



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكرو فيلم

بسم الله الرحمن الرحيم



MONA MAGHRABY



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جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

**Processing of Composite Materials by Severe Plastic Deformation (SPD)-
Structure and Mechanical Properties**

A Thesis

A Thesis submitted in partial fulfillment for the requirements of the degree
Doctor of Philosophy in Mechanical Engineering
(Design and Production Engineering)

By

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M.Sc. in Mechanical Engineering, 2013
B.Sc. in Design and Production Engineering, 2002

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(2020)



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DESIGN AND PRIDUCTION ENGINEERING DEPATMENT

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The author carried out the work included in this thesis, and no Part of it has been submitted for a degree or qualification at any other scientific entity.

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ACKNOWLEDGEMENT

In the name of Allah, most gracious, most merciful

I would like to express my deep and sincere gratitude to my research supervisor, Prof. **Nahed El-Mahallway** for giving me the opportunity to do research and providing invaluable guidance throughout this research. Her dynamism, vision, sincerity and motivation have deeply inspired me. She has taught me the methodology to carry out the research and to present the research works as clearly as possible. It was a great privilege and honor to work and study under her guidance. I am extremely grateful for what she has offered me. I would also like to thank her for her friendship, empathy, and great sense of humor.

I am especially thankful and grateful to my thesis chief supervisor Prof. **Mohamed Kamal Shoukry** for his constant help, guidance and the countless hours of attention he devoted throughout the work in this thesis.

I express my special thanks, Prof. *Ahmed Abd El-Aziz*, Vice Dean for EMS Student Affairs, Materials Engineering Department, German University in Cairo, for his genuine support throughout this research (corrosion work).

I am extremely grateful to my parents for their love, prayers, caring and sacrifices for educating and preparing me for my future. I am very much thankful to my daughters for their love, understanding, prayers and continuing support to complete this research work. Also I express my thanks to my sisters, brothers for their support and valuable prayers. My Special thanks go to *Mohamed Ibrahim* (workshop), German University in Cairo, for the keen interest shown to complete the practical work successfully.

Finally, my thanks go to all the people who have supported me to complete the research work directly or indirectly.

(2020)

ABSTRACT

Severe plastic deformation (SPD) is one of the most effective methods of producing very fine crystalline structure in different metallic systems (e.g. Aluminium, Iron, and Magnesium). The main objectives of SPD are the creation of micro and sub-micro sized subgrains in the original coarse grains of the material. The microstructure changes caused by SPD are result in improved mechanical and physical properties of metals.

The grain size of the materials plays a very important role on the physical and mechanical properties such as strength, hardness, wear rate and corrosion resistance. According to Hall–Petch relationships, the yield strength and the hardness increase with decreasing square root of grain size.

In the present work cyclic extrusion compression (CEC) process is carried out for the Al 6061, Al 6061/SiC 5 wt%, and Al 6061/SiC 10 wt% composites with different number of cycles. Using extrude diameter of 12 mm and chamber diameter of 14 mm and imposed strain of 0.62 per cycle. The microstructure evaluation of the processed materials was investigated before and after the CEC process using optical, scanning electron microscope (SEM), and energy dispersive analysis of X-rays (EDX). The results indicated the grain refinement of the Al 6061, and its composites due to the increase of the number of cycles, where, the grain sizes of the processed Al 6061, Al 6061/SiC 5 wt%, and Al 6061/SiC 10 wt% samples reduced by 90%, 91.5%, and 89% after 6, 5, and 6 cycles respectively, compared to the annealed condition. An expected decrease in the SiC particles size, and more homogenous distribution were obtained with increasing of the CEC number of cycles. The particle size decreased from 35 μm to 22.4 μm and to 21.9 μm by 36% and 38% reduction percent for 5wt% and 10wt% SiC respectively. The effect of further cycles on particle breakage decreases gradually; to reach 9 μm and 7 μm for 5wt% and 10wt% SiC respectively. After post-CEC process, the SiC_p was reduced to about

1 μm for Al 6061/SiC 5wt% after 5 cycles and to about 0.95 μm for Al 6061/SiC 10wt% after 4 cycles.

The ultimate tensile strength and the yield strength were found to be increased with increasing the CEC cycles, while the elongation was decreased in the first and second cycles and it start to increase again after the forth cycle up to 6 cycle in case of Al 6061 due to the recovery process. Notable increase in the hardness with increasing the number of CEC cycles was observed for Al 6061, Al 6061/SiC 5 wt%, and Al 6061/SiC 10 wt%, by 48%, 37%, and 19% respectively, compared to the annealed samples, the hardness distribution was uniform in the sample cross section.

The wear rate of Al 6061, Al 6061/SiC 5 wt%, and Al 6061/SiC 10 wt% was improved by increasing the number of CEC cycles due to the increase in the hardness via grain refinement resulting from the imposed strain during the CEC cycles, and the homogenous distribution of the fine SiC particles in the composite material.

The corrosion resistance, the pitting initiation and pitting area fraction of Al 6061, Al 6061/SiC 5 wt%, and Al 6061/SiC 10 wt% were decreased by increasing the number of CEC cycles.

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