UNIVERSITI TEKNOLOGI MARA

PERFORMANCE EVALUATION OF THERMAL BARRIER COATING ON HEAT SHIELD FOR ELECTRICAL TURBO COMPOUNDING SYSTEM

MUHAMMAD SYAZANI FARHAN BIN ZAINI

MSc

May 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Muhammad Syazani Farhan bin Zaini
Student I.D. No.	:	2017809208
Programme	:	Master of Science (Mechanical Engineering) – EM750
Faculty	:	Mechanical Engineering
Thesis Title	:	Performance Evaluation of Thermal Barrier Coating on Heat Shield for Electrical Turbo Compounding System
Signature of Student	:	……..
Date	:	May 2020

ABSTRACT

Thermal Barrier Coating (TBC) is usually deposited on nickel-based superalloy substrates and widely used in extremely high temperature applications in order to improve the performance and efficiency of their systems. In this study however, TBC is deposited on medium carbon steel for heat shield to protect electrical motor in electrical turbo compounding system. During the operation, high temperature heat generated could damage the electrical motor. The purpose of this research is to study the characteristic of TBC deposited on medium carbon steel substrate with different top coat materials. Two different top coat material which are 8 wt% yttria stabilized zirconia (8YSZ) and mullite were deposited by using air plasma spraying (APS) method at different voltage and current which is 50 and 70 V for voltage and 400 and 600 A for current. There are 8 samples produced with different deposition parameters which are Sample 1, 3, 5 and 7 using 8YSZ as top coat and Sample 2, 4, 6 and 8 using mullite. Sample 1, 2, 3 and 4 using 50 V as the top coat deposition voltage while Sample 5, 6, 7 and 8 using 70 V. The current for top coat deposition for Sample 1, 2, 5 and 6 is 400 A and 600 A for Sample 3, 4, 7 and 8. The microstructure, porosity, microhardness, phase and element, thermal cycle life and thermal conductivity of the deposited TBC are investigated. From the SEM image, both the 8YSZ and mullite coatings are uniformly deposited on medium carbon steel substrates where the porosity and the microhardness of the 8YSZ coatings is lower than of the mullite coatings. The element composition of the TBC layer is of the element from that material itself. Besides that, the phases appeared at the peak of the XRD patterns for 8YSZ and mullite samples are zirconium yttrium oxide (ZrY_2O_5) phase and mullite ($3Al_2O_3.2SiO_2$) phase, respectively. In addition, the lifetime of 8YSZ coatings is higher than of the mullite coating where its longest cycle lifetime is Sample 7 with 64 cycles while its shortest lifetime goes to Sample 4 with only 12 cycles before TBC failure. The thermal conductivity of 8YSZ and mullite samples are lower compared to the uncoated samples. Consequently, in using medium carbon steel as a substrate, the applicable top coat material for TBC application is the 8YSZ rather than the mullite in terms of better thermal cycle life and lower thermal conductivity.

ACKNOWLEDGEMENT

Praise be to Allah S.W.T, Lord of the Universe. Salawat and salam for the Prophet Muhammad S.A.W. Alhamdulillah and thank you Allah for giving me good health and enough time for me to complete my research study.

First and foremost, I would like to thank my main supervisor Dr. Mohd Shahriman Adenan for his guidance, encouragement and advices throughout my research study. May Allah bless him; provide good health, a long life and well-being towards him. Not to forget, I would also like to acknowledge my co-supervisor Dr. Juri Saedon who gave a lot of advices and assisted me in this study. May Allah return your kindness.

My gratitude also goes out for the staffs of Material Science Laboratory, Heat Treatment Laboratory, Thermodynamic Laboratory Faculty of Mechanical Engineering, Universiti Teknologi MARA who gave full cooperation in helping me do this research. A special thanks to the special persons in my life which are my parents Zaini Ahmad and Noorleda Khamis that always supported me, motivated me when I am down and prays for my success. Without both of you, I am nothing. Also not to forget, thanks to my siblings and others family member for also morally supporting me. This acknowledgement also goes out to my friends and people surrounding me that were directly and indirectly involved in helping me complete my studies.

Lastly, I hope all my hard work and tears in completing this research study can benefit others in the future.

Thank you.

TABLE OF CONTENTS