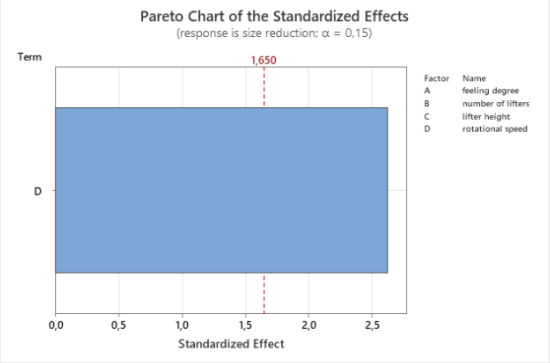
Alias Structure

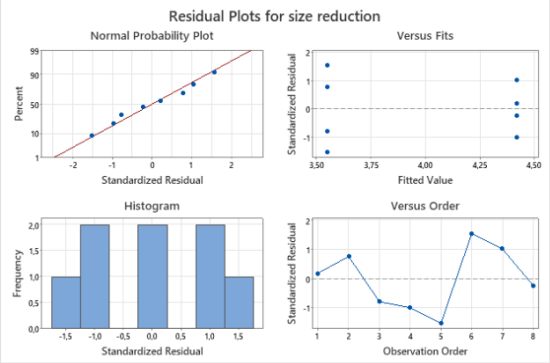
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
D + ABC









DRY_300

Factorial Regression: energy consumed versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		147159	2785	52,85	0,000	
rotational speed	19676	9838	2785	3,53	0,012	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
7876,27	67,54%	62,12%	42,29%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	774309628	774309628	12,48	0,012
Linear	1	774309628	774309628	12,48	0,012
rotational speed	1	774309628	774309628	12,48	0,012
Error	6	372213541	62035590		
Total	7	1146523169			

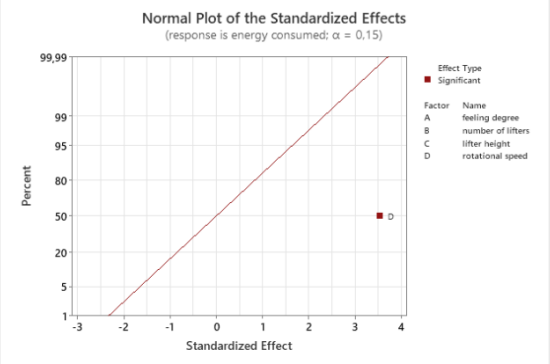
Regression Equation in Uncoded Units

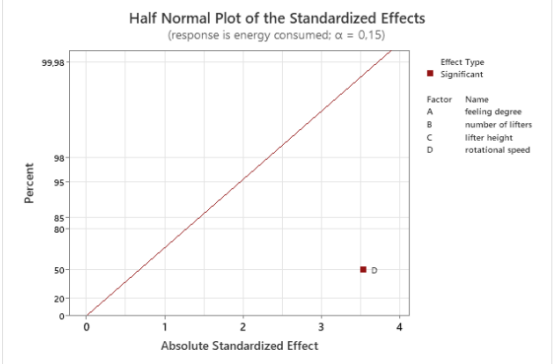
energy consumed = 48809 + 1587 rotational speed

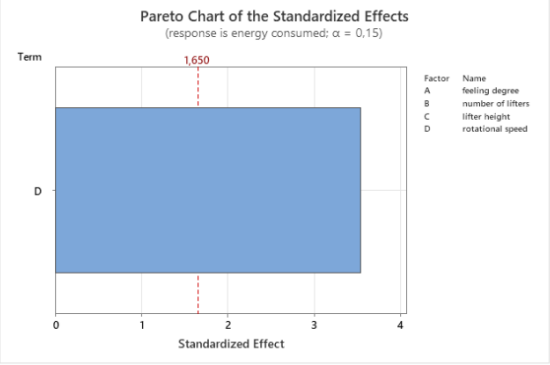
Alias Structure

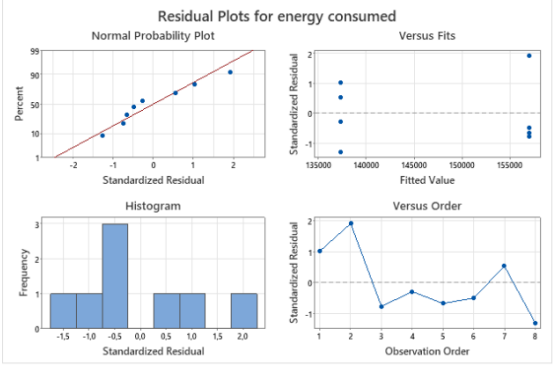
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
D + ABC









Factorial Regression: energy intake per mass unit versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		30249	442	68,39	0,000	
feeling degree	-14488	-7244	442	-16,38	0,000	1,00
rotational speed	3791	1895	442	4,29	0,008	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1251,03	98,29%	97,60%	95,61%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	448529371	224264686	143,29	0,000
Linear	2	448529371	224264686	143,29	0,000
feeling degree	1	419789800	419789800	268,22	0,000
rotational speed	1	28739571	28739571	18,36	0,008
Error	5	7825418	1565084		
Total	7	456354789			

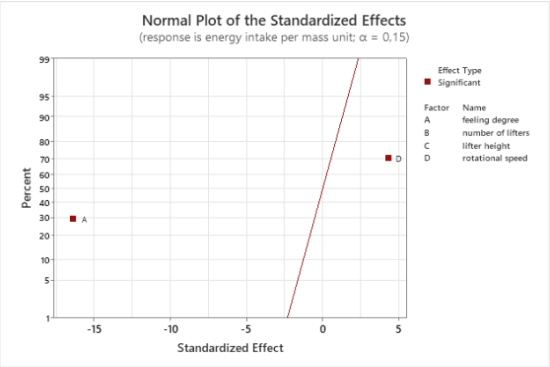
Regression Equation in Uncoded Units

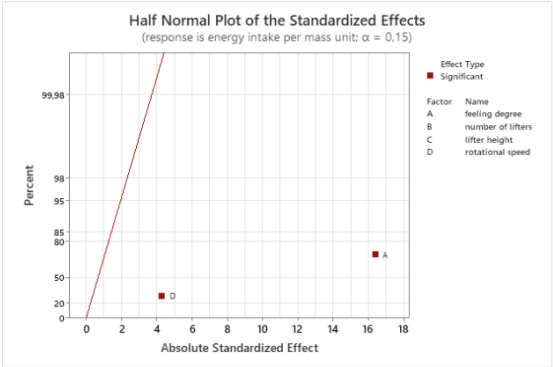
energy intake per mass unit = 40277 - 72439 feeling degree + 305,7 rotational speed

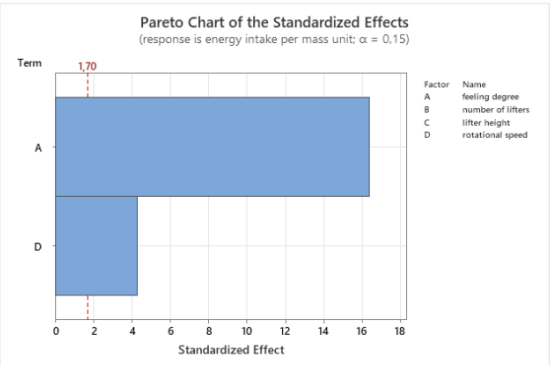
Alias Structure

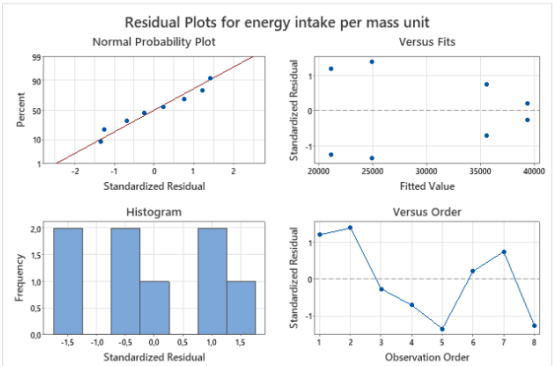
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









DRY_300

Factorial Regression: mean torque versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		2,1800	0,0127	171,01	0,000	
feeling degree	0,6550	0,3275	0,0127	25,69	0,000	1,00
number of lifters	-0,1400	-0,0700	0,0127	-5,49	0,012	1,00
lifter height	-0,3750	-0,1875	0,0127	-14,71	0,001	1,00
rotational speed	-1,3100	-0,6550	0,0127	-51,38	0,000	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0360555	99,92%	99,80%	99,40%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	4,61070	1,15267	886,67	0,000
Linear	4	4,61070	1,15267	886,67	0,000
feeling degree	1	0,85805	0,85805	660,04	0,000
number of lifters	1	0,03920	0,03920	30,15	0,012
lifter height	1	0,28125	0,28125	216,35	0,001
rotational speed	1	3,43220	3,43220	2640,15	0,000
Error	3	0,00390	0,00130		
Total	7	4,61460			

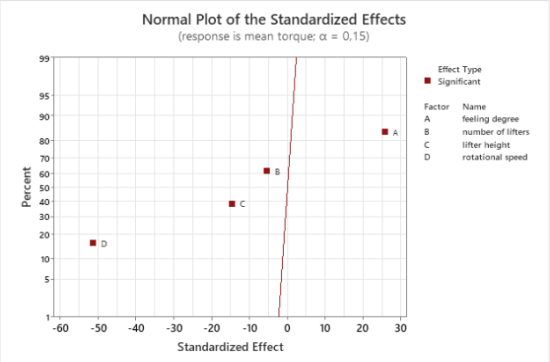
Regression Equation in Uncoded Units

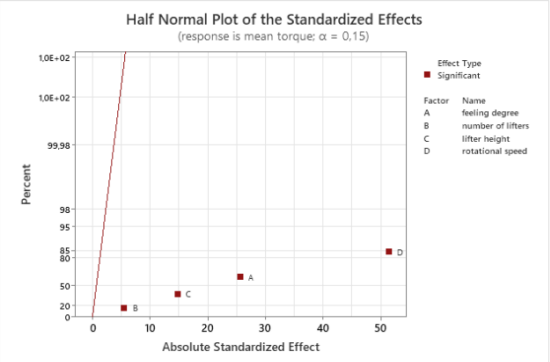
mean torque = 8,003 + 3,275 feeling degree - 0,03500 number of lifters - 37,50 lifter height
- 0,10565 rotational speed

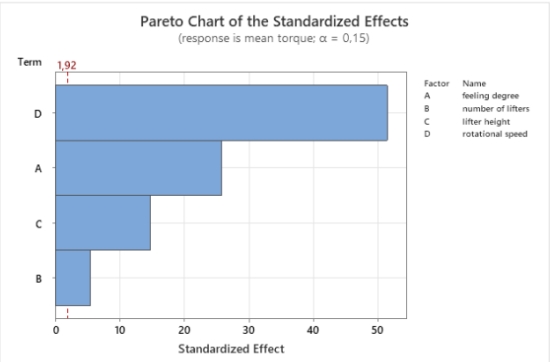
Alias Structure

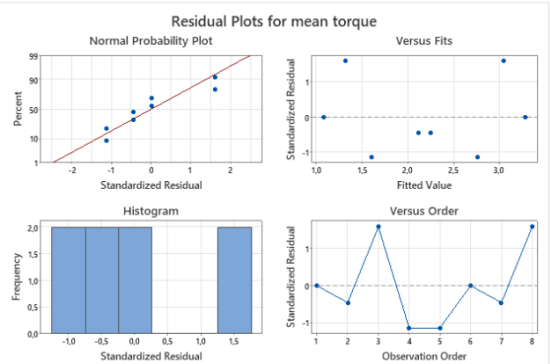
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
B + ACD
C + ABD
D + ABC









DRY_300

Factorial Regression: force ratio versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		0,8651	0,0101	85,39	0,000	
feeling degree	0,0418	0,0209	0,0101	2,06	0,094	1,00
rotational speed	-0,0412	-0,0206	0,0101	-2,04	0,097	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0286553	62,66%	47,72%	4,41%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	0,006889	0,003445	4,20	0,085
Linear	2	0,006889	0,003445	4,20	0,085
feeling degree	1	0,003486	0,003486	4,25	0,094
rotational speed	1	0,003403	0,003403	4,14	0,097
Error	5	0,004106	0,000821		
Total	7	0,010995			

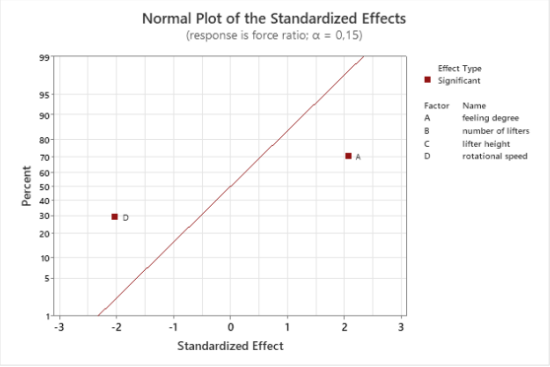
Regression Equation in Uncoded Units

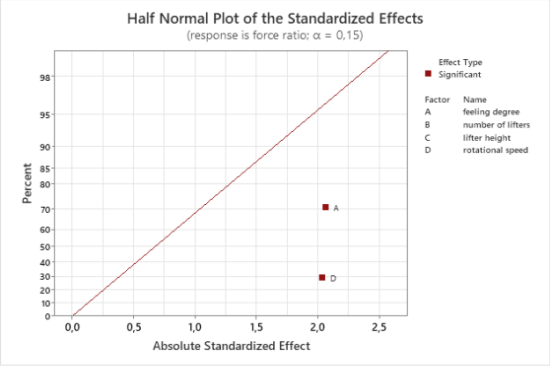
force ratio = 0,988 + 0,209 feeling degree - 0,00333 rotational speed

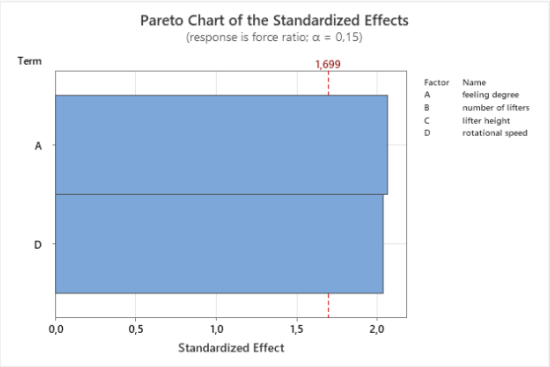
Alias Structure

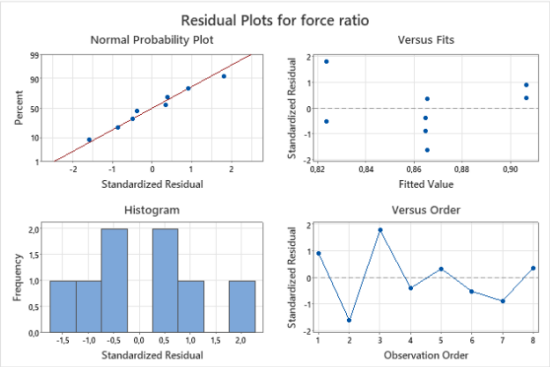
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









Factorial Regression: energy per mass per rotation versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		15,671	0,295	53,13	0,000	
feeling degree	-7,553	-3,776	0,295	-12,80	0,000	1,00
rotational speed	-1,292	-0,646	0,295	-2,19	0,080	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,834298	97,12%	95,97%	92,63%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	117,422	58,711	84,35	0,000
Linear	2	117,422	58,711	84,35	0,000
feeling degree	1	114,081	114,081	163,90	0,000
rotational speed	1	3,341	3,341	4,80	0,080
Error	5	3,480	0,696		
Total	7	120,902			

