INFLUENCE OF PROCESSING PARAMETERS ON THE PROPERTIES OF AISI 4340 STEEL COATED WITH TIC POWDER FABRICATED BY TUNGSTEN INERT GAS ARC MELTING

BY

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ABSTRACT

The incorporation of TiC through surface melting at high energy input was found to produce a thin layer of hard coated material on the surface of the substrate beneficial for wear resistant. This work involved the cheap TIG melting technique to melt the hard TiC particulates on the AISI 4340 low alloy steel substrate material rather than the expensive laser or electron beam method. The experimental work involving three phases were initiated by producing single melt layers at different processing conditions in order to identify the sample that exhibits high hardness values that is crack free associated with densed population of TiC microstructures. The characterization of the single layer and multipass layers were affected by the microstructural features and surface topography investigated using optical microscope (OM), scanning electron microscope (SEM) and X-Ray diffraction (XRD) while the microhardness values were conducted using Vicker microhardness machine. Under the first phase, the calculated energy used was varied from the lowest at 1008 J/mm to 2640 J/mm while the powder content was in the range of 0.4 mg/mm^2 to 2 mg/mm^2. The shielding argon gas was from 10 l/min to 30 l/min and the measured working distance was at 0.5 mm to 1.5 mm. The optimum processing condition for this single layer at 1344 J/mm with 1 mg/mm^2 powder content produced crack free sample with hardness value up to 4 times than the substrate material. The second stage involved melting for multipass layers using the single layer optimum processing condition to be overlapped at the 50% of offset distance. The preheating effect from re-melting of the previous layers at this stage dissolved more of TiC particulates for homogeneity of re-precipitated TiC microstructures across the melt track. With the multipass layers, the microhardness ranges from 600 HV to 1000 HV which is over two times than the substrate. In the third stage, investigation of the wear behavior was conducted at the room temperature of 20^{o}C under the dry sliding wear test using alumina ball as the counterpart. The improvement of hardness by the coated layer up to 2.3 times than the substrate exhibited 13 times lesser of wear rate than the uncoated sample that was seen to endure wear severance dominated by deformation. The persistency of oxidative, adhesive and abrasive wear mechanism appeared on the samples resulted difference of surface morphologies that had much influenced the value of friction coefficients. The research may provide additional knowledge and information to produce hard coated layer for the suitability of technology application in industries like, automotive, aerospace and oil and gas.

ملخّص البحث

تضمن هذا العمل استخدام تقنية الصهر الرخيصة لـ TIG لإذابة حبيبات الـ TiC الصلبة على سطح معدن AISI 4340 ، بدلاً من لحام الليزر والشعاع الإلكتروني ذو التكلفه العالية .العمل المعملي تضمن ثلاثة مراحل بدأت بإنتاج طبقات مفردة مذابة في ظروف تشغيلية مختلفة، لتحديد العينه التي لها قيم صلادة عاليه وخالية من التشققات مرتبطة مع كثافة جسيمات TIG في البنية المجهريه. ان وصف الطبقة المفردة او الطبقات المتعدد المتأثرة بميزات الهيكل المجهري والسطح الطبوغرافي قد تحقق منها باستخدام المجهر الضوئي (OM)، المجهر الالكتروني الماسح (SEM) وحيود الأشعة السينية (XRD)، في حين قيست الصلادة باستخدام آلة Vicker .في إطار المرحلة الأولى كانت الطاقة المستخدمة تتراوح مابين 1008 جول/ملم إلى 2640 جول/ملم ، بينما كانت كمية المسحوق في حدود 0.4 ملغ/ملم ^{2} إلى 2 ملغ/ملم ^{2}. وكان معدل تدفق غاز الارجون من 10 لتر/دقيقة إلى 30 لتر/دقيقة، وأيضاً المسافة المستخدمه للعمل كانت من 0.5 ملم إلى 1.5 ملم. وكانت الظروف التشغيلية المثلى لهذه الطبقة المفردة عند 1344 جول/ملم مع محتوى مسحوق 1 ملغ / ملم^2 قد انتجت عينة خالية من الشقوق مع قيمة صلادة وصلت إلى اعلى 4 مرات من المعدن الاساسي. المرحلة الثانية تضمنت الذوبان لطبقات متعددة باستخدام ظروف التشغيل المثلى للطبقة المفرده لكي تتداخل عند 50% من مسافة التوازن. ان تأثير عملية التسخين المسبق الناتج من إعادة ذوبان الطبقات السابقة ادى الى تحلل جسيمات الـ TiC أكثر مما اعطى تجانس البنية المجهرية عبر مسار الذوبان. مع الطبقات المتعددة ، تراوحت الصلادة من HV600 الى HV 1000، حيث كانت أكثر مرتين من المعدن الاساسي. في المرحلة الثالثة تم التحقق من خواص الاحتكاك عند درجة حرارة الغرفة 20°C باستخدام الانزلاق الجاف وكرة من الألومينا. وتحسنت الصلادة للعينة المطلية إلى 2.3 مرة اعلى من السطح الاساسي للمعدن واظهرت معدل تأكل 13 مرة أقل من العينة الغير مصقولة وكان ذلك واضح من قدرتها على تحمل القص المهيمن عليها من خلال التشوه. ان ثبات تواجد الأكسدة، الالتصاق والكشط كآلية للبلى التي ظهرت على العينات أدى الى تكون أشكال تضاريسية سطحية مختلفة والتي كان لها تأثير كبير على قيمة معامل الاحتكاك .وقد وفر البحث المعرفة والمعلومات الإضافية لإنتاج طبقة صلدة ملائمة من اجل التطبيق التكنولوجي في الصناعات مثل صناعة السيارات والطيران والنفط والغاز.

APPROVAL PAGE

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DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF ABBREVIATIONS

AEA	Atomic Energy Authority
Ag	Silver
AISI	American Iron and Steel Institute – Society of Automotive Engineers
Al	Aluminum
Au	Gold
B	Boron
BOD	Block on disk
C	Carbon
CaF_2	Calcium flouride
CNC	Computer numerical control
CO_2	Carbon dioxide
CPS	Count per second
Cr	Chromium
CRT	Cathode ray tube
Cu	Copper
CVD	Chemical vapor deposition
DCEN	Direct current electrode negative
DLC	Diamond like coating
DMD	Direct metal deposition
d/w	depth to width
EBW	Electron beam welding
EDX	Electron disperse X-Ray