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Review
of the doctoral dissertation by Willy Prastiyo, M.Sc. (Eng.) „Balancing of slider-crank and Scotch-yoke mechanisms by the use of mechanical resonance"

Formal basis for the review:

This review of the doctoral thesis of Willy Prastiyo, MSc, Eng., was prepared in accordance with Resolution No. 410/20/RDND07/2024-2028 of the Scientific Discipline Council for Mechanical Engineering at the Wrocław University of Technology, dated April 28, 2026.

1. Comments on the choice of thesis topic

The demand to combine the safe, trouble-free operation of modern technical facilities with their high energy efficiency necessitates the refinement of design methods aimed at minimizing variable loads that initiate fatigue processes. In this regard, the use of vibrations accompanying machine operation (which typically have a negative impact on the structure) as a factor supporting operational processes and reducing the load on components appears particularly interesting.

Given the above, I believe that the topic of this thesis is timely, and research on the use of the resonance phenomenon to limit dynamic interactions in mechanical systems has both practical and scientific significance.

2. Characteristics of the Thesis

The thesis submitted for evaluation is 153 pages long. The main body of the text comprises 132 pages, including figures and tables. The remainder consists of: a bibliography of 129 entries, a title page, a table of contents, a list of terms and symbols, an author's statement, acknowledgments, and abstracts in English and Polish.

In the first chapter, titled "Introduction," the author highlights the specific nature of the loads on mechanisms for converting rotary motion into reciprocating motion, provides an overview of scientific publications related to the thesis's subject matter, and outlines the thesis's objective and scope.

The second chapter addresses issues concerning the parameters of the slider-crank and Scotch-yoke mechanisms in terms of optimizing the energy demand of the drive motor. The doctoral student performed model calculations using equations of motion, which he derived following a discussion of the resonance properties of a single-degree-of-freedom system (under three external excitations and various values of the damping coefficient).

The third chapter, "Analysis," is devoted to model studies of dynamic interactions during the motion of individual components of the slider-crank and Scotch-yoke mechanisms. Particular emphasis was placed on analyzing the relationships between mass, elasticity, and frictional damping with varying torque and load on the components of both mechanisms.

The laboratory setup and the series of active validation experiments are described in the fourth chapter. Comparative analyses of the results of numerical simulations with the results of tests on real objects enabled the development of a methodology for designing Scotch-yoke and slider-crank mechanisms intended for operation in resonance.

The fifth chapter illustrates the practical applications of the dissertation. Here, the candidate presents a description and the results of tests on two example machine prototypes designed using the developed methodology: a piston compressor (based on a slider-crank mechanism) and a resonance press with a Scotch-yoke mechanism.

The title "Conclusions and Future Work" accurately reflects the content of the final, sixth chapter. The author emphasized the importance of utilizing the resonant

properties of mechanical systems to minimize the reciprocating loads on working components. He identified research aimed at developing adaptive or semi-active resonance control strategies under conditions of varying load and rotational speed as particularly significant for the future.

3. Evaluation of the Thesis

The structure of the thesis is clear and logical. In the opening sections, the candidate discussed the kinematics of the mechanisms under consideration, emphasizing dynamic loads in rotational and reciprocating motion. He discussed the essence, assumptions, and limitations of measures for balancing the components, referencing previous works. The literature review presented is well-prepared. It reflects the current state of knowledge and refers to previous research related to the thesis's subject matter conducted at foreign and domestic institutions. The author's selection of literature is appropriate, and the citation method is correct, demonstrating proficiency in handling bibliographic material.

The candidate highlighted the validity of using resonance vibrations to minimize the forces acting on the working components of slider-crank and Scotch-yoke mechanisms. He discussed selected aspects of resonance phenomena; based on his own model description, he performed a series of simulation calculations, the results of which enabled analyses to be conducted for the purpose of optimizing the design features and operational parameters of the equipment.

Crucial to drawing conclusions about machine properties based on model considerations was the development of a research concept and the examination of real mechanical systems. **I consider the well-planned and executed bench experiments to be a strength of the dissertation, and the candidate's demonstrated ability to use empirical data to effectively validate the results of simulation studies bodes well for his future scientific development.**

The proposed methodology for designing Scotch-yoke and piston-crank mechanisms is the candidate's original achievement; it has practical significance and contributes to the development of the discipline of mechanical engineering. The two examples of machines presented clearly illustrate the usefulness of this methodology.

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The thesis concludes with well-formulated conclusions and an indication of the direction for the development of the tool created as a result of this work.

I evaluate the entirety of the work presented in the thesis positively in terms of content and methodology. The author has presented an interesting approach to the issue of utilizing mechanical resonance to minimize dynamic loads in mechanisms that convert rotary motion into reciprocating motion, and the results achieved should improve the solution of specific engineering problems

4. Detailed Critical Comments

While reading the paper, the following questions arise:

- What justifies the high values of the friction coefficients (0.5; 0.25) adopted in some variants of the simulation calculations (Table 3.4, Figs. 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21)?
- How were the changes in braking force shown in the graph in Figure 4.5 recorded?
- What significance does the air pressure limitation (100 kPa) during the piston compressor prototype tests have for the validity of conclusions based on model calculations?
- Why was the estimation of the uncertainty of the experimental results omitted? Does measurement uncertainty matter for verifying the correctness of the model calculations?

5. Comments on the editorial aspects of the dissertation

The work has been edited quite carefully; however, the author has not avoided minor flaws that were not eliminated during the editing process. Below are a few such examples.

- Figure 2.6 does not show the calculation results for the zero damping coefficient value
- The captions for some figures appear entirely or partially on subsequent pages instead of below the figure (this applies to Figures 2.11, 3.1, 3.9, 3.10, and 3.11).

- The caption for Figure 3.5 is not fully consistent with the content of the graphs: none of the waveforms are shown using dashed lines.
- The term "Motor Synchronous Speed [RPM]" used to describe the horizontal axes of the graphs in Figures 4.4, 4.6, 4.7, and 4.8 in reference to motor rotational speed raises some concerns.
- The presentation of some illustrations split into two parts across consecutive pages (for example, Figures 4.13 and 5.7) makes it somewhat difficult to follow the line of reasoning.

6. Concluding Remarks

The critical remarks I have mentioned do not detract from the positive overall assessment of the work. I believe that the dissertation submitted for review is valuable in terms of both knowledge and practical application; it offers an innovative perspective on the use of dynamic vibration elimination to reduce the loads on mechanisms that convert rotary motion into reciprocating motion.

Willy Prastiyo, M.Sc. (Eng.), has demonstrated the ability to formulate and independently solve a scientific problem, namely the proper planning and execution of literature, simulation, and experimental research, as well as the use of the results to correctly draw conclusions. The proposed methodology for designing piston-crank and Scotch-yoke mechanisms utilizing the phenomenon of mechanical resonance is commendable. The candidate has demonstrated sufficient theoretical knowledge and practical skills in the field of mechanical engineering.

I hereby certify that the reviewed doctoral dissertation by Willy Prastiyo, M.Sc. (Eng.), titled "Balancing of slider-crank and Scotch-yoke mechanisms by the use of mechanical resonance," meets the requirements for doctoral dissertations set forth in Article 187, paragraphs 1 and 2, of the Act of July 20, 2018, Law on Higher Education and Science (Journal of Laws of 2024, item 1571) and may be admitted to a public defense.

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