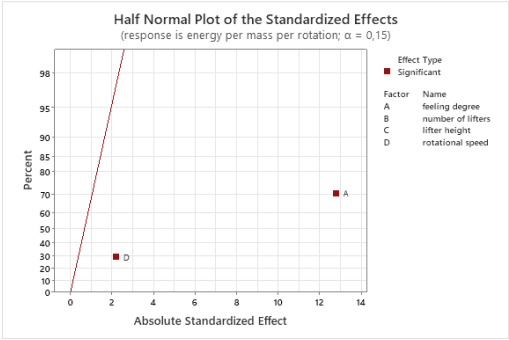
Regression Equation in Uncoded Units

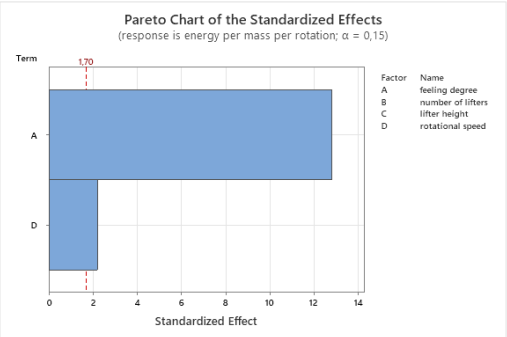
energy per mass per rotation = 37,24 - 37,76 feeling degree - 0,1042 rotational speed

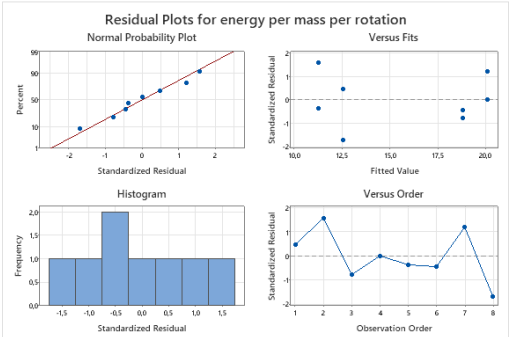
Alias Structure

Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC







Factorial Regression: size reduction versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		5,030	0,188	26,72	0,000	
feeling degree	-0,809	-0,404	0,188	-2,15	0,084	1,00
rotational speed	-0,682	-0,341	0,188	-1,81	0,130	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,532489	61,23%	45,72%	0,75%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	2,2391	1,1195	3,95	0,094
Linear	2	2,2391	1,1195	3,95	0,094
feeling degree	1	1,3082	1,3082	4,61	0,084
rotational speed	1	0,9309	0,9309	3,28	0,130
Error	5	1,4177	0,2835		
Total	7	3,6568			

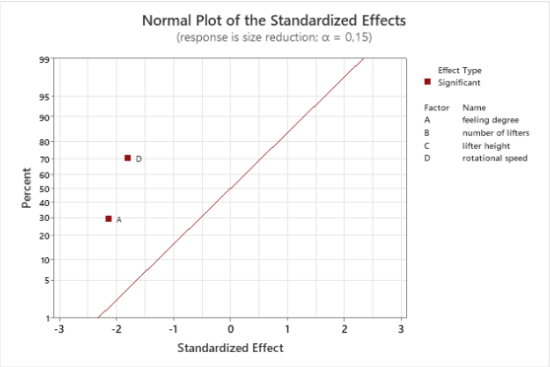
Regression Equation in Uncoded Units

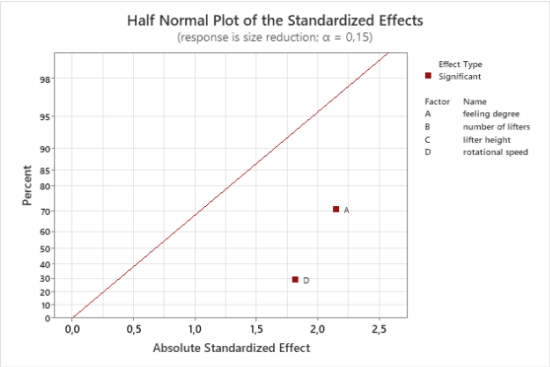
size reduction = 10,06 - 4,04 feeling degree - 0,0662 rotational speed

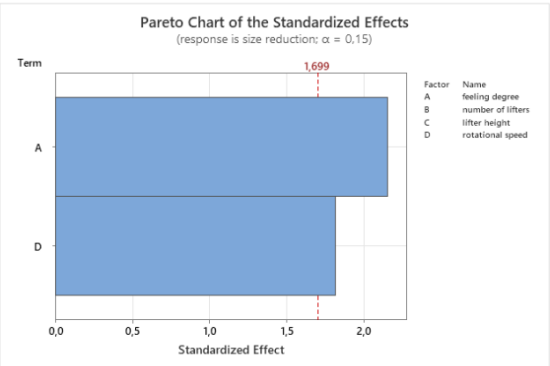
Alias Structure

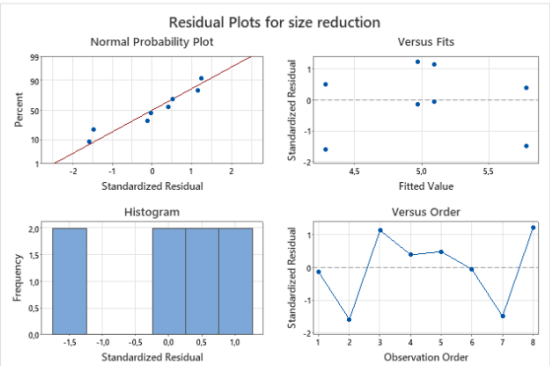
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









DRY_400

Factorial Regression: energy consumed versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		200513	2877	69,69	0,000	
feeling degree	23950	11975	2877	4,16	0,009	1,00
rotational speed	15684	7842	2877	2,73	0,042	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
8138,24	83,19%	76,47%	56,97%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	1639132813	819566406	12,37	0,012
Linear	2	1639132813	819566406	12,37	0,012
feeling degree	1	1147157100	1147157100	17,32	0,009
rotational speed	1	491975712	491975712	7,43	0,042
Error	5	331154619	66230924		
Total	7	1970287432			

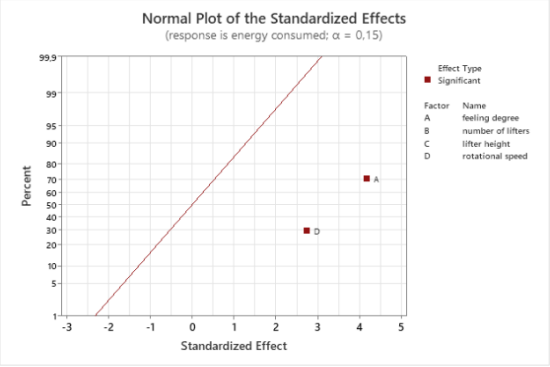
Regression Equation in Uncoded Units

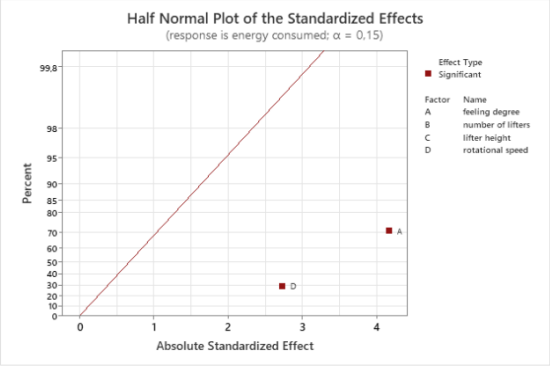
energy consumed = 74201 + 119748 feeling degree + 1521 rotational speed

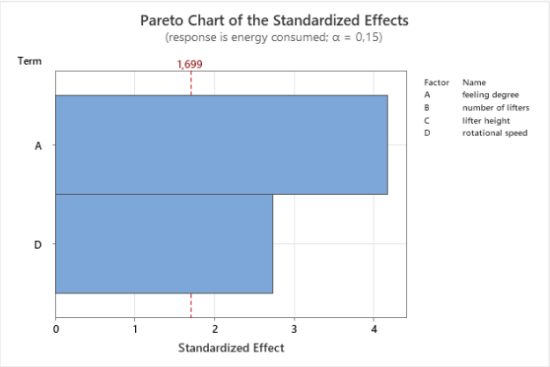
Alias Structure

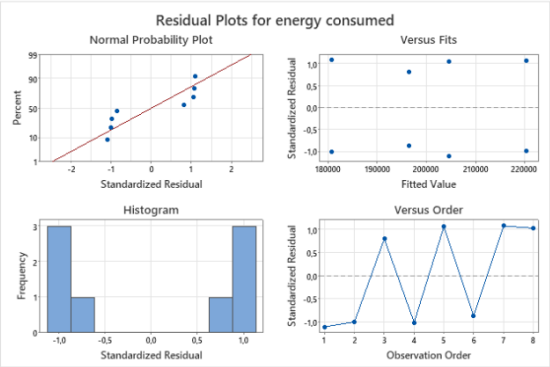
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









DRY_400

Factorial Regression: energy intake per mass unit versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		22598	343	65,97	0,000	
feeling degree	-8749	-4374	343	-12,77	0,000	1,00
rotational speed	1782	891	343	2,60	0,048	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
968,815	97,14%	96,00%	92,68%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	159430519	79715260	84,93	0,000
Linear	2	159430519	79715260	84,93	0,000
feeling degree	1	153081253	153081253	163,09	0,000
rotational speed	1	6349266	6349266	6,76	0,048
Error	5	4693016	938603		
Total	7	164123535			

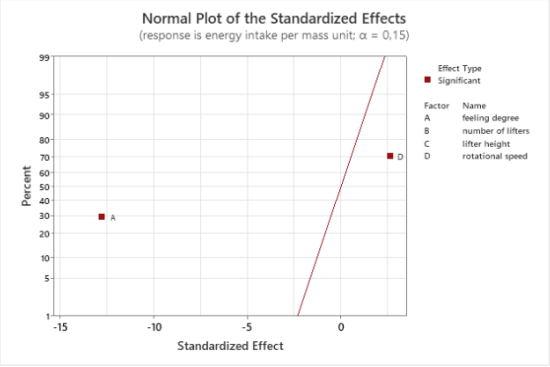
Regression Equation in Uncoded Units

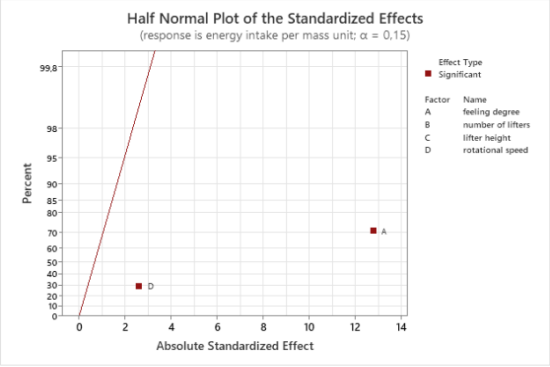
energy intake per mass unit = 31188 - 43744 feeling degree + 172,8 rotational speed

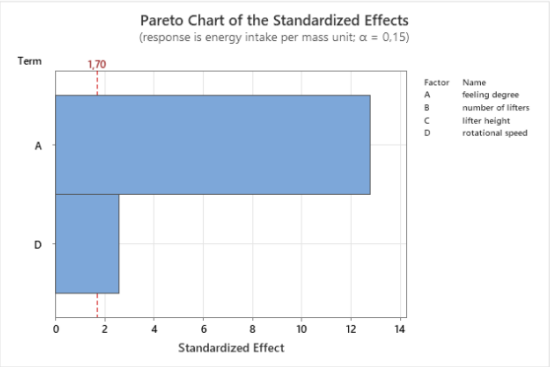
Alias Structure

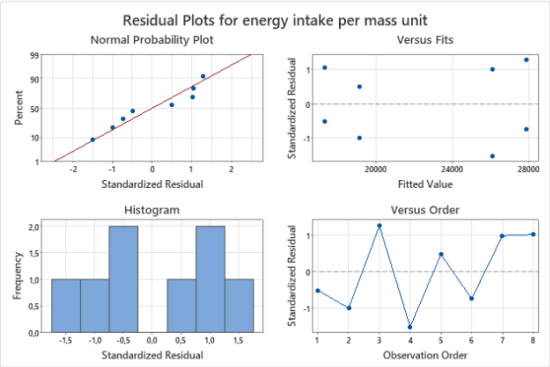
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









DRY_400

Factorial Regression: mean torque versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		9,944	0,256	38,80	0,000	
feeling degree	1,968	0,984	0,256	3,84	0,012	1,00
rotational speed	-2,373	-1,186	0,256	-4,63	0,006	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,724922	87,85%	82,99%	68,90%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	19,000	9,4998	18,08	0,005
Linear	2	19,000	9,4998	18,08	0,005
feeling degree	1	7,742	7,7421	14,73	0,012
rotational speed	1	11,258	11,2575	21,42	0,006
Error	5	2,628	0,5255		
Total	7	21,627			

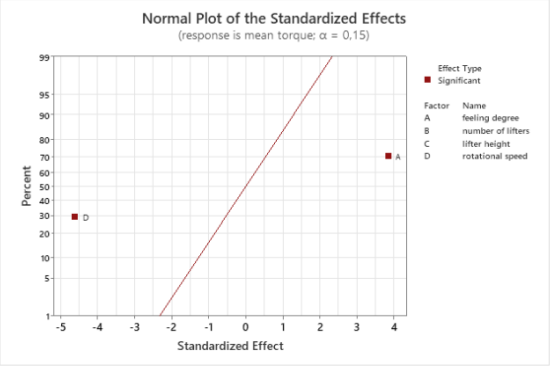
Regression Equation in Uncoded Units

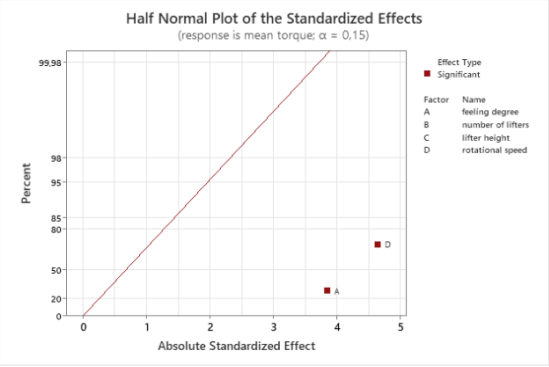
mean torque = 17,87 + 9,84 feeling degree - 0,2301 rotational speed

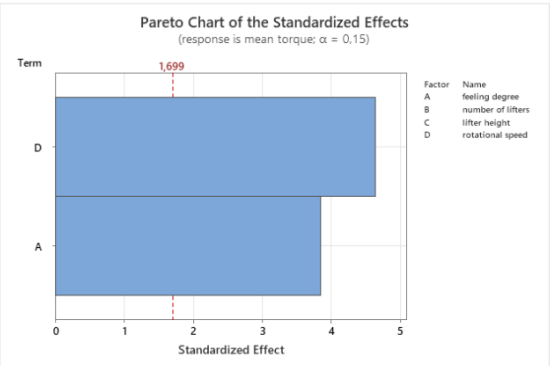
Alias Structure

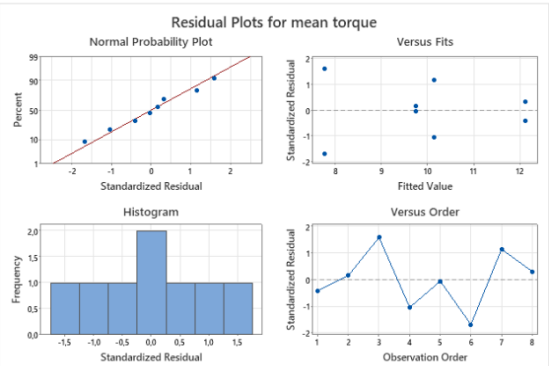
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









Factorial Regression: force ratio versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		1,24738	0,00260	479,56	0,000	
feeling degree	0,06775	0,03388	0,00260	13,02	0,001	1,00
lifter height	-0,03125	-0,01562	0,00260	-6,01	0,009	1,00
rotational speed	-0,03425	-0,01712	0,00260	-6,58	0,007	1,00
feeling degree*lifter height	0,01575	0,00787	0,00260	3,03	0,056	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0073570	98,85%	97,32%	91,83%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	0,013975	0,003494	64,55	0,003
Linear	3	0,013479	0,004493	83,01	0,002
feeling degree	1	0,009180	0,009180	169,61	0,001
lifter height	1	0,001953	0,001953	36,09	0,009
rotational speed	1	0,002346	0,002346	43,35	0,007
2-Way Interactions	1	0,000496	0,000496	9,17	0,056
feeling degree*lifter height	1	0,000496	0,000496	9,17	0,056
Error	3	0,000162	0,000054		
Total	7	0,014138			

