Cairo University

FRICTION STIR WELDING OF CARBON STEEL AND AUSTENITIC STAINLESS STEEL

By

Ahmed Elsayed Abd Elaziz Dawoud

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Metallurgical Engineering

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Under the Supervision of

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Title of Thesis:
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Key Words:
Friction Stir Welding; Carbon Steel; Stainless Steel; Microstructure; Tensile Strength

Summary:

- Friction stir welding (FSW) was invented for the purpose of joining metals which were known to be non-weldable such as some aluminum alloys. FSW has rapidly progressed into a viable joining technology for a variety of metals and alloys.
- FSW provide a solution to weld dissimilar alloys which are difficult to be welded by conventional processes.
- In the present work, FSW was used to weld 3 mm thick St37 carbon-steel and 304 austenitic stainless-steel
- A tool of tungsten carbide was used for welding due to high melting point of steel.
- Welded joints were inspected with visual inspection, radiography, and macrostructure.
- The mechanical properties of the joints in terms of tensile and hardness testing were also conducted.
- Further studies were applied using an optical microscope and XRD to examine the microstructure of the joints.
- Different microstructural regions were obtained due to the influence of tool rotation, vertical force and generated heat.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Ahmed Elsayed Abdelaziz Dawoud Date: / /

Signature:

Dedication

This thesis is dedicated:

To the soul of my **father**, who taught me the love of knowledge, learning, also the importance of excellence and competence at work.

To the soul of my **mother**, who inspired me to be serious and look forward to a better future,

To my dear **wife,** who stands behind me in every good work I did.

To my beloved **children**.

To my **brothers** and **sister**.

Acknowledgments

Firstly, I have to recognize the efforts of the supervisors. The thesis could not be achieved without the time, support and dedication of **Prof. Dr. Mohamed Raafat El-Koussy** and **Assoc. Prof. Dr. Mohamed Zaky Ahmed**.

Both of them gave me valuable suggestions, and whenever I had a question, they were always there to solve it. They let me take the opportunity to explore the lab. They read my work and made comments on it. What I learned from them is not just how to write a thesis to meet the full requirement, but how to view anything from a new angle. So, it will be my honor if they permitted me to proceed to work under their supervision in the future.

Also, **Petrojet** Company is deeply acknowledged for providing samples and collaboration.

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Nomenclature

Al	Aluminum
As	Advancing side
ASS	Austenitic Stainless Steel
BM	Base metal.
CGHAZ	Course Grained HAZ
CS	Carbon Steel
EBSP	Electron Back-scattering Pattern
EDS	Energy-Dispersive X-ray Spectroscopy
FE-SEM	Field Emission Type Scanning Electron Microscope
FN	Ferrite Number
FW	Friction Welding
FSP	Friction stir processing
FSW	Friction stir welding
FSSW	Friction stir spot welding.
GMAW	Gas metal arc welding
GTAW	Gas tungsten arc welding
HAZ	Heat affected zone
HV	Hardness Vickers
LBW	Laser beam welding
MIG	Metal inert gas
OM	Optical Microscope
PCBN	Polycrystalline cubic boron nitride
Rs	Retreating side
SEM	Scanning electron microscope
SMAW	Shielded Metal Arc Welding
SSW	Solid State Welding
SS	Stainless Steel
SZ	Stir zone
TEM	Transmission Electron Microscope
TIG	Tungsten arc welding
TM	Tool material