STUDY ON FAILURE MAPS OF LASER-WELDED I-CORE SANDWICH PLATES

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MASTER OF SCIENCE

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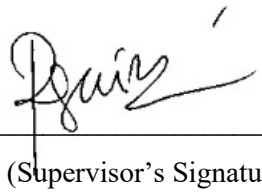

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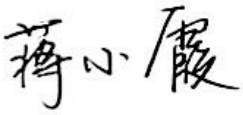

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STUDY ON FAILURE MAPS OF LASER-WELDED I-CORE SANDWICH PLATES

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

Faculty of Mechanical and Automotive Engineering Technology

UNIVERSITI MALAYSIA PAHANG

AUGUST 2022

ACKNOWLEDGEMENTS

As a first and foremost thank you, the author wishes to express her gratitude to Dr. Ruzaimi bin Mat Rejab and Dr. Jiang Xioaxia, who guided her effectively through her master's research education and gave her academic support and motivational encouragement throughout the writing process. Their interest and dedication, above all, their enthusiasm for helping and provide recommendation for the thesis writing, had a significant impact on the success of this work.

Moreover, the author would like to thank the technician of the laboratory of the Faculty of Mechanical and Automotive Engineering Technology (FTKMA) at Universiti Malaysia Pahang, who assisted her in learning the tools and equipment. Accommodation, laboratories, and other services, provided by Ningxia University are greatly appreciated, during the COVID-19 pandemic. The exchange program has been a memorable experience that she will cherish forever. Also highly regarded by the author is the Institute of Postgraduate Studies (IPS), which provides her with financial support through scholarship for one year.

The author is thankful for her parents, Mohd Soffie Suppiah and Salina Binti Ajib, in particular her sister, Soffarina Binti Mohd Soffie, who is always there to motivate, set forth her momentum, and keep her motivated. During this difficult time in completing the thesis, the author is thankful for Moussa Mahamat Issa who provided supportive care. Author cannot express how thankful she is for her family's passion, efforts, support, and faith in helping her achieve her research goals. Finally, thanks and appreciation are provided to all members of Universiti Malaysia Pahang, lecturers, supervisors, and postgraduate students who were carefully selected to ensure the successful implementation of this project, as well as all those who contributed to its success.

ABSTRAK

Tesis ini memberikan tumpuan kepada peta kegagalan plat sandwic teras-I kimpalan laser. Oleh kerana kepelbagaian penggunaannya, plat sandwic yang digunakan untuk struktur kapal mengambil kira ciri-cirinya yang ringan. Pelbagai topologi boleh terokai, tetapi teras-I mempunyai beban dalam satah yang sesuai untuk ujian lenturan. Busa PVC diisi sel tertutup dengan sifat fizikal berketumpatan rendah meningkatkan kekuatan dan kekukuhan plat sandwic. Kimpalan laser adalah kaedah yang biasa digunakan untuk menyambung bahagian-bahagian logam bersama. Tesis ini bertujuan menganalisis parameter yang dipengaruhi oleh geometri, menjalankan kajian parametrik terhadap lenturan tiga titik untuk pelbagai topik melalui kaedah simulasi, dan, akhirnya, membangunkan peta kegagalan untuk plat sandwic teras-I. Ujian telah dijalankan ke atas 48 plat sandwic teras-I. Melalui ujian lenturan tiga titik, ciri-ciri geometri seperti penggunaan busa PVC, bilangan teras, dan sentuhan sambungan-T diperhatikan. Objektif kedua dijalankan melalui simulasi. Ini dicapai oleh sifat bahan yang serupa dan berbeza, hubungan sentuhan sambungan-T, dan lebar kimpalan. Secara keseluruhannya, keputusan menunjukkan bahawa penggunaan busa PVC yang diisi dengan teras-I menyelesaikan masalah kelemahan setempat di kawasan yang tidak mempunyai teras. Ciri A adalah ideal, ciri B adalah eksentrik tanpa sela akar, ciri C adalah berpusat dengan sela akar, dan ciri D adalah eksentrik dengan sela akar. Ciri-ciri ini adalah kegagalan yang berlaku pada hubungan sambungan-T. Pemerhatian terhadap ciri-ciri kimpalan sambungan-T menentukan bahawa ciri A adalah kaedah kimpalan pilihan. Oleh kerana ia tidak mempunyai sela akar (*rootgap*) dan penembusan ketinggian berlaku di bahagian tengah, ia memberikan nilai 815.20 N berdasarkan keputusan eksperimen. Kajian menggunakan pelbagai bahan sama ada pada bahagian plat muka atau teras-I memberikan hasil yang besar. Apabila besi digunakan sebagai teras dan aluminium digunakan sebagai plat muka, ketegaran plat sandwic berkurangan. Pengaruh sela akar dan tiada selar akar kemudian diperiksa, menyimpulkan bahawa ketiadaan sela akar memghasilkan kekuatan yang lebih tinggi berbanding dengan kehadiran sela akar. Semakin tebal kimpalan, semakin tinggi kekuatan dihasilkan. Peta kegagalan disediakan dalam tesis untuk menerangkan data terkumpul. Kawasan tanpa teras tidak dapat menampung daya dan menyebabkan pemisahan teras. Kawasan yang dikenali sebagai kelemahan diperbaiki dengan meningkatkan bilangan teras. Dalam amalan, penggunaan teras-I dan busa PVC memberikan sokongan mekanikal untuk plat muka. Akhir sekali, projek mencapai objektif tesis ini. Penggunaan teras-I dan busa PVC terisi untuk menguatkan sandwic adalah pendekatan yang baik. Mod kegagalan diperhatikan sehingga ubah bentuk berlaku, dan jenis mod kegagalan ditentukan. Metodologi untuk simulasi lenturan tiga titik dilakukan dalam perisian Abaqus. Bagi perbandingan menggunakan bahan yang berbeza untuk plat muka dan teras-I, analisis pertama menunjukkan bahawa penggunaan bahan yang kuat untuk kedua-dua komponen meningkatkan kekakuan elastik sebanyak 1.83 kN/mm. Hasil analisis kedua menunjukkan bahawa kehadiran sela akar pada permukaan sentuhan menyebabkan nyahikatan. Kajian terakhir menyimpulkan bahawa keseimbangan sambungan-T tidak boleh dicapai dengan berkesan; oleh itu, adaah dinasihatkan untuk menganggap bahawa panjang kimpalan adalah hampir sama dengan panjang teras.

ABSTRACT

This thesis focuses on failure maps of laser-welded I-core sandwich plates. Due to the area of its application, the sandwich plate used in ship structures considers the lightweight feature. Many different topologies can be explored but I-core carries an in-plane load suitable for bending testing. The PVC foam with closed-cell and low-density physical features, increases the strength and stiffness of sandwich plate. Laser welding is a common method for joining metal parts together. This thesis intends to analyze geometrical influence parameters, to conduct parametric studies on 3-point bending for various topics through simulation work, and finally, to develop failure maps of I-core sandwich plates. The tests were carried out on 48 I-core sandwich plates. Through the 3-point bending test, geometrical characteristics such as the use of PVC foam, the number of cores, and T-joint contact were observed. The second objective was carried out through simulation. This was accomplished by similar and dissimilar material properties, T-joint contact relationships, and weld widths. Overall, the results showed that using PVC foam infilled with I-core solved the problem of local weakness in areas where cores were missing. The A characteristic is ideal, the B characteristic is eccentric with no rootgap, the C characteristic is centric with a rootgap, and the D characteristic is eccentric with a rootgap. These characteristics is the failure occur at the T-joint contact. Observation of T-joint weld characteristics determined that A is the preferred welding method. As it has no rootgap and height penetration occurs at the center, it gives 815.20 N in the experimental result. Work on various materials on either faceplate or I-core portion yielded substantial results. When steel is used as the core and aluminum is used as the faceplate, the sandwich plate's rigidity is reduced. The influence of rootgap and no rootgap was then examined, concluding that the absence of rootgap results in greater strength than the presence of rootgap. The greater the thickness of the weld, the greater the strength produced. The failure maps are provided in the thesis to explain the data accumulated. The area without cores could not bear the force, resulting in core detachment. The area known as weakness is improved by increasing the number of cores. In practice, the use of I-cores and PVC foam provides mechanical support for the faceplate. Finally, the project achieved the objectives of this thesis. The use of I-cores and PVC foam infilled to strengthen the sandwich is a good approach. The failure mode was observed until deformation occurred, and the type of failure mode was determined. The methodologies for 3-point bending simulation were performed in Abaqus software. In comparison to different materials on the faceplate and I-core, the first analysis determined that using strong materials on both components improved the elastic stiffness by 1.83 kN/mm. The results of the second analysis showed that the presence of a rootgap at the contact surface caused debonding. The final study concluded that a wholesome T-joint could not be achieved effectively; thus, it is advisable to assume that the weld length is close to the core length.

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