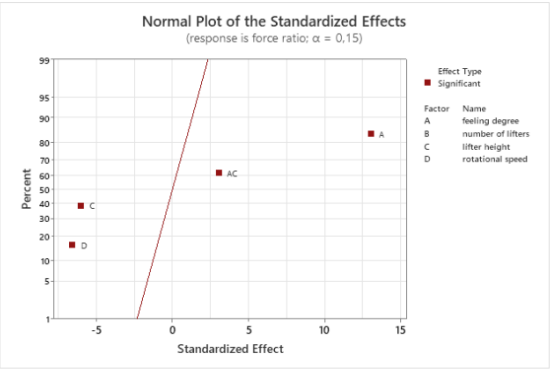
Regression Equation in Uncoded Units

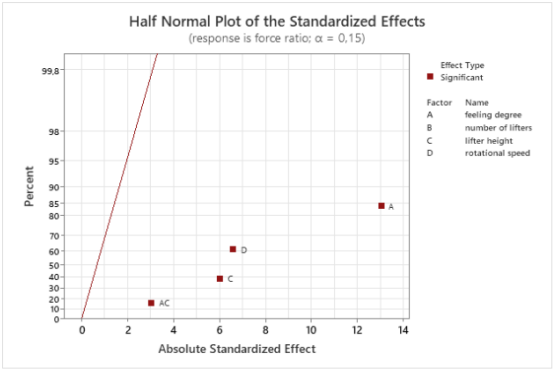
force ratio = 1,3774 + 0,1813 feeling degree - 9,42 lifter height - 0,003322 rotational speed
+ 15,75 feeling degree*lifter height

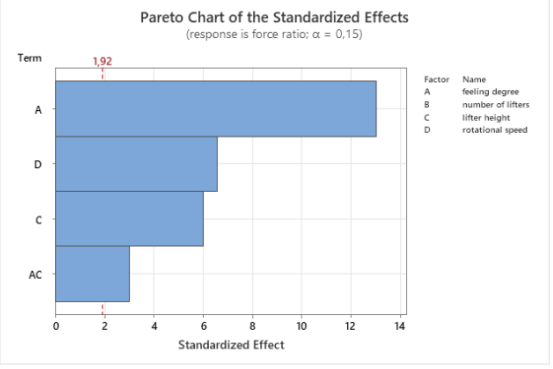
Alias Structure

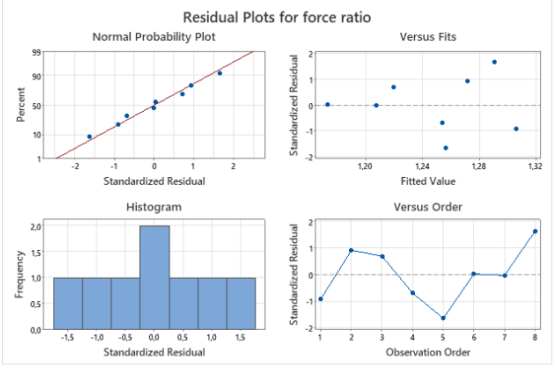
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
C + ABD
D + ABC
AC + BD









Factorial Regression: energy per mass per rotation versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		14,246	0,230	61,91	0,000	
feeling degree	-5,498	-2,749	0,230	-11,94	0,000	1,00
rotational speed	-1,802	-0,901	0,230	-3,92	0,011	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,650871	96,93%	95,71%	92,15%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	66,943	33,4715	79,01	0,000
Linear	2	66,943	33,4715	79,01	0,000
feeling degree	1	60,445	60,4450	142,68	0,000
rotational speed	1	6,498	6,4980	15,34	0,011
Error	5	2,118	0,4236		
Total	7	69,061			

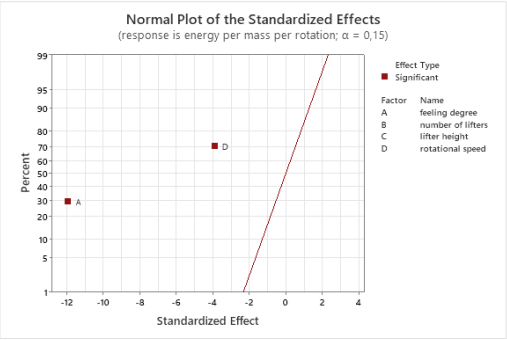
Regression Equation in Uncoded Units

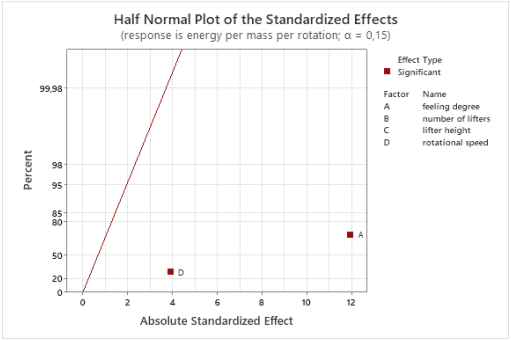
energy per mass per rotation = 34,25 - 27,49 feeling degree - 0,1748 rotational speed

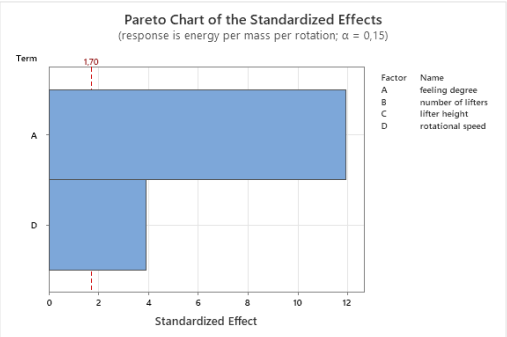
Alias Structure

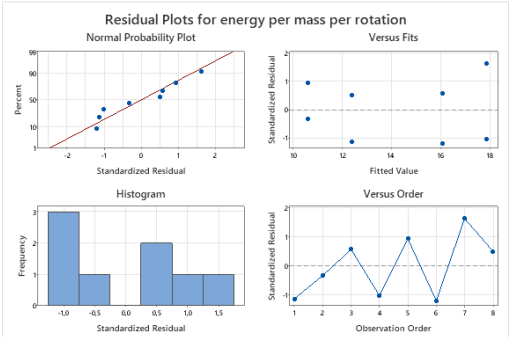
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
D + ABC









DRY_500

Factorial Regression: size reduction versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		5,7580	0,0962	59,84	0,000	
feeling degree	-1,1055	-0,5527	0,0962	-5,74	0,005	1,00
lifter height	-0,9165	-0,4582	0,0962	-4,76	0,009	1,00
feeling degree*lifter height	0,7100	0,3550	0,0962	3,69	0,021	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,272157	94,54%	90,45%	78,17%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	5,1324	1,71080	23,10	0,005
Linear	2	4,1242	2,06210	27,84	0,004
feeling degree	1	2,4443	2,44426	33,00	0,005
lifter height	1	1,6799	1,67994	22,68	0,009
2-Way Interactions	1	1,0082	1,00820	13,61	0,021
feeling degree*lifter height	1	1,0082	1,00820	13,61	0,021
Error	4	0,2963	0,07407		
Total	7	5,4287			

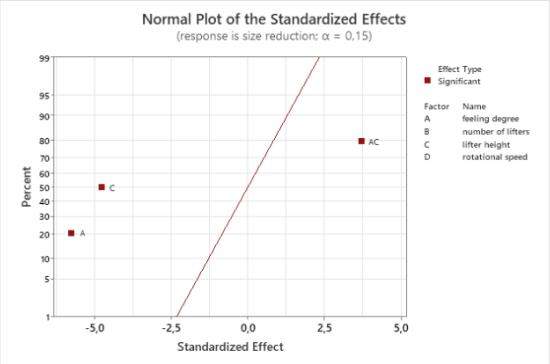
Regression Equation in Uncoded Units

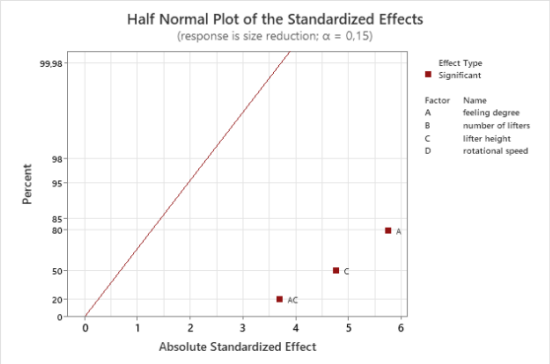
size reduction = 11,726 - 12,63 feeling degree - 375,6 lifter height
+ 710 feeling degree*lifter height

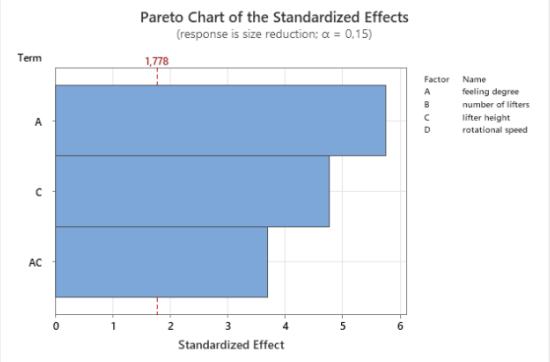
Alias Structure

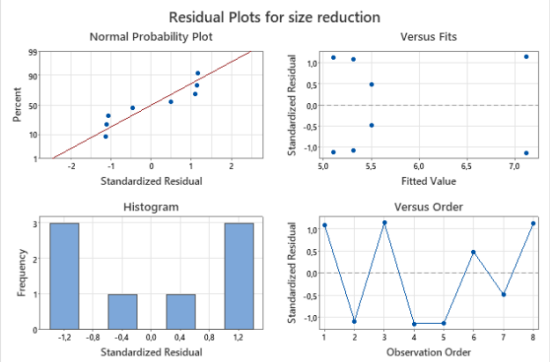
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
C + ABD
AC + BD









Factorial Regression: energy consumed versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		314324	7645	41,11	0,000	
feeling degree	53509	26754	7645	3,50	0,025	1,00
lifter height	-35910	-17955	7645	-2,35	0,079	1,00
rotational speed	33660	16830	7645	2,20	0,093	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
21624,2	84,97%	73,69%	39,87%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	10571417803	3523805934	7,54	0,040
Linear	3	10571417803	3523805934	7,54	0,040
feeling degree	1	5726372653	5726372653	12,25	0,025
lifter height	1	2579020290	2579020290	5,52	0,079
rotational speed	1	2266024860	2266024860	4,85	0,093
Error	4	1870419270	467604818		
Total	7	12441837074			

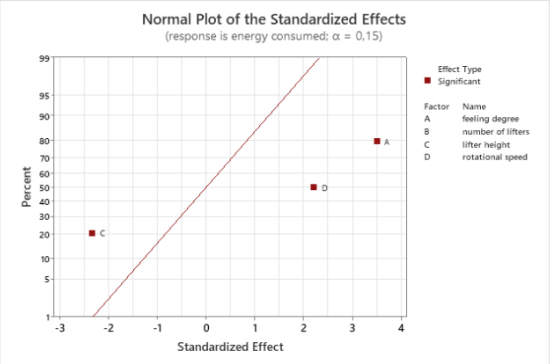
Regression Equation in Uncoded Units

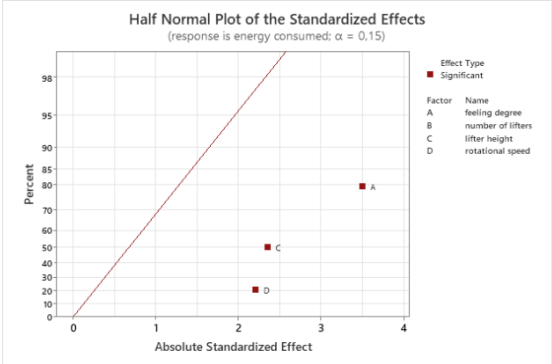
energy consumed = 74934 + 267544 feeling degree - 3590975 lifter height
+ 3795 rotational speed

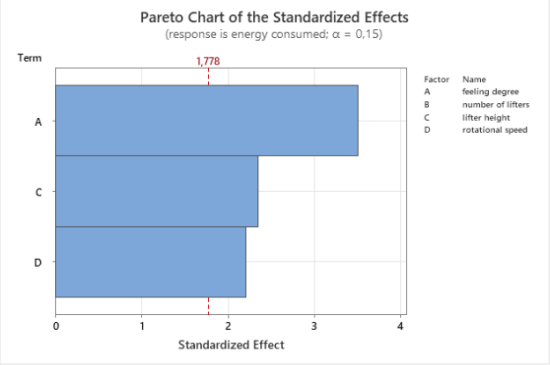
Alias Structure

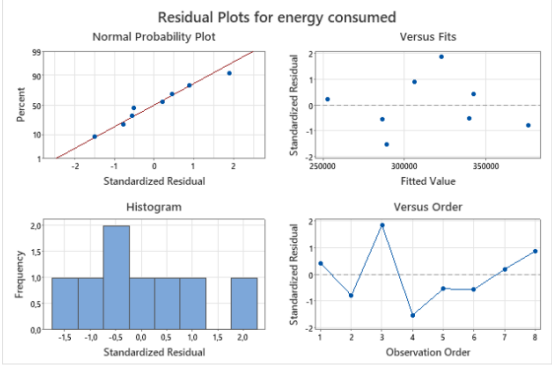
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
C + ABD
D + ABC









Factorial Regression: energy intake per mass unit versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		22336	1015	22,02	0,000	
feeling degree	-7518	-3759	1015	-3,71	0,010	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2869,62	69,59%	64,52%	45,93%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	113040648	113040648	13,73	0,010
Linear	1	113040648	113040648	13,73	0,010
feeling degree	1	113040648	113040648	13,73	0,010
Error	6	49408472	8234745		
Total	7	162449120			

Regression Equation in Uncoded Units

energy intake per mass unit = 37372 - 37590 feeling degree

Fits and Diagnostics for Unusual Observations

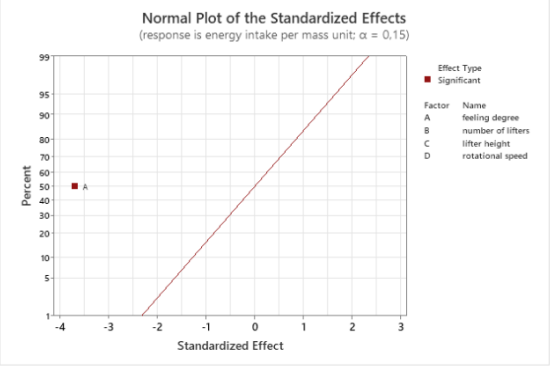
Obs	energy intake per mass unit	Fit	Resid	Std Resid	
3	31845	26095	5750	2,31	R

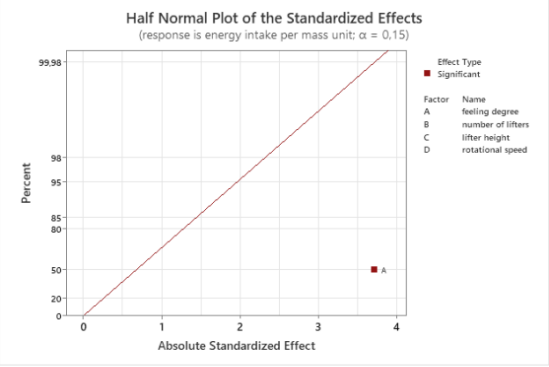
R Large residual

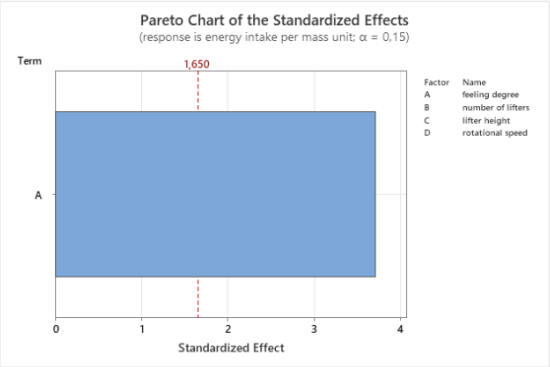
Alias Structure

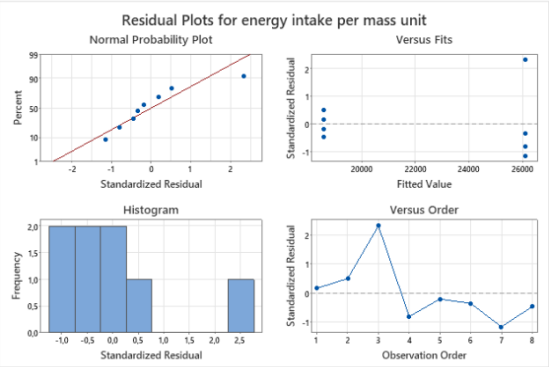
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD









Factorial Regression: mean torque versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		23,119	0,459	50,31	0,000	
feeling degree	4,688	2,344	0,459	5,10	0,007	1,00
lifter height	-1,708	-0,854	0,459	-1,86	0,137	1,00
rotational speed	-1,947	-0,974	0,459	-2,12	0,101	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1,29965	89,46%	81,56%	57,85%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	57,362	19,121	11,32	0,020
Linear	3	57,362	19,121	11,32	0,020
feeling degree	1	43,945	43,945	26,02	0,007
lifter height	1	5,831	5,831	3,45	0,137
rotational speed	1	7,586	7,586	4,49	0,101
Error	4	6,756	1,689		
Total	7	64,118			

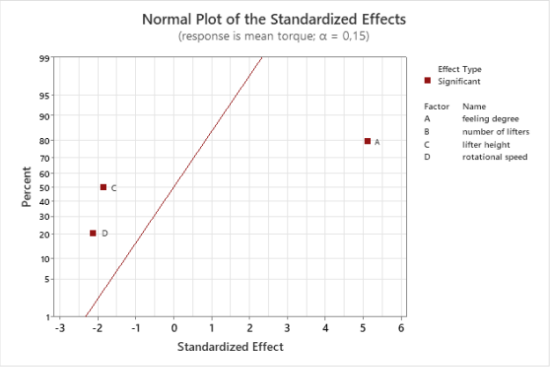
Regression Equation in Uncoded Units

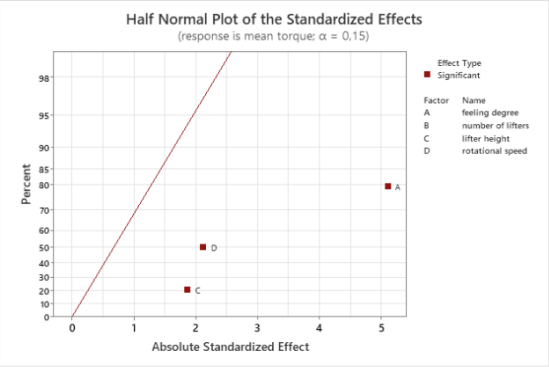
mean torque = 25,19 + 23,44 feeling degree - 170,8 lifter height - 0,220 rotational speed

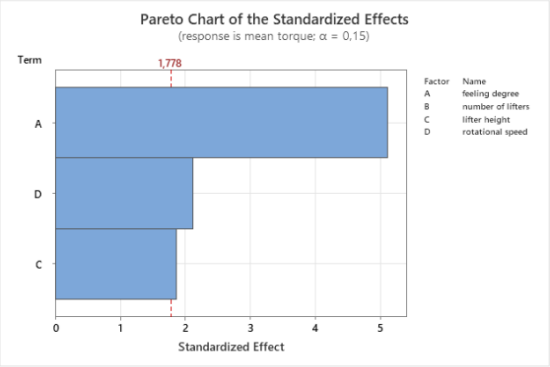
Alias Structure

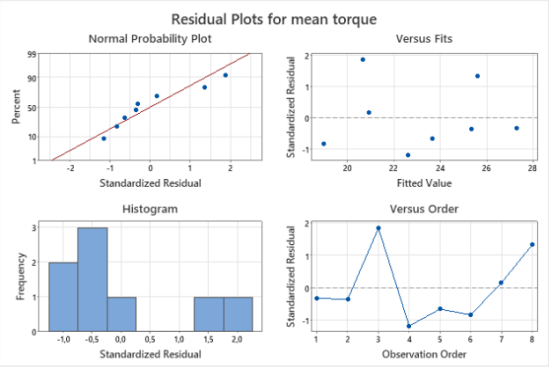
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
C + ABD
D + ABC









DRY_500

Factorial Regression: force ratio versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		1,13900	0,00174	655,33	0,000	
feeling degree	0,06050	0,03025	0,00174	17,40	0,000	1,00
lifter height	-0,01950	-0,00975	0,00174	-5,61	0,011	1,00
rotational speed	-0,03450	-0,01725	0,00174	-9,92	0,002	1,00
feeling degree*lifter height	0,00800	0,00400	0,00174	2,30	0,105	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0049160	99,32%	98,41%	95,16%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	0,010589	0,002647	109,55	0,001
Linear	3	0,010461	0,003487	144,30	0,001
feeling degree	1	0,007320	0,007320	302,92	0,000
lifter height	1	0,000761	0,000761	31,47	0,011
rotational speed	1	0,002380	0,002380	98,50	0,002
2-Way Interactions	1	0,000128	0,000128	5,30	0,105
feeling degree*lifter height	1	0,000128	0,000128	5,30	0,105
Error	3	0,000073	0,000024		
Total	7	0,010662			

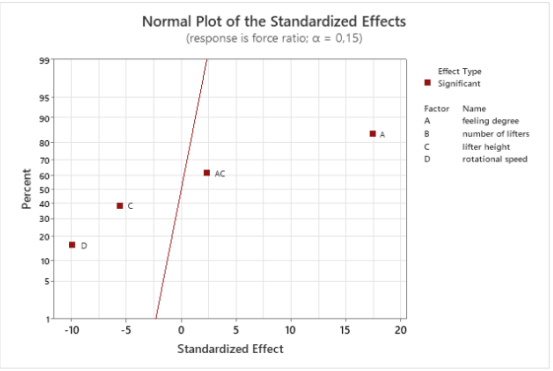
Regression Equation in Uncoded Units

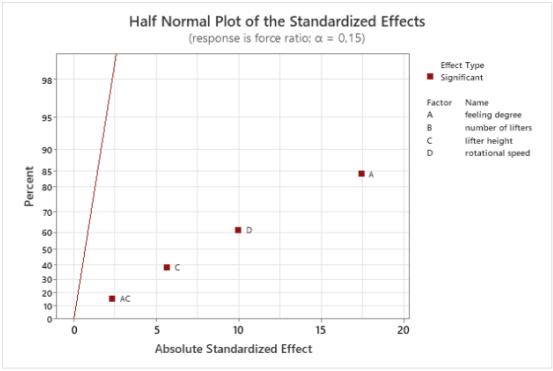
force ratio = 1,2420 + 0,2225 feeling degree - 5,15 lifter height - 0,003890 rotational speed
+ 8,00 feeling degree*lifter height

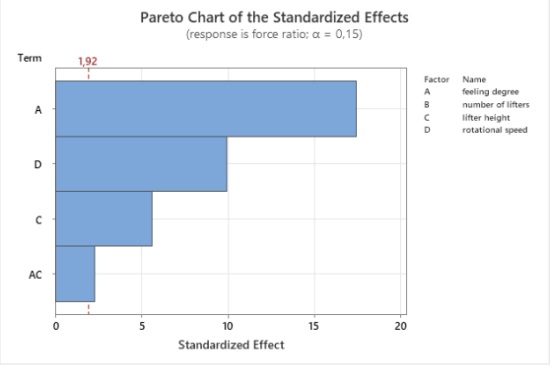
Alias Structure

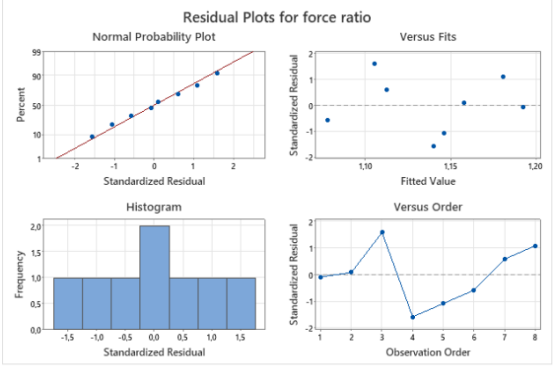
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
C + ABD
D + ABC
AC + BD









Factorial Regression: energy per mass per rotation versus feeling degree; number of lifters; lifter height; rotational speed

The following terms are totally confounded with other terms and were removed:
number of lifters*lifter height; number of lifters*rotational speed; lifter height*rotational speed; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*lifter height*rotational speed; number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*rotational speed

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		16,461	0,504	32,63	0,000	
feeling degree	-5,313	-2,656	0,504	-5,27	0,003	1,00
lifter height	-1,947	-0,974	0,504	-1,93	0,111	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1,42688	86,28%	80,80%	64,88%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	64,031	32,015	15,72	0,007
Linear	2	64,031	32,015	15,72	0,007
feeling degree	1	56,445	56,445	27,72	0,003
lifter height	1	7,586	7,586	3,73	0,111
Error	5	10,180	2,036		
Total	7	74,211			

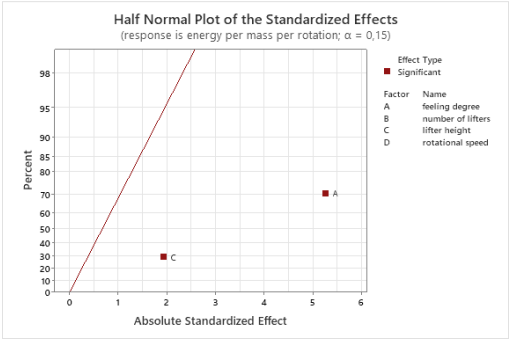
Regression Equation in Uncoded Units

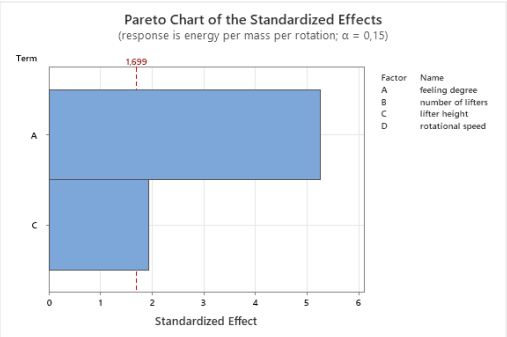
energy per mass per rotation = 29,03 - 26,56 feeling degree - 195 lifter height

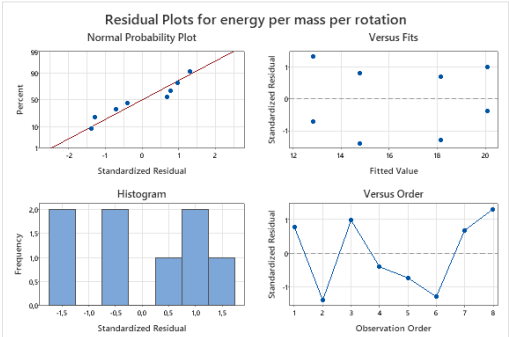
Alias Structure

Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed

Aliases
I + ABCD
A + BCD
C + ABD







WET_500

Factorial Regression: size reduction versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		7,955	0,811	9,81	0,000	
slurry density	-8,071	-4,035	0,811	-4,97	0,003	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2,29456	80,48%	77,23%	65,30%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	130,27	130,274	24,74	0,003
Linear	1	130,27	130,274	24,74	0,003
slurry density	1	130,27	130,274	24,74	0,003
Error	6	31,59	5,265		
Total	7	161,86			

Regression Equation in Uncoded Units

size reduction = 40,24 - 0,02018 slurry density

Fits and Diagnostics for Unusual Observations

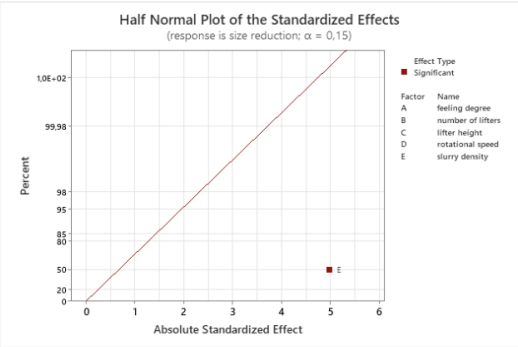
Obs	size reduction	Fit	Resid	Std Resid	
2	16,14	11,99	4,15	2,09	R

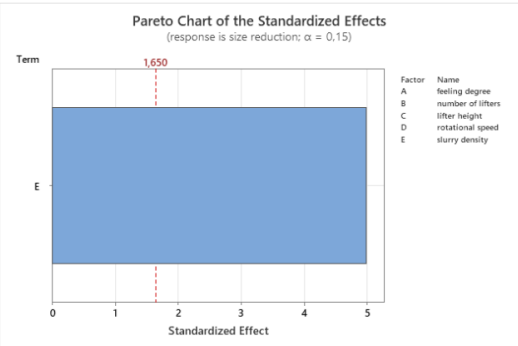
R Large residual

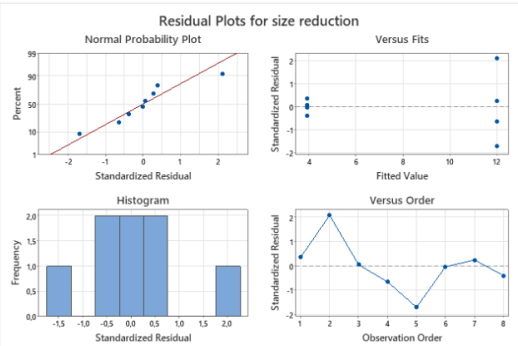
Alias Structure

Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
E + BD + ABC + ACDE







WET_500

Factorial Regression: energy consumed versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		285546	13710	20,83	0,000	
slurry density	-275191	-137595	13710	-10,04	0,000	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
38778,2	94,38%	93,44%	90,01%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	1,51460E+11	1,51460E+11	100,72	0,000
Linear	1	1,51460E+11	1,51460E+11	100,72	0,000
slurry density	1	1,51460E+11	1,51460E+11	100,72	0,000
Error	6	9022514912	1503752485		
Total	7	1,60482E+11			

Regression Equation in Uncoded Units

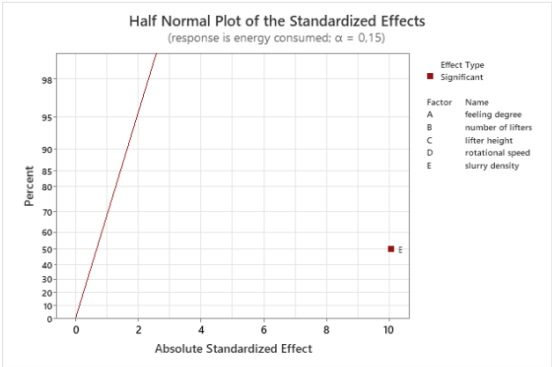
energy consumed = 1386309 - 688,0 slurry density

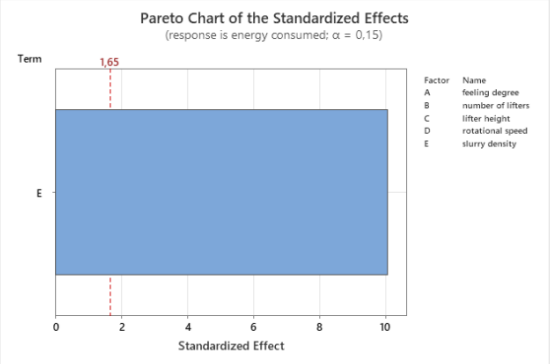
Alias Structure

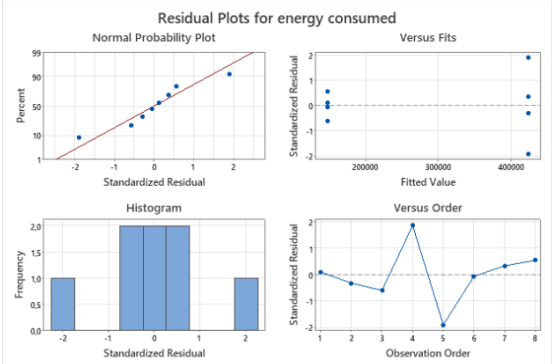
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases

I + ACD + BDE + ABCE
E + BD + ABC + ACDE







WET_500

Factorial Regression: energy intake per mass unit versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		52758	2114	24,95	0,000	
feeling degree	-18936	-9468	2114	-4,48	0,011	1,00
slurry density	-73402	-36701	2114	-17,36	0,000	1,00
feeling degree*slurry density	10763	5382	2114	2,55	0,064	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
5980,55	98,79%	97,89%	95,18%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	11724557264	3908185755	109,27	0,000
Linear	2	11492851400	5746425700	160,66	0,000
feeling degree	1	717144192	717144192	20,05	0,011
slurry density	1	10775707208	10775707208	301,28	0,000
2-Way Interactions	1	231705864	231705864	6,48	0,064
feeling degree*slurry density	1	231705864	231705864	6,48	0,064
Error	4	143067817	35766954		
Total	7	11867625081			

Regression Equation in Uncoded Units

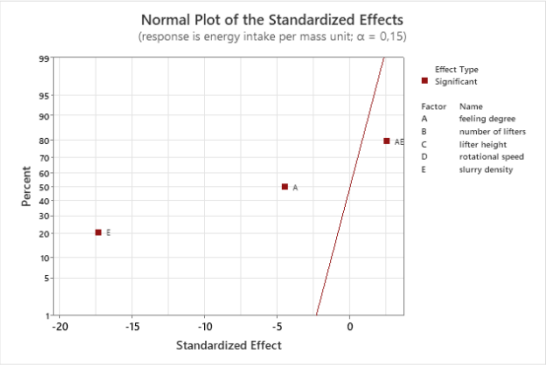
energy intake per mass unit = 556454 - 525220 feeling degree - 291,1 slurry density
+ 269 feeling degree*slurry density

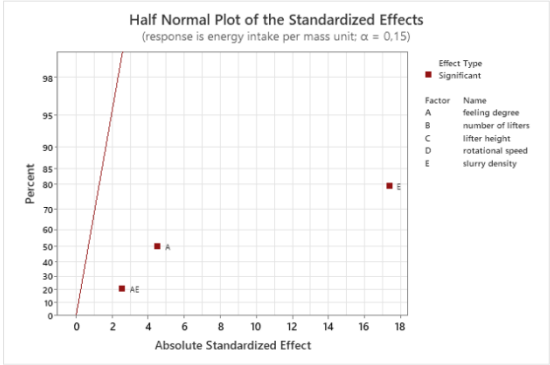
Alias Structure

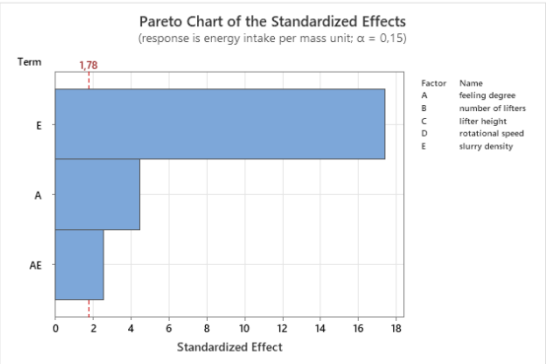
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

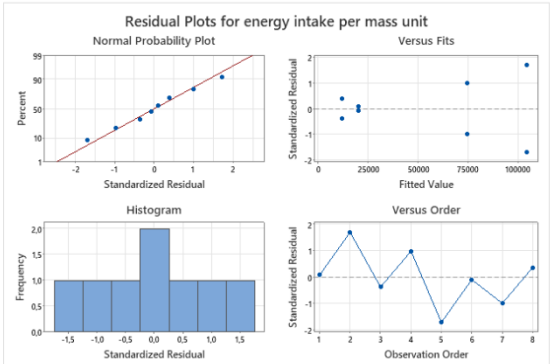
Aliases

I + ACD + BDE + ABCE
A + CD + BCE + ABDE
E + BD + ABC + ACDE
AE + BC + ABD + CDE









WET_500

Factorial Regression: mean torque versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		15,96	1,11	14,37	0,000	
slurry density	-21,66	-10,83	1,11	-9,75	0,000	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3,14130	94,06%	93,07%	89,44%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	937,88	937,878	95,04	0,000
Linear	1	937,88	937,878	95,04	0,000
slurry density	1	937,88	937,878	95,04	0,000
Error	6	59,21	9,868		
Total	7	997,08			

Regression Equation in Uncoded Units

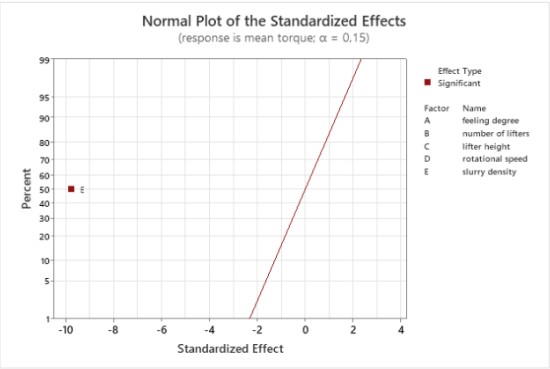
mean torque = 102,58 - 0,05414 slurry density

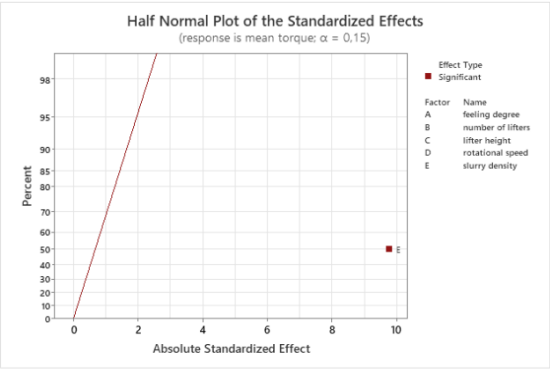
Alias Structure

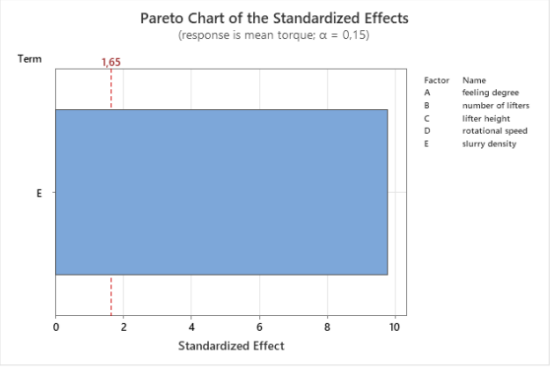
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

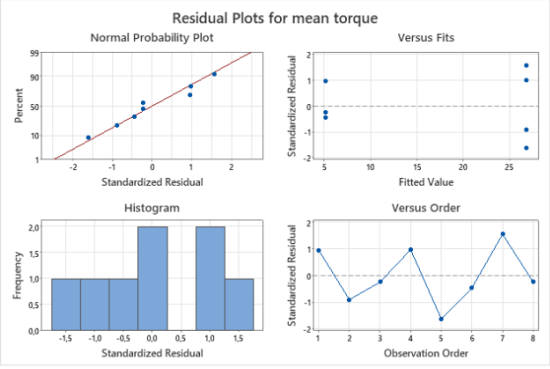
Aliases

I + ACD + BDE + ABCE
E + BD + ABC + ACDE









WET_500

Factorial Regression: force ratio versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		1,15200	0,00763	151,04	0,000	
lifter height	-0,05300	-0,02650	0,00763	-3,47	0,025	1,00
rotational speed	-0,08300	-0,04150	0,00763	-5,44	0,006	1,00
slurry density	-0,03850	-0,01925	0,00763	-2,52	0,065	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0215726	92,31%	86,55%	69,26%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	0,022360	0,007453	16,02	0,011
Linear	3	0,022360	0,007453	16,02	0,011
lifter height	1	0,005618	0,005618	12,07	0,025
rotational speed	1	0,013778	0,013778	29,61	0,006
slurry density	1	0,002964	0,002964	6,37	0,065
Error	4	0,001862	0,000465		
Total	7	0,024222			

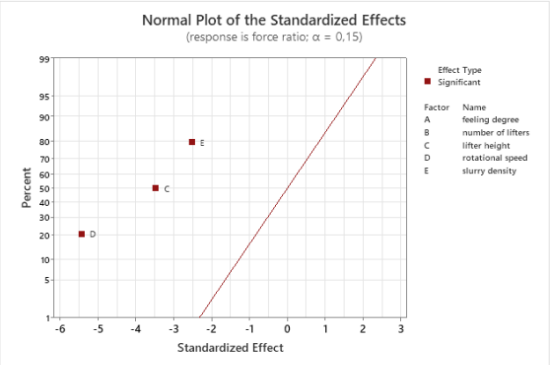
Regression Equation in Uncoded Units

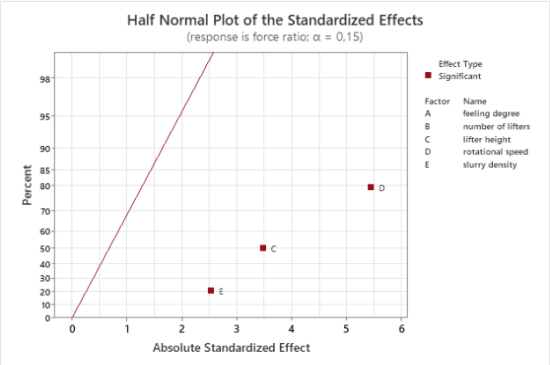
force ratio = 1,7740 - 5,30 lifter height - 0,00936 rotational speed
- 0,000096 slurry density

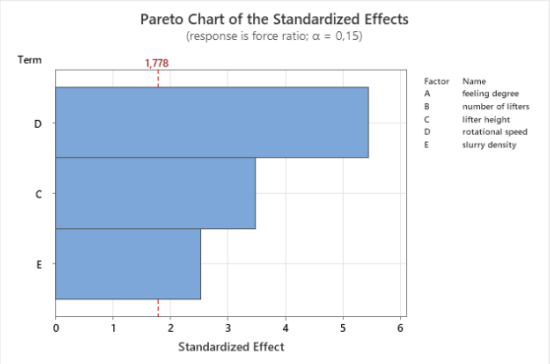
Alias Structure

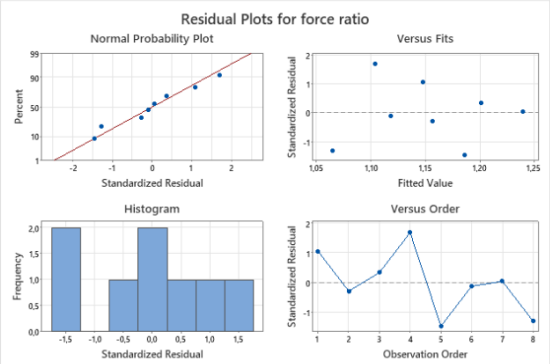
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
C + AD + ABE + BCDE
D + AC + BE + ABCDE
E + BD + ABC + ACDE









WET_500

Factorial Regression: energy per mass per rotation versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		39,121	0,743	52,68	0,000	
feeling degree	-13,848	-6,924	0,743	-9,32	0,003	1,00
rotational speed	-3,687	-1,844	0,743	-2,48	0,089	1,00
slurry density	-54,782	-27,391	0,743	-36,89	0,000	1,00
feeling degree*slurry density	7,687	3,844	0,743	5,18	0,014	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2,10031	99,80%	99,53%	98,56%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	6531,14	1632,79	370,14	0,000
Linear	3	6412,95	2137,65	484,58	0,000
feeling degree	1	383,51	383,51	86,94	0,003
rotational speed	1	27,20	27,20	6,16	0,089
slurry density	1	6002,24	6002,24	1360,65	0,000
2-Way Interactions	1	118,20	118,20	26,79	0,014
feeling degree*slurry density	1	118,20	118,20	26,79	0,014
Error	3	13,23	4,41		
Total	7	6544,38			

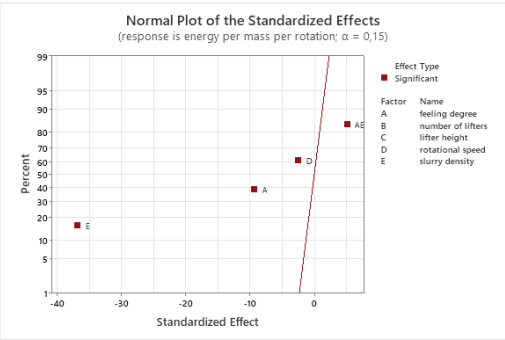
Regression Equation in Uncoded Units

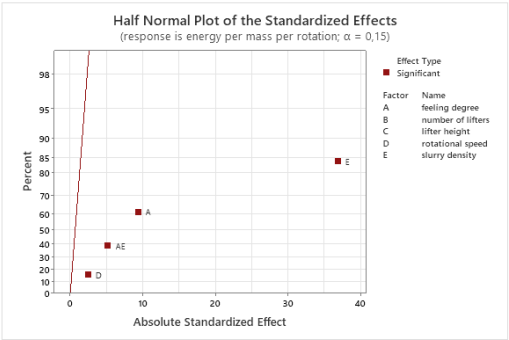
energy per mass per rotation = 427,4 - 376,7 feeling degree - 0,416 rotational speed
- 0,2138 slurry density + 0,1922 feeling degree*slurry density

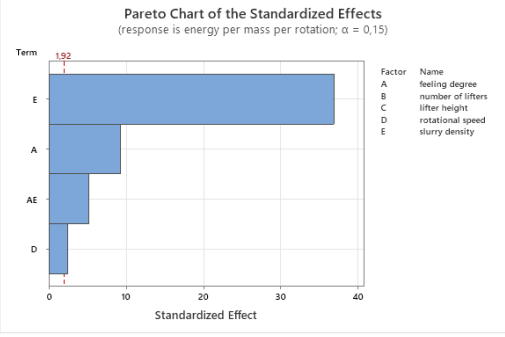
Alias Structure

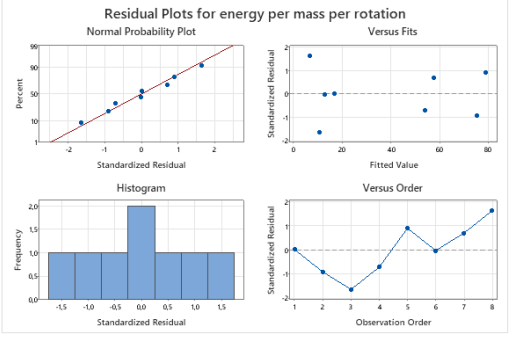
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
A + CD + BCE + ABDE
D + AC + BE + ABCDE
E + BD + ABC + ACDE
AE + BC + ABD + CDE









WET_400

Factorial Regression: size reduction versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		9,04	1,10	8,19	0,000	
slurry density	-8,71	-4,36	1,10	-3,95	0,008	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3,12222	72,18%	67,55%	50,55%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	151,79	151,789	15,57	0,008
Linear	1	151,79	151,789	15,57	0,008
slurry density	1	151,79	151,789	15,57	0,008
Error	6	58,49	9,748		
Total	7	210,28			

Regression Equation in Uncoded Units

size reduction = 43,88 - 0,02178 slurry density

Fits and Diagnostics for Unusual Observations

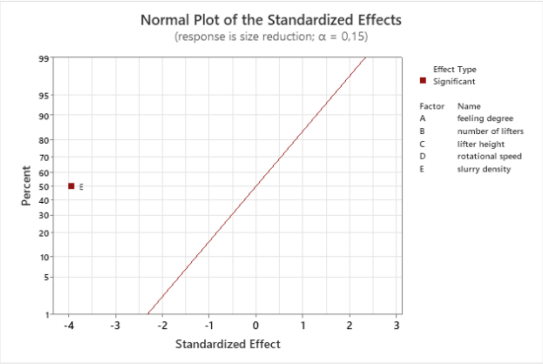
Obs	size reduction	Fit	Resid	Std Resid	
2	19,21	13,39	5,82	2,15	R

