Assoc. Prof. M. Yavuz SOLMAZ, Ph.D, Ing
Firat University
Faculty of Engineering
Mechanical Engineering Department
Elazig, 23000, TURKEY
Tel.: +90 424237 0000-5302, Mobile: +90 505 785 7530
E-mail: mysolmaz@firat.edu.tr

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Review Report on PhD Thesis of Ing. İbrahim KOCABAŞ

entitled

"Strength of Glue Joints of Metallic Materials in Connection with Design of Joints"

prepared based on the invitation letter from the dean of Transport Means and Infrastructure Department, Pardubice University- doc.Ing. Ivo Drahotsky, Ph.D.

Supervisor: doc. Ing. Pavel Svanda, Ph.D.

DESCRIPTION

İbrahim Kocabaş submitted the doctoral thesis dealing with the estimation of failure loads in axially loaded single lap joints with metallic substrates using fracture mechanic approach both numerically and experimentally. In this doctoral dissertation, in order to obtain a prediction of failure load of single lap joints at various design parameters, İbrahim Kocabaş used bilinear cohesive zone model approach in ABAQUS performing sufficient experiments to validate the numerical model. He also examined the effects of each design parameters on the joint failure, individually.

This PhD thesis is well structured and correctly presented. It consists of 7 main chapters. At the beginning of this dissertation summary and list of symbols are introduced. Finally, references and scientific activity of the PhD student in appendix are presented. The thesis is written on 98 pages altogether, and enriched by number of figures (60), equations (23) and tables (4). The theoretical principles as well as the research part were validated with 55 valuable references.

In the first chapter İbrahim Kocabaş introduce reader to the dissertation topic. Chapter 2 (literature review) presents history of cohesive zone models, indicates adhesive joint fundamentals, and properties of polymer based adhesives with their advantages and limitations in service. Some key features to improve joint efficiency of adhesive joints as well as their performance are additionally described. In this work, an adequate valuable literature review regarding to failure prediction with conventional approaches, especially the application of single lap joints have been performed.

Chapter 3 is dedicated to the description of the aims and motivation of the doctoral dissertation. The next part of the dissertation (Chapter 4) is focused on the description of cohesive zone model and influence of adhesive thickness on the cohesive zone parameters. The details of nonlinear

material model for adhesive and adherend material are presented clearly as well as the details of numerical model, mesh structure, boundary conditions and numerical solution methodology. The details of theoretical background is well expressed with the high quality figures and easy to understand thanks to normalized quantities.

The next part of the thesis (Chapter 5) describes the experimental test procedures for the characterization of adhesive and adherend material. Therefore, the cohesive zone model parameters (DCB and ENF tests) are determined in this section for the validation process of numerical simulations. To perform validation, İbrahim Kocabaş - using 15 different joint configurations at various overlap length, adhesive thickness and glue type - has proven that the proximity of experimental result is within the quite acceptable limits (by a max. error of 18%). In chapter 6 the author mentions the results and discussion of numerical solutions. The distribution of normalized stress components, the effects of normalized design parameters and trends of the failure loads with respect to selected joint variables are described in an extensive manner. Then the damage analysis of the joints including load-displacement diagrams and normalized new design parameters for optimum joint manufacture are well presented. Consequently, the general outcomes and conclusions referring to aims of the thesis (in chapter 3) are explained consecutively by the author in chapter 7.

The doctoral dissertation ends with references, glossary of terms and the list of author's publications (5 papers) in which İbrahim Kocabaş is the first author in 2 papers.

EVALUATION

a) Adhesives and adhesive joints play an important role in industrial applications. Those materials and their connections must fulfill the mechanical, and practical requirements of the machine components to hold them together in terms of strength aspects in service. Currently, the prediction of failure phenomena in adhesive joints are still uncertain and depends on many design and manufacture parameters. Therefore, the novelty as well as scientific level of the thesis is very good, considering the importance of the research subject, market requirements and failure evaluation demands.

b) This thesis is perfectly written and very well documented. There are no typing errors and the text is well written in clear and concise manner. The figures, schemes, and tables are shown properly as well. The hypothesis and arguments are well formulated with meritorious conclusions based on valuable and actual literature.

c) The general conclusions of the performed research confirm that the formed objectives of the work (in chapter 3) was successfully finished.

d) The significance and positive outcomes drawn from the thesis are summarized as follows:

- İbrahim Kocabaş has created a numerical model (in ABAQUS) to analyze failure of single lap joints using fully non-linear material behaviors which is more realistic. Proposing an analytical equation to construct stress strain diagrams of the certain adhesives is quite useful and practical.

- L/t, $\sigma_a/\sigma y$ and $F/\sigma_y t$ is defined and proposed to be the most considerable normalized design parameter by the author to achieve optimum design conditions. Author implies that the adherend rigidity affects the joint strength up to a limit point then no effect on load carrying capacity. I should say that this is very important result in joint manufacture.
- Additionally initial stiffness effect is evaluated to be negligible for the joints modelled infinitely thin adhesive layers. I think this is also a critical conclusion for the thin adhesive layer applications.
e) Regarding to above outcomes, the thesis presents invaluable information and new approaches in order to help obtaining an optimum adhesive joint design to meet required strength.

f) Author's publications (5 papers) are well arranged and measurements techniques and methods are correctly applied. It is generally well presented and very interesting to read. The publications are suitable, sufficient and focused on the relevant topics of the doctoral dissertation.

g) To summarize, this thesis is worth to note that the Author has studied carefully research subject with critical view. It is an evident fact that İbrahim Kocabaş deeply understood the topic and discussed problems. Therefore, this doctoral dissertation meets the main requirements for awarding the title Ph.D.

REMARKS

There are some remarks and questions which occurred to me and need to be explained in details.

1) Fig. 5.15 on page 59 should be replaced by Fig. 5.14 on the previous page.
2) A brief explanation on how Poisson's ratios obtained should be added to "*Uniaxial tensile test of bulk samples" part* on page 51.
3) The effect of overlap length in Fig. 5.14 and 5.15 should be expressed extensively.
4) The same label of vertical axis in Fig. 5.16 and 5.17 should be considered since they both indicate the same quantity.
5) The difference in experimental and numerical displacements (in x-direction) is quite larger (see Fig. 5.16 and 5.17). What could be the major reason for such difference?
6) The σ_y and σ_c values in Table 5.4 should be revised and corrected according to what they are given in the corresponded text (on page 64).

To sum up, the dissertation thesis represents high level scientific work. It seems to be an interesting topic for scientists working on failure of adhesive joints.

In my opinion, the reviewed thesis fulfills all requirements aimed for obtaining PhD degree. This thesis is ready to be defended orally, in front of respective committee.

M. Yavuz SOLMAZ
Associate Professor