STUDY OF PLASMA SPRAY ALUMINUM CONDITIONS UNDER MICROWAVE OVEN DRIVEN ON COATING CHARACTERISTICS

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MASTER OF SCIENCE

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis, and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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STUDENT’S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kaedah penyemburan plasma merupakan teknik salutan yang serba boleh bagi pemendapan bahan yang mempunyai takat lebur yang tinggi seperti seramik dan *cermet*. Kaedah ini digunakan bagi mencegah sesuatu bahan daripada mengalami hakisan dan dapat menjadikan bahan lebih berketahanan. Kaedah ini menggunakan sumber haba yang dihasilkan oleh arus terus, frekuensi radio atau gelombang mikro sebagai sumber tenaga untuk mencairkan zarah penyembur yang disalurkan sama ada secara paksi atau jejari ke dalam plasma. Kaedah plasma yang di hasilkan dari ketuhar gelombang mikro adalah aplikasi yang baru bagi menghasilkan plasma bagi tujuan salutan. Ia menggunakan tenaga gelombang mikro sebanyak 2.45 GHz dan kuasa pengeluaran 0.8 kW untuk menghasilkan plasma yang mampu mencairkan hampir kesemua bahan yang dianggap boleh dicairkan. Walaubagaimanapun, penyelidikan mengenai penyembur plasma gelombang mikro ini sangat terhad dan kurang. Dalam kajian ini, Struktur penyalaan plasma yang sesuai diperlukan bagi semburan plasma gelombang mikro untuk menghasilkan aliran laminar bagi membentuk plasma yang diingini untuk aplikasi salutan. Kaedah serta ciri prosesnya masih belum dapat dipelajari dengan baik. Oleh itu, objektif utama penyelidikan ini adalah untuk mengkaji ciri-ciri operasi kaedah penyemburan plasma berasaskan ketuhar gelombang mikro. Selain itu, penambahbaikan dan pengubahsuaian alat penyembur juga dikaji dan dipersembahkan. Pertamanya, kami merancang dan membangunkan alat penyembur plasma yang dijanakan oleh ketuhar gelombang mikro untuk aplikasi penyembur haba. Dalam objektif ini, kami mencuba mengebal pasti cara terbaik menghasilkan plasma yang boleh digunapakai untuk aplikasi salutan. Terdapat banyak faktor yang perlu diberi perhatian untuk penghasilan reka bentuk ini dan salah satunya adalah pengiraan nombor *Reynold*. Dari eksperimen kami, semua diameter luar antenna yang kami kaji berada di bawah bacaan 2000 sekaligus menunjukkan ia berada pada bacaaan aliran laminar. Plasma menunjukkan keadaan yang lebih stabil apabila aliran laminar berlaku berbanding aliran turbulensi. Kajian seterusnya adalah untuk mengkaji ciri operasi penyembur plasma yang dihasilkan oleh ketuhar gelombang mikro ini. Dalam kajian penyalaan plasma, plasma gelombang mikro dapat dihasilkan dan distabilkan menggunakan ketuhar gelombang mikro yang direka oleh kami. Semasa melakukan kajian penyalaan, beberapa reka bentuk telah diuji dan banyak faktor yang perlu dipertimbangkan kerana ia akan mempengaruhi peranti gelombang mikro kami. Dari pemerhatian kami, kesan daripada ‘*thermal pinching*’ memainkan peranan penting dalam proses kajian reka bentuk ini. Seterusnya, penyelidikan mengenai penyalutan lapisan Aluminium (Al) pada substrat *SUS304* dilaksanakan. Al adalah salah satu bahan kos rendah dan mempunyai ketahanan pengoksidaan. Al dapat mencegah substrat daripada bertindak balas dengan oksigen semasa kajian dijalankan. Berdasarkan kajian ini, dapat disimpulkan bahawa, semakin dekat jarak hujung antenna dengan substrat, semakin banyak zarah-zarah yangd apat di cairkan disalut dan tersebar di permukaan substrat. Kesimpulannya, semburan plasma yang dijanakan oleh ketuhar gelombang mikro ini terbukti berfungsi dan mampu menghasilakn salutan. Penyelidikan masa depan harus dilakukan untuk penambahbaikkan beberapa ciri ke arah mewujudkan kaedah ini dalam aliran teknik penyemburan termal.

ABSTRACT

The plasma spraying method is the most versatile coating technique for depositing high melting point materials such as ceramics and cermets, used for wear, corrosion, and heat resistance purposes. It uses a heat source generated by direct current, radio frequency, or microwave as the power source to melt the spray particles injected either axially or radially inside the plasma plume. The microwave oven-induced plasma method is a novel application of the microwave oven to generate plasma for the coating process. It uses 2.45 GHz microwave power and only 0.8 kW input power to produce the plasma capable of depositing all sprayable materials for coating. However, more research regarding this microwave plasma spray is needed to be discovered. A suitable plasma torch with laminar flow is needed to produce the desired microwave-generated plasma for coating application. Our research group generated the plasma with a microwave oven and succeeded in fabricating an aluminum coating. However, the mechanism and characteristics of the process are not studied well yet. Thus, the main objective of this research is to study the operational characteristics of the microwave oven-driven plasma spray method. Moreover, the improvements and renovation of the spray device are also studied and presented. A microwave oven-driven plasma spray device was designed and developed for thermal spray application. In this objective, we learn to optimize how to produce acceptable plasma for coating application. Many factors need to be addressed for this design; one of them is the ignition condition which led to Reynold's number calculation. From our experiment, all outer diameter of the antenna is below 2000, which indicates laminar flow. The plasma shows more stable discharge when laminar flow occurs rather than turbulence. The microwave plasma can be generated and stabilized using our designed microwave oven as a result of the plasma ignition study. Argon gas is a working gas to produce plasma for our device. During ignition study, several designs are tested, and many factors are considered to affect our microwave device. From our observation, the presence of a waveguide is significant in helping plasma production; using an 8 mm gap between the tip of the antenna and a 13 mm window diameter results in the thermal pinching effect, which plays a vital role in this design experiment process. For the coating deposited using microwave oven-driven plasma spray device evaluation, aluminum powder coating onto stainless steel SUS304 substrate was successfully deposited. Based on the result, a higher working gas flow rate will produce a more fine coating. With the decrease of spray distance, more melted particles are being impinged and less dispersed on the surface of the substrate. In conclusion, this microwave oven-driven plasma spray is able to produce a stable plasma with adequate power to deposit coating. Future research should be conducted to improve some of its features towards realizing this method in the mainstream thermal spray technique.

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