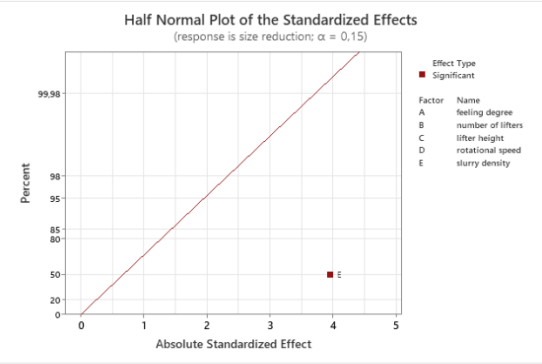
R Large residual

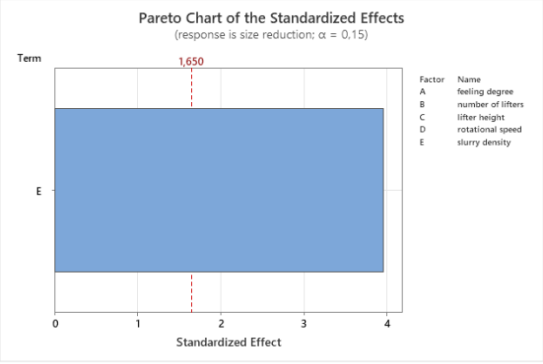
Alias Structure

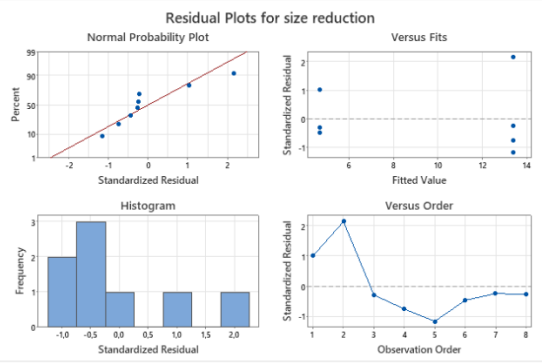
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
E + BD + ABC + ACDE









WET_400

Factorial Regression: energy consumed versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		204014	11060	18,45	0,000	
slurry density	-152907	-76454	11060	-6,91	0,000	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
31282,4	88,84%	86,99%	80,17%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	46761254205	46761254205	47,78	0,000
Linear	1	46761254205	46761254205	47,78	0,000
slurry density	1	46761254205	46761254205	47,78	0,000
Error	6	5871514807	978585801		
Total	7	52632769012			

Regression Equation in Uncoded Units

energy consumed = 815643 - 382,3 slurry density

Fits and Diagnostics for Unusual Observations

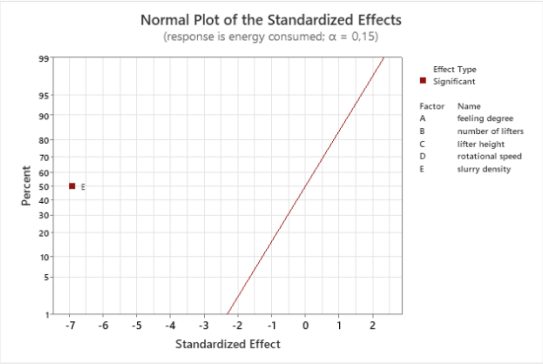
Obs	energy consumed	Fit	Resid	Std Resid	
5	218806	280468	-61662	-2,28	R

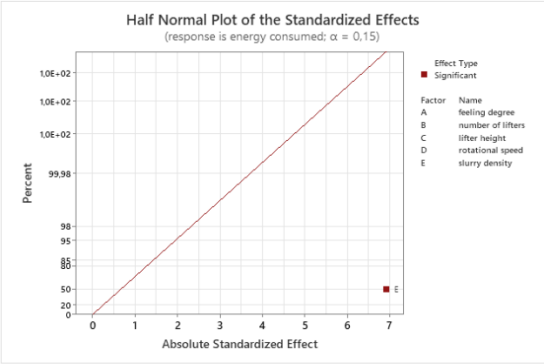
R Large residual

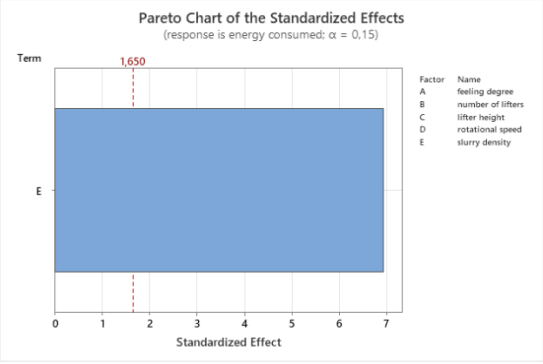
Alias Structure

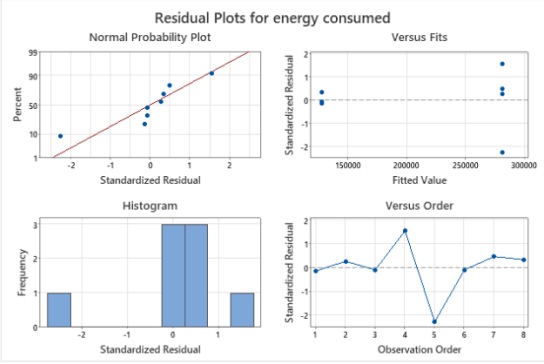
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
E + BD + ABC + ACDE









Factorial Regression: energy intake per mass unit versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		57378	4025	14,26	0,000	
feeling degree	-19517	-9759	4025	-2,42	0,060	1,00
slurry density	-71498	-35749	4025	-8,88	0,000	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
11384,2	94,43%	92,20%	85,74%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	10985702605	5492851303	42,38	0,001
Linear	2	10985702605	5492851303	42,38	0,001
feeling degree	1	761846095	761846095	5,88	0,060
slurry density	1	10223856510	10223856510	78,89	0,000
Error	5	648002414	129600483		
Total	7	11633705019			

Regression Equation in Uncoded Units

energy intake per mass unit = 382404 - 97586 feeling degree - 178,7 slurry density

Fits and Diagnostics for Unusual Observations

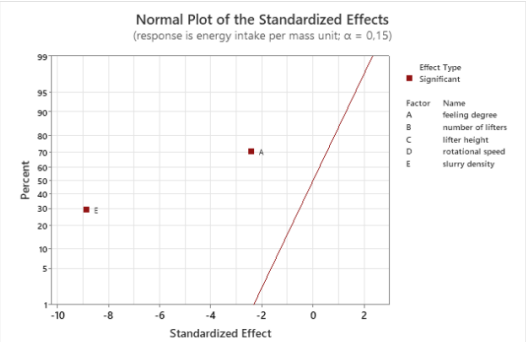
Obs	energy intake per mass unit	Fit	Resid	Std Resid	
2	122408	102886	19522	2,17	R

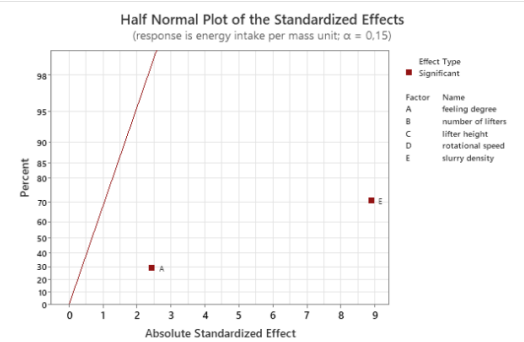
R Large residual

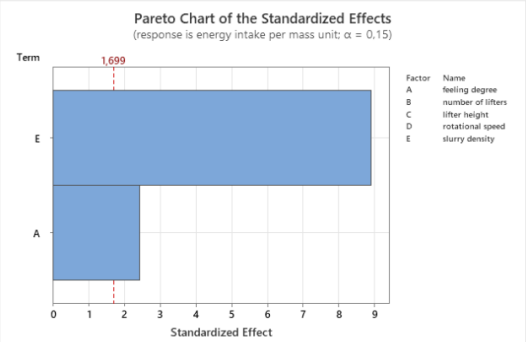
Alias Structure

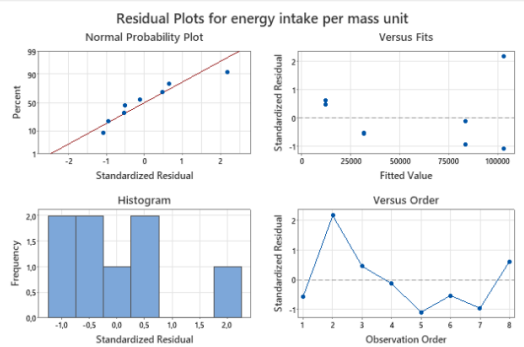
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
A + CD + BCE + ABDE
E + BD + ABC + ACDE









WET_400

Factorial Regression: mean torque versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		6,395	0,452	14,15	0,000	
feeling degree	1,990	0,995	0,452	2,20	0,079	1,00
slurry density	-9,680	-4,840	0,452	-10,71	0,000	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1,27869	95,98%	94,38%	89,72%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	195,325	97,663	59,73	0,000
Linear	2	195,325	97,663	59,73	0,000
feeling degree	1	7,920	7,920	4,84	0,079
slurry density	1	187,405	187,405	114,62	0,000
Error	5	8,175	1,635		
Total	7	203,500			

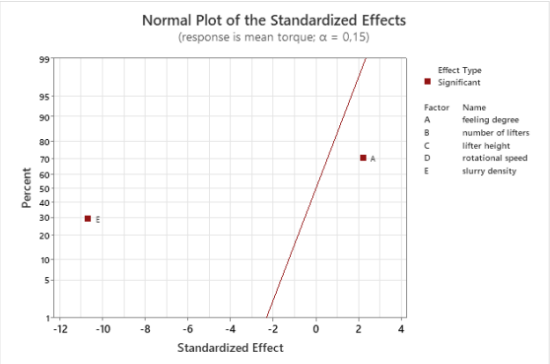
Regression Equation in Uncoded Units

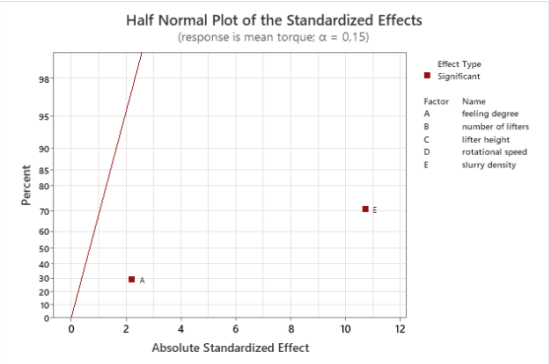
mean torque = 41,14 + 9,95 feeling degree - 0,02420 slurry density

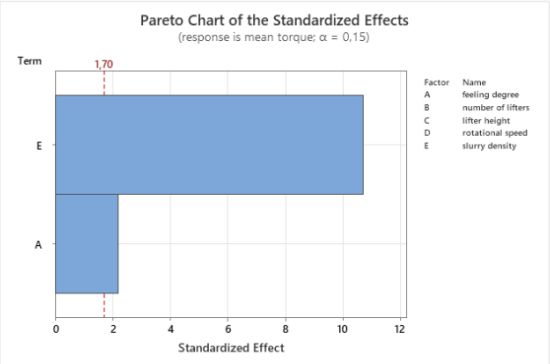
Alias Structure

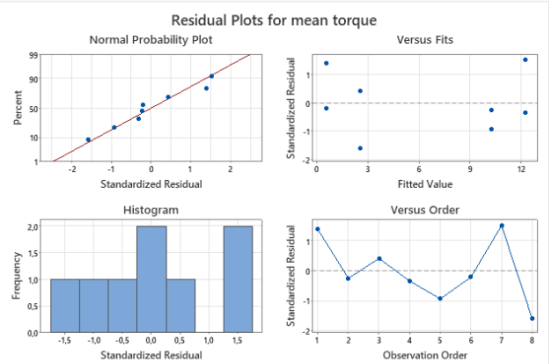
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
A + CD + BCE + ABDE
E + BD + ABC + ACDE









Factorial Regression: force ratio versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		1,21700	0,00770	158,05	0,000	
feeling degree	0,05100	0,02550	0,00770	3,31	0,045	1,00
lifter height	-0,06350	-0,03175	0,00770	-4,12	0,026	1,00
rotational speed	-0,09350	-0,04675	0,00770	-6,07	0,009	1,00
slurry density	-0,04900	-0,02450	0,00770	-3,18	0,050	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0217792	96,15%	91,02%	72,63%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	0,035553	0,008888	18,74	0,018
Linear	4	0,035553	0,008888	18,74	0,018
feeling degree	1	0,005202	0,005202	10,97	0,045
lifter height	1	0,008064	0,008064	17,00	0,026
rotational speed	1	0,017484	0,017484	36,86	0,009
slurry density	1	0,004802	0,004802	10,12	0,050
Error	3	0,001423	0,000474		
Total	7	0,036976			

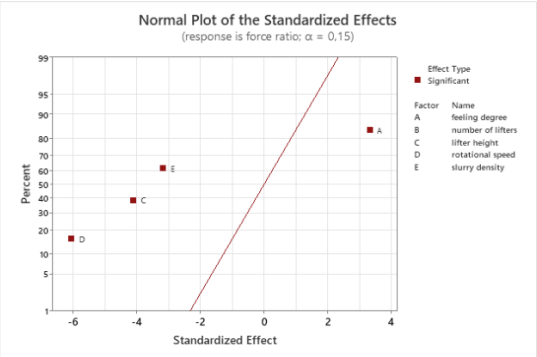
Regression Equation in Uncoded Units

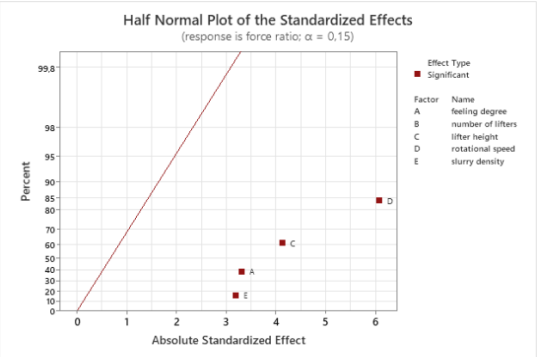
force ratio = 1,842 + 0,2550 feeling degree - 6,35 lifter height - 0,00907 rotational speed
- 0,000123 slurry density

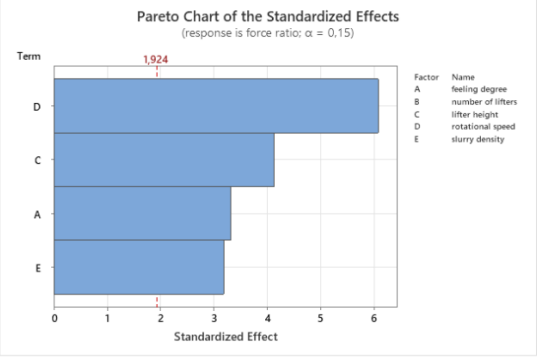
Alias Structure

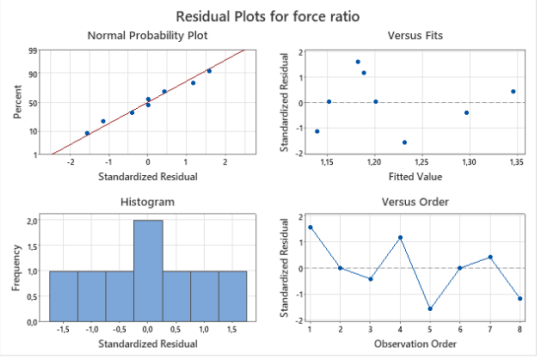
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
A + CD + BCE + ABDE
C + AD + ABE + BCDE
D + AC + BE + ABCDE
E + BD + ABC + ACDE









WET_400

Factorial Regression: energy per mass per rotation versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		36,017	0,901	39,96	0,000	
feeling degree	-12,010	-6,005	0,901	-6,66	0,003	1,00
slurry density	-44,825	-22,413	0,901	-24,87	0,000	1,00
feeling degree*slurry density	5,820	2,910	0,901	3,23	0,032	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2,54945	99,41%	98,97%	97,64%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	4374,79	1458,26	224,36	0,000
Linear	2	4307,04	2153,52	331,33	0,000
feeling degree	1	288,48	288,48	44,38	0,003
slurry density	1	4018,56	4018,56	618,27	0,000
2-Way Interactions	1	67,74	67,74	10,42	0,032
feeling degree*slurry density	1	67,74	67,74	10,42	0,032
Error	4	26,00	6,50		
Total	7	4400,78			

