International Journal of Mechanical Engineering (IJME)
ISSN(P): 2319-2240; ISSN(E): 2319-2259
Vol. 8, Issue 3, Apr - May 2019; 1-6

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

INFLUENCE OF THE SECONDARY AIR PRESSURE IN THE DEPOSITION EFFICIENCY OF A TWIN WIRE ELECTRIC ARC SPRAYING

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ABSTRACT

One of the major concerns of today's manufacturing sector is the in-crease in the cost of the materials and not able to utilize them to its fullest potential. This can be recovered by increasing the efficiency of the process. This paper attempts to decrease the monetary losses that are caused by insufficient deposition of tin and tin/zinc on the surface of a thin film capacitor by the process of electric arc spraying. Various modifications in the existing parameters have been put forth and amongst them, the feasible one is worked upon. Experimental investigation shows that the introduction of secondary passage in the air cap of the electric gun leads to more deposition of the material, thereby decreasing the temperature and increasing the coating thickness of the substrate. This will cater to the effective utilization of both the material as well as cost.

KEYWORDS: *Electric Arc Spray, Design, Secondary Air Pressure, Deposition Ef-Ficiency*

Article History

Received: *01 Mar 2019* | ***Revised:*** *18 Mar 2019* | ***Accepted:*** *01 Apr 2019*

INTRODUCTION

As far as the manufactures sector is considered thin film capacitors are one of the fastest growing industries in the field of electronics. The manufacturing process involves various processes such as winding, pressing, spraying, welding etc. and ultimately leading it to the final testing and inspection. There is also a non-value-added process in this and focus must be done on the important process. A deep analysis into one of its process can lead to huge improvement in the overall manufacturing of the capacitors both in terms of quality and cost. One such process is spraying which uses the concept of electric arc spraying. In this, a spray of molten metallic droplets is formed by the impingement of a fast-moving air pressure upon the melting tips of consumable wires fed. These wires are in the form of positive and negative electrodes and on meeting with a high potential difference, turns into an arc [1]. These molten materials of tin and tin-zinc are sprayed onto the capacitor to develop a good bond that will eventually help in welding.

LITERATURE REVIEW

Over the years, many researchers have contributed to the study of twin wire electric arc spraying by involving the parameter of air pressure. Some of the earliest usages of air pressure mentioned in a research paper is during the spraying of aluminum and zinc on mild steel [2]. S Sprayed air pressure was plotted against surface roughness and profile height in order to determine the variation. The pressure must be maintained at 0.45-0.50 MPa in order to not to increase the surface roughness. Also, with the increase in this, porosity decreases. One of the earliest concepts of using secondary air pressure in the electric arc spraying was used for conducting design of experiments [3]. It was varied at 50, 60 and 70 psia and the deposition efficiency ranged from 55.8 to 76.9%. Results revealed that low atomizing air pressure produced rough coatings.

Then, using either compressed air or nitrogen as spraying gas, experimental designs were framed by considering both primary and secondary spray pressure at various values [4]. Oxide content, Youngs modulus and hardness were directly related to the spray. [5] investigated the influence of particle velocity in the arc spray.it was observed that higher air pressure accounts for higher impact velocity of smaller particles and breaks up the molten particles into smaller particles. Use of primary pