OPPONENT´S ASSESSMENT ON DIPLOMA THESIS

Student´s name and surname: Gafaru Moro

Name of the diploma thesis: Experimental Investigations of Fans for Personal Protective Equipment

Supervisor of the thesis: doc, Ing Václav Dvořák, Ph.D.

Opponent: Ing. David Šimurda, Ph.D.

1. Diploma thesis evaluation

Evaluation	excellent	excellent minus	very good	very good minus	good	failed
Meeting the goal and fulfilling task of the thesis		x				
Quality of conducted survey		X				
Methodology of solutions		X				
Expert level of the thesis			x			
Merit of the thesis and its potential applicability of results	X					
Formal and graphic level of the thesis			x			
Student´s personal approach						

*Mark **x** in the corresponding box.*
Supervisor´s final evaluation is based on his/her overall subjective evaluation.
Grading is stated literally in the article no. 5, neither by a number, nor by a letter.

2. Comments and remarks on diploma thesis:

The diploma thesis "Experimental Investigations of Fans for Personal Protective Equipment" by Mr. Gafaru Moro consists of 82 pages of the text divided into 7 chapters, Nomenclature and References. In the end, 16 technical drawings are appended. Formally, the thesis fulfills all requirements.

Aim of the thesis is experimental and theoretical assessment and analysis of various centrifugal fans performance. And it can be stated that all the objectives were fulfilled. The author based his work on a thorough literature review provided in the chapter 2. The review concerns mainly a fan design and methods of measurement. A review of one dimensional flow theory for radial fans is also provided. Chapter 3 provides considerations and solutions for the design of the test stand following ISO 5167. The test stand consists of sufficiently long pipe with a fan attachment section at inlet and back pressure control at outlet. Mass flow through the pipe is measured using an orifice. The experimental setup and tested fan variants are described in the chapter 4. Altogether 33 fan impeller variants were investigated. Author focused on fan geometric parameters such as number of blades, inlet and outlet blade angles, quality of surface, and regularity of blade mutual positions. Three impeller variants have been designed with radial blades and the rest has been designed with backward curved blades. Surface quality was accounted for by using different materials for 3D printed impellers. Chapter 5 contains definitions of various pressure losses and their theoretical expressions. In the following chapter 6 consisting of results and discussions, the author documents manufactured parts of the test stand with corresponding photos. Furthermore relative performance of the investigated impeller variants are discussed and analyzed based on pressure coefficient/flow coefficient diagrams. Main results are summarized in the conclusions.

Formally, the thesis meets all necessary criteria. Order of chapters in the thesis is logical, thus the thesis is relatively easy to follow. Level of English is in my opinion on a good level, although there is a considerable number of formal errors consisting e.g. of mistypings, wrong spelling or sentences with missing words. There are also mistakes in equations. Quality of figures especially in the explanatory chapters could be improved. In general more figures especially in the paragraph 2.4.1 and chapter 5 would be desirable. Cited references are relevant and citations are complete. Following is a list of some formal errors:
- while or whilst not whiles,
- choking not chocking,
- eq. (2.12) and (2.13) contain specific work not absolute work, e.g. *w* not *W* should be used,
- in several cases information is repeated in one paragraph (e.g. 3.1.1)
- several sentences make no sense, e.g. the first sentences in the paragraph 2.4 and 3.1.1.
- Fig. 5.1 could be used also for explanation of the inter-blade circulation loss
- eq. (5.14) expresses c2 and not c2'. For c2', velocity slip needs to be taken into account,
- probably static pressure not total pressure on the last line of page 27,
- the second sentence in the paragraph 2.5.2.1.1.2 on the page 33 makes no sense,
- in the first sentence in the paragraph 3.1.1 on the page 37 should probably be: "The stand inlet section ..."
- control not regulate
- probably investigated or measured impellers rather than experimented impellers
- in eq. (5.4) n is used instead of z for number of blades and in eq. (5.5) number of blades z is missing
- line 6, page 68 in the sentence "However as shown in Figure 6.16..." should be Fig. 6.17 and high flow rate not low flow rate
- Fig. 2.7 (b) should be outlet
- labeling in the Fig. 5.1 is incomplete

To assess performance of the fans, author employed both theoretical and experimental approach. Theory of centrifugal fans is used to complete experimental investigations. Euler equation derived in the paragraph 2.3 is complemented by theoretical loss models accounting for various sources of pressure loss. The theoretical approach is very useful as it provides fast estimate of a fan performance. Predictions fit experimental data reasonably well in cases with higher exit flow angle and higher number of blades. Some improvements of theoretical models are suggested in the conclusions. It should be stated here that equations (2.1), (2.2), (2.3) and (2.5) are not correct. Absolute mass flow is conserved not differentials as in the eq. (2.1). Change of the fluid angular momentum throughout a fan should be defined as the difference of the angular momentum at inlet and angular momentum at outlet eqs. (2.2), (2.3) and (2.5).

Practical part of the thesis lies in the design and manufacture of the test stand which was proven to perform well. Each part of the stand was carefully considered to fulfill all the requirements. Author also conducted large number of experiments in order to investigate all the geometric variants of the fans. Pressures and mass flow were measured in order to evaluate pressure and loss coefficients. It should be highlighted that despite the high number of fan variants, the author managed to group variants according to parameters of interest so that different variants could be clearly assessed. However, proper description of experiments should contain information on what pressure transducers were used. Also measurements uncertainties should be assessed. Fig. 2.12 (a) showing schematic of a wall pressure tapping is strange with the cavity preceding the orifice.

Analysis of a fan performance is based solely on fan characteristics (pressure coeff. vs floe coeff.). In this regard, CFD could be used to shed more light on the discrepancies between experiments and the theory, but this would probably exceed extent of a diploma thesis and it is not part of the objectives.

Summary
A test stand for investigations of centrifugal fans was designed in frame of the thesis. Criteria of the design were clearly stated and the design takes these into account. Performance characteristics of various fan geometries were obtained using independent methods, i.e. analytical methods and experiments.
Original work of the student (as far as I can tell) consists of the design of the test stand and various fan impeller geometries, conducting experiments and analyzing the results. Designs and use of theoretical models were based on a proper literature review. This proves student's ability to deal with an engineering problem.

3. Questions about diploma thesis:

1) Please state what pressure transducers were used (type, range, accuracy) and assess measurement uncertainties and include them to one of the diagrams, i.e. Fig. 6.17.
2) Please document each of the pressure loss considered in the theoretical model with an explaining or situation showing figure.
3) Which 3D printer technology /material is in the authors' opinion best suited for investigated fans? Please consider various viewpoints (strength, surface quality, speed of printing, cost of the material, ...)

4. Opponent´s statement whether the diploma thesis meets the academic title requirements and whether it is recommended for defense:

Mr. Gafaru Moro in his diploma thesis proved ability to work as an engineer. He gathered required information, suggested investigation plan regarding geometric variants of the fans. He designed, had manufactured and successfully used the test stand. To assess performance of individual fan variants, Mr. Moro, employed both experiment and theoretical models. Results were analyzed in a way standard for engineering work and conclusions concerning performance of individual variants were drawn. Therefore the diploma thesis meets the requirements of the engineering title and it is of course recommended for the defense.

5. Opponent´s grading: excellent minus

Date 22.5.2019, in Prague

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Opponent's signature