Regression Equation in Uncoded Units

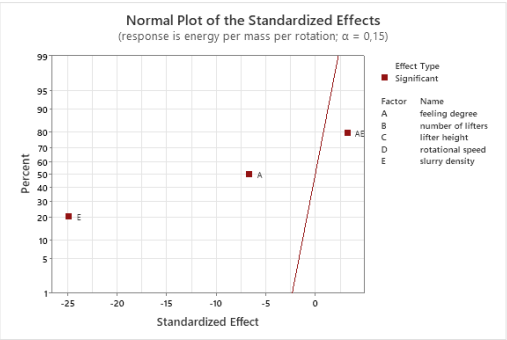
energy per mass per rotation = 332,5 - 292,9 feeling degree - 0,1703 slurry density
+ 0,1455 feeling degree*slurry density

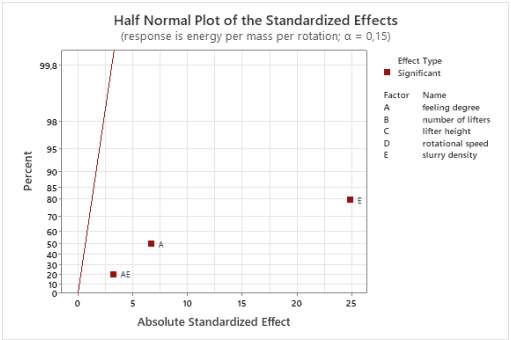
Alias Structure

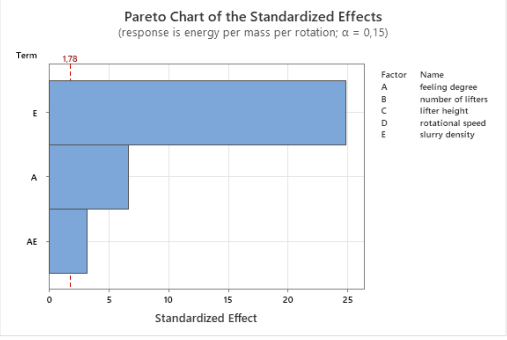
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

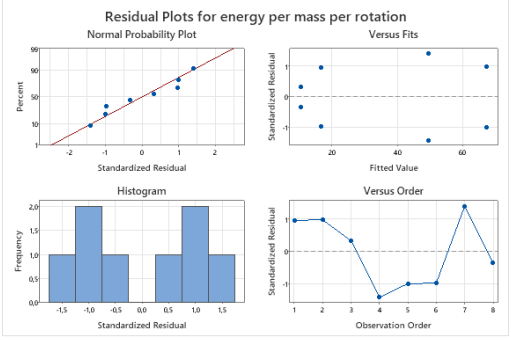
Aliases

I + ACD + BDE + ABCE
A + CD + BCE + ABDE
E + BD + ABC + ACDE
AE + BC + ABD + CDE









WET_300

Factorial Regression: size reduction versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		6,880	0,556	12,38	0,000	
lifter height	-2,251	-1,125	0,556	-2,03	0,099	1,00
slurry density	-7,641	-3,821	0,556	-6,88	0,001	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1,57169	91,13%	87,58%	77,29%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	126,90	63,452	25,69	0,002
Linear	2	126,90	63,452	25,69	0,002
lifter height	1	10,13	10,134	4,10	0,099
slurry density	1	116,77	116,770	47,27	0,001
Error	5	12,35	2,470		
Total	7	139,25			

Regression Equation in Uncoded Units

size reduction = 39,69 - 225 lifter height - 0,01910 slurry density

Fits and Diagnostics for Unusual Observations

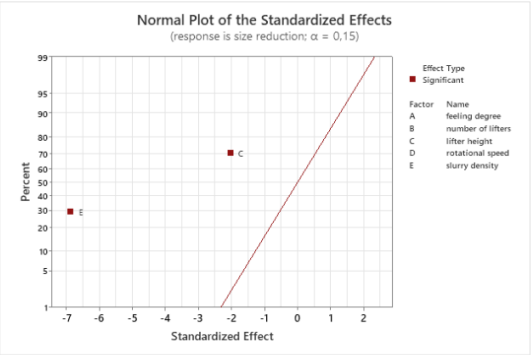
Obs	size reduction	Fit	Resid	Std Resid	
5	6,965	9,575	-2,610	-2,10	R

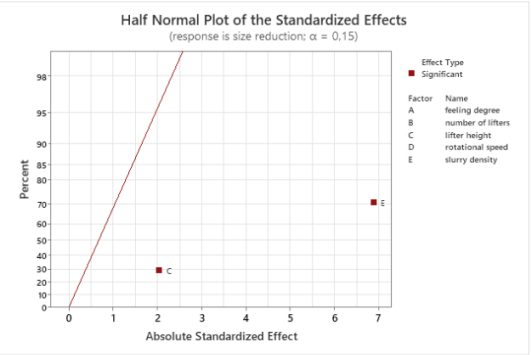
R Large residual

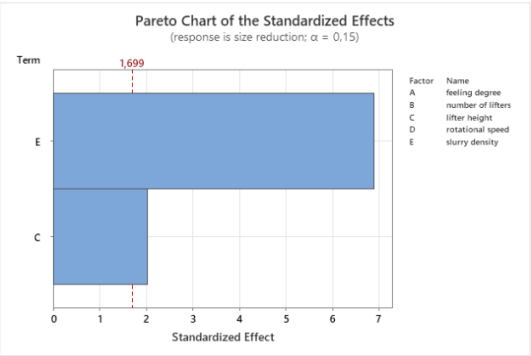
Alias Structure

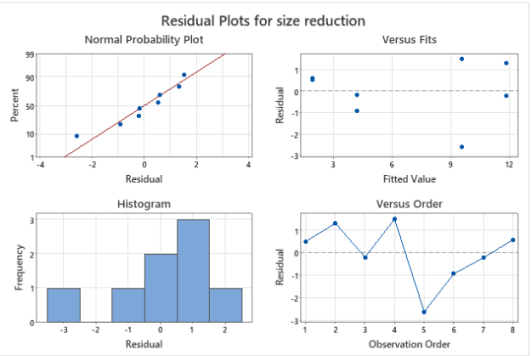
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
C + AD + ABE + BCDE
E + BD + ABC + ACDE









WET_300

Factorial Regression: energy consumed versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		117704	10046	11,72	0,000	
rotational speed	49300	24650	10046	2,45	0,058	1,00
slurry density	-48215	-24107	10046	-2,40	0,062	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
28415,5	70,20%	58,28%	23,71%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	9510256021	4755128010	5,89	0,048
Linear	2	9510256021	4755128010	5,89	0,048
rotational speed	1	4860980000	4860980000	6,02	0,058
slurry density	1	4649276021	4649276021	5,76	0,062
Error	5	4037198393	807439679		
Total	7	13547454414			

Regression Equation in Uncoded Units

energy consumed = 64142 + 3976 rotational speed - 120,5 slurry density

Fits and Diagnostics for Unusual Observations

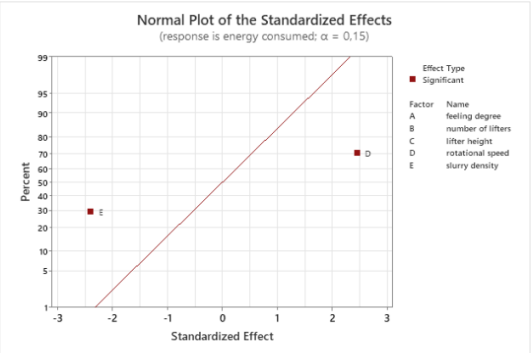
Obs	energy consumed	Fit	Resid	Std Resid	
5	67655	117162	-49507	-2,20	R

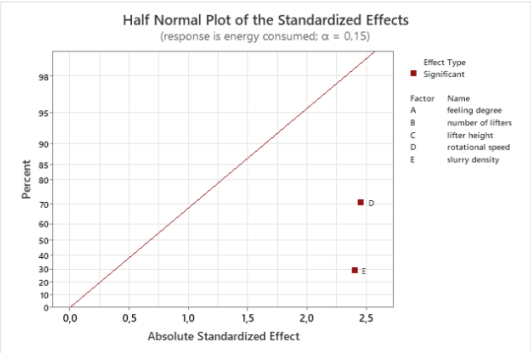
R Large residual

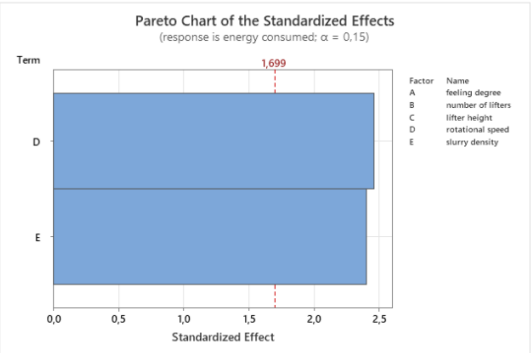
Alias Structure

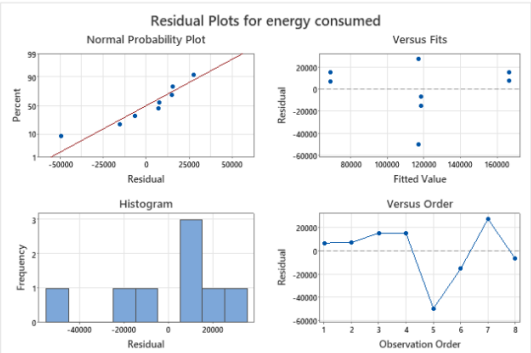
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
D + AC + BE + ABCDE
E + BD + ABC + ACDE









Factorial Regression: energy intake per mass unit versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		56218	7643	7,36	0,001	
rotational speed	28811	14406	7643	1,88	0,118	1,00
slurry density	-55482	-27741	7643	-3,63	0,015	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
21619,1	76,98%	67,78%	41,08%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	7816652090	3908326045	8,36	0,025
Linear	2	7816652090	3908326045	8,36	0,025
rotational speed	1	1660147442	1660147442	3,55	0,118
slurry density	1	6156504648	6156504648	13,17	0,015
Error	5	2336917582	467383516		
Total	7	10153569672			

Regression Equation in Uncoded Units

energy intake per mass unit = 134138 + 2323 rotational speed - 138,7 slurry density

Fits and Diagnostics for Unusual Observations

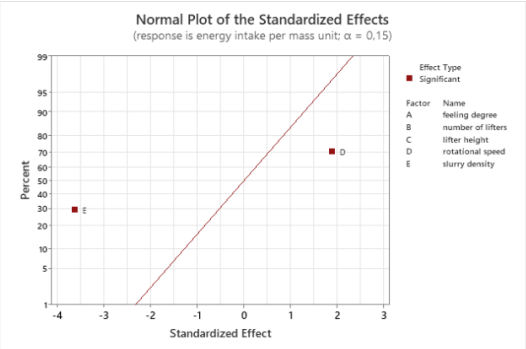
Obs	energy intake per mass unit	Fit	Resid	Std Resid
2	133615	98365	35250	2,06 R

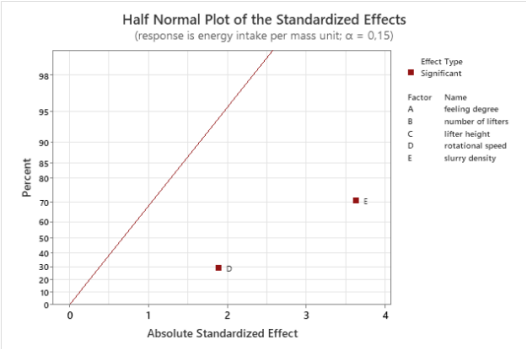
R Large residual

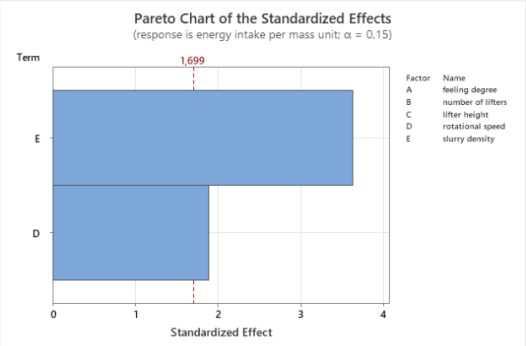
Alias Structure

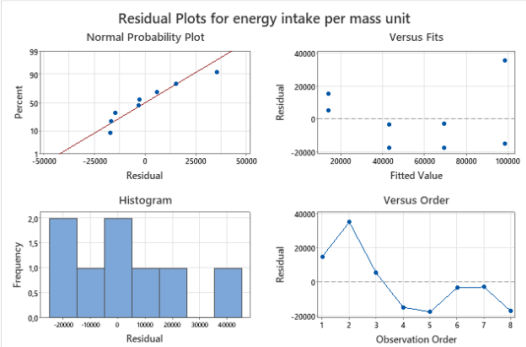
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
D + AC + BE + ABCDE
E + BD + ABC + ACDE









WET_300

Factorial Regression: mean torque versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		3,565	0,560	6,37	0,001	
feeling degree	2,085	1,043	0,560	1,86	0,122	1,00
slurry density	-2,560	-1,280	0,560	-2,29	0,071	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1,58414	63,47%	48,86%	6,48%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	21,802	10,901	4,34	0,081
Linear	2	21,802	10,901	4,34	0,081
feeling degree	1	8,694	8,694	3,46	0,122
slurry density	1	13,107	13,107	5,22	0,071
Error	5	12,548	2,510		
Total	7	34,349			

Regression Equation in Uncoded Units

mean torque = 9,64 + 10,42 feeling degree - 0,00640 slurry density

Fits and Diagnostics for Unusual Observations

Obs	mean torque	Fit	Resid	Std Resid	
5	1,110	3,802	-2,692	-2,15	R

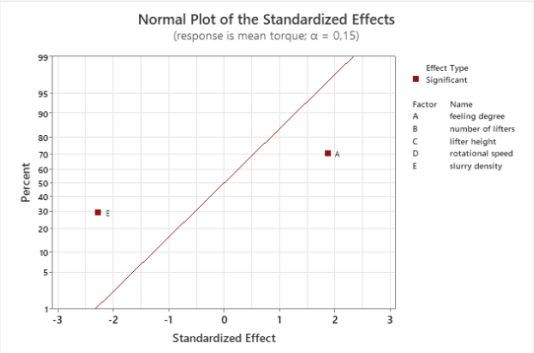
R Large residual

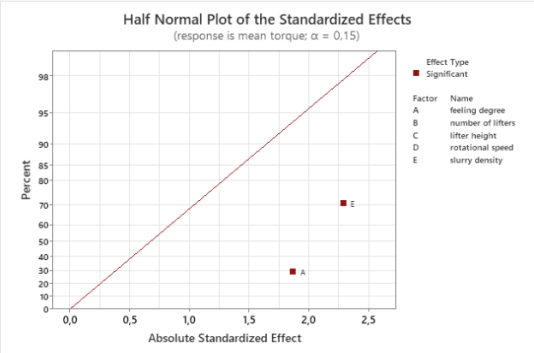
Alias Structure

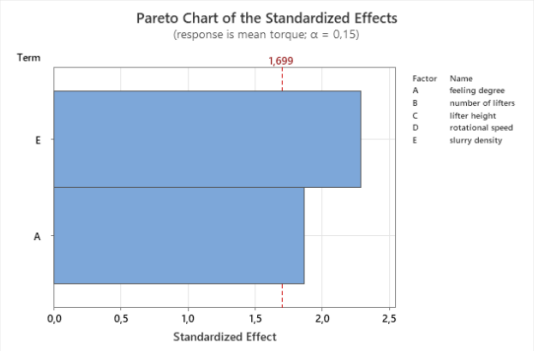
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

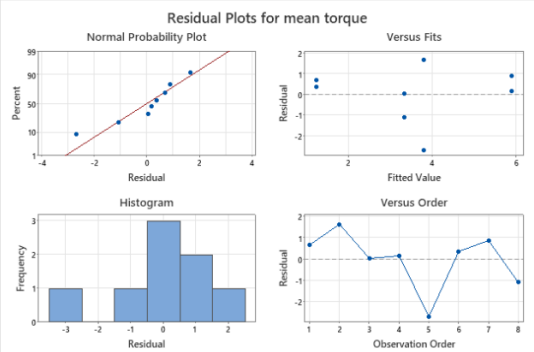
Aliases

I + ACD + BDE + ABCE
A + CD + BCE + ABDE
E + BD + ABC + ACDE









WET_300

Factorial Regression: force ratio versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		0,85087	0,00182	467,87	0,000	
feeling degree	0,06225	0,03113	0,00182	17,11	0,000	1,00
lifter height	-0,05275	-0,02637	0,00182	-14,50	0,001	1,00
rotational speed	-0,07125	-0,03563	0,00182	-19,59	0,000	1,00
slurry density	-0,04525	-0,02262	0,00182	-12,44	0,001	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0051438	99,71%	99,33%	97,96%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	0,027563	0,006891	260,44	0,000
Linear	4	0,027563	0,006891	260,44	0,000
feeling degree	1	0,007750	0,007750	292,92	0,000
lifter height	1	0,005565	0,005565	210,34	0,001
rotational speed	1	0,010153	0,010153	383,74	0,000
slurry density	1	0,004095	0,004095	154,78	0,001
Error	3	0,000079	0,000026		
Total	7	0,027643			

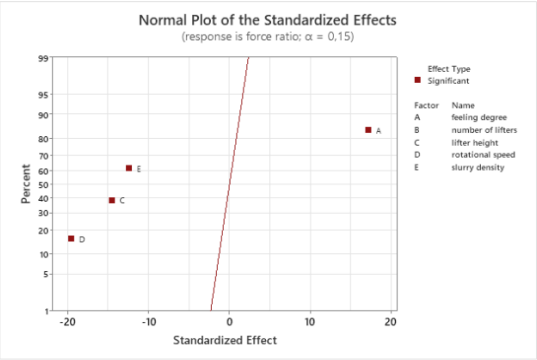
Regression Equation in Uncoded Units

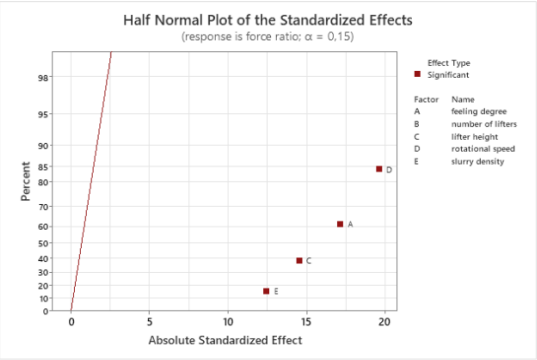
force ratio = 1,3163 + 0,3113 feeling degree - 5,275 lifter height
- 0,005746 rotational speed - 0,000113 slurry density

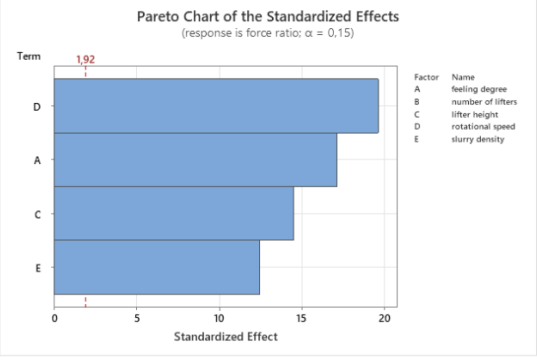
Alias Structure

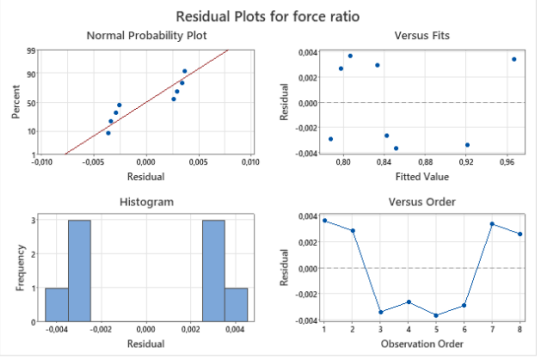
Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
A + CD + BCE + ABDE
C + AD + ABE + BCDE
D + AC + BE + ABCDE
E + BD + ABC + ACDE









WET_300

Factorial Regression: energy per mass per rotation versus feeling degree; number of lifters; lifter height; rotational speed; slurry density

The following terms are totally confounded with other terms and were removed:
feeling degree*lifter height; feeling degree*rotational speed; number of lifters*lifter height; number of lifters*rotational speed; number of lifters*slurry density; lifter height*rotational speed; lifter height*slurry density; rotational speed*slurry density; feeling degree*number of lifters*lifter height; feeling degree*number of lifters*rotational speed; feeling degree*number of lifters*slurry density; feeling degree*lifter height*rotational speed; feeling degree*lifter height*slurry density; feeling degree*rotational speed*slurry density; number of lifters*lifter height*rotational speed; number of lifters*lifter height*slurry density; number of lifters*rotational speed*slurry density; lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed; feeling degree*number of lifters*lifter height*slurry density; feeling degree*number of lifters*rotational speed*slurry density; feeling degree*lifter height*rotational speed*slurry density; number of lifters*lifter height*rotational speed*slurry density; feeling degree*number of lifters*lifter height*rotational speed*slurry density

Stepwise Selection of Terms

α to enter = 0,15; α to remove = 0,15

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		28,63	3,60	7,96	0,000	
slurry density	-27,96	-13,98	3,60	-3,89	0,008	1,00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
10,1716	71,57%	66,84%	49,46%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	1563,0	1563,0	15,11	0,008
Linear	1	1563,0	1563,0	15,11	0,008
slurry density	1	1563,0	1563,0	15,11	0,008
Error	6	620,8	103,5		
Total	7	2183,7			

Regression Equation in Uncoded Units

energy per mass per rotation = 140,5 - 0,0699 slurry density

Fits and Diagnostics for Unusual Observations

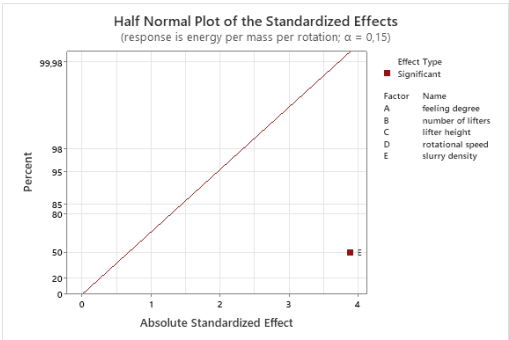
Obs	energy per mass per rotation	Fit	Resid	Std Resid
2	62,55	42,61	19,94	2,26 R

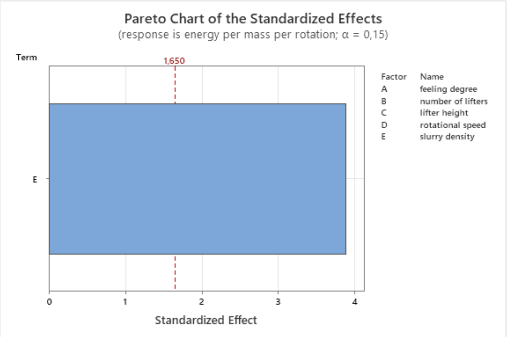
R Large residual

Alias Structure

Factor	Name
A	feeling degree
B	number of lifters
C	lifter height
D	rotational speed
E	slurry density

Aliases
I + ACD + BDE + ABCE
E + BD + ABC + ACDE





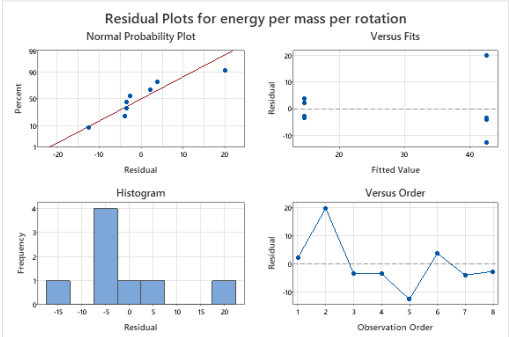


Table N.1: Final dataset for dry milling

Run ID	Internal Diameter	Filling Degree	Number of Lifters	Lifter Height	Ore Mass	Ball Mass	Rotational Speed	Balls per Working Area	Size Reduction	Energy Consumed	Specific Energy	Mean Torque	Force Ratio	Measured Rotational Speed	Specific Energy per Rotation	Scaling Constant
d1-3	0.292	0.5	8	0.005	6.47	34.48	55.78	479.5	4.499	144333	22308	3.28	0.927	57.83	12.86	83.6
d2-3	0.292	0.5	4	0.005	6.47	34.48	68.18	479.5	3.859	170041	26281	2.1	0.829	71.28	12.29	121.37
d3-3	0.292	0.3	8	0.005	3.88	20.69	68.18	479.7	3.226	151817	39128	1.35	0.864	71.3	18.29	103.05
d4-3	0.292	0.3	4	0.005	3.88	20.69	55.78	479.7	4.018	135410	34899	2.74	0.856	57.89	20.1	70.98
d5-3	0.292	0.5	8	0.015	6.47	34.48	68.18	479.5	2.923	152472	23566	1.57	0.873	71.33	11.01	121.37
d6-3	0.292	0.3	4	0.015	3.88	20.69	68.18	479.7	4.178	153658	39603	1.08	0.812	71.32	18.51	103.05
d7-3	0.292	0.3	8	0.015	3.88	20.69	55.78	479.7	4.841	141006	36342	2.24	0.845	58	20.89	70.98
d8-3	0.292	0.5	4	0.015	6.47	34.48	55.78	479.5	4.327	128534	19866	3.08	0.915	57.98	11.42	83.6
d1-4	0.392	0.5	8	0.005	11.66	62.14	46.39	425	4.91	197545	16942	11.88	1.302	47.76	11.82	87.02
d2-4	0.392	0.5	4	0.005	11.66	62.14	56.7	425	3.62	213922	18347	9.83	1.276	58.66	10.43	126.08
d3-4	0.392	0.3	8	0.005	6.99	37.28	56.7	425.1	5.58	201537	28832	8.68	1.223	58.65	16.39	108.77
d4-4	0.392	0.3	4	0.005	6.99	37.28	46.39	425.1	5.94	174200	24921	9.55	1.251	47.83	17.37	75.05
d5-4	0.392	0.5	8	0.015	11.66	62.14	56.7	425	4.49	227185	19484	9.71	1.249	58.61	11.08	126.08
d6-4	0.392	0.3	4	0.015	6.99	37.28	56.7	425.1	5.07	190775	27293	6.81	1.173	58.76	15.48	108.77
d7-4	0.392	0.3	8	0.015	6.99	37.28	46.39	425.1	5.15	187640	26844	10.8	1.207	47.76	18.74	75.05
d8-4	0.392	0.5	4	0.015	11.66	62.14	46.39	425	5.49	211298	18122	12.29	1.298	47.72	12.66	87.02
d1-5	0.492	0.5	8	0.005	18.36	97.88	39.91	370.1	5.52	348772	18996	27	1.192	40.42	15.67	86.97
d2-5	0.492	0.5	4	0.005	18.36	97.88	48.78	370.1	5.10	363900	19820	25.01	1.158	49.99	13.22	125.5
d3-5	0.492	0.3	8	0.005	11.02	58.73	48.78	370	7.34	350933	31845	22.36	1.11	50.08	21.2	109.15
d4-5	0.492	0.3	4	0.005	11.02	58.73	39.91	370	6.90	265509	24093	21.52	1.135	40.87	19.65	75.63
d5-5	0.492	0.5	8	0.015	18.36	97.88	48.78	370.1	4.88	331858	18075	23.03	1.143	50.13	12.02	125.5
d6-5	0.492	0.3	4	0.015	11.02	58.73	48.78	370	5.59	277924	25220	18.18	1.076	50.35	16.7	109.15
d7-5	0.492	0.3	8	0.015	11.02	58.73	39.91	370	5.40	255911	23222	21.04	1.114	40.91	18.92	75.63
d8-5	0.492	0.5	4	0.015	18.36	97.88	39.91	370.1	5.32	319782	17417	26.81	1.184	40.56	14.31	86.97

Table N.2: Final dataset for wet milling

Run ID	Internal Diameter	Filling Degree	Number of Lifters	Lifter Height	Slurry Density	Ore Mass	Ball Mass	Rotational Speed	Balls per Working Area	Size Reduction	Energy Consumed	Specific Energy	Mean Torque	Force Ratio	Measured Rotational Speed	Specific Energy per Rotation	Scaling Constant
w1-3	0.292	0.3	4	0.015	1800	2.6	20.69	55.78	479.7	2.452	75693	29113	1.92	0.81	57.64	16.84	70.98
w2-3	0.292	0.3	4	0.005	1400	1.3	20.69	68.18	479.7	13.143	173699	133615	5.45	0.836	71.21	62.55	103.05
w3-3	0.292	0.5	4	0.005	1800	4.33	34.48	55.78	479.5	4.002	84277	19464	3.37	0.918	57.72	11.24	83.6
w4-3	0.292	0.5	4	0.015	1400	2.17	34.48	68.18	479.5	11.079	181300	83548	6.05	0.84	71.12	39.16	121.37
w5-3	0.292	0.3	8	0.015	1400	1.3	20.69	55.78	479.7	6.965	67655	52042	1.11	0.848	57.73	30.05	70.98
w6-3	0.292	0.3	8	0.005	1800	2.6	20.69	68.18	479.7	3.262	102901	39577	1.61	0.785	71.34	18.49	103.05
w7-3	0.292	0.5	8	0.005	1400	2.17	34.48	55.78	479.5	11.613	144592	66632	6.77	0.97	57.43	38.67	83.6
w8-3	0.292	0.5	8	0.015	1800	4.33	34.48	68.18	479.5	2.520	111517	25755	2.24	0.8	71.33	12.04	121.37
w1-4	0.392	0.3	4	0.015	1800	4.69	37.28	46.39	425.1	7.4	123715	26378	1.96	1.203	47.65	18.45	75.05
w2-4	0.392	0.3	4	0.005	1400	2.35	37.28	56.7	425.1	19.2	287659	122408	9.99	1.201	59.03	69.12	108.77
w3-4	0.392	0.5	4	0.005	1800	7.81	62.14	46.39	425	3.9	124997	16005	2.97	1.291	48.02	11.11	87.02
w4-4	0.392	0.5	4	0.015	1400	3.92	62.14	56.7	425	11.4	322292	82217	11.89	1.204	58.34	46.98	126.08
w5-4	0.392	0.3	8	0.015	1400	2.35	37.28	46.39	425.1	10.3	218806	93109	9.3	1.21	47.33	65.57	75.05
w6-4	0.392	0.3	8	0.005	1800	4.69	37.28	56.7	425.1	3.4	124999	26652	0.35	1.152	59.41	14.95	108.77
w7-4	0.392	0.5	8	0.005	1400	3.92	62.14	46.39	425	12.8	293115	74774	13.76	1.351	47.89	52.05	87.02
w8-4	0.392	0.5	8	0.015	1800	7.81	62.14	56.7	425	4.0	136532	17482	0.94	1.124	58.83	9.91	126.08
w1-5	0.492	0.3	4	0.015	1800	7.38	58.73	39.91	370	4.6	151388	20513	7.71	1.164	41	16.68	75.63
w2-5	0.492	0.3	4	0.005	1400	3.7	58.73	48.78	370	16.1	412535	111496	24.34	1.152	50.04	74.27	109.15
w3-5	0.492	0.5	4	0.005	1800	12.3	97.88	39.91	370.1	4.0	128018	10408	4.47	1.206	41.37	8.39	86.97
w4-5	0.492	0.5	4	0.015	1400	6.17	97.88	48.78	370.1	10.7	486002	78769	29.42	1.129	49.55	52.99	125.5
w5-5	0.492	0.3	8	0.015	1400	3.7	58.73	39.91	370	8.6	359350	97122	22.38	1.164	40.32	80.29	75.63
w6-5	0.492	0.3	8	0.005	1800	7.38	58.73	48.78	370	3.9	145929	19774	3.87	1.116	50.93	12.94	109.15
w7-5	0.492	0.5	8	0.005	1400	6.17	97.88	39.91	370.1	12.5	434679	70450	31	1.24	40.14	58.5	86.97
w8-5	0.492	0.5	8	0.015	1800	12.3	97.88	48.78	370.1	3.1	166468	13534	4.47	1.045	50.66	8.91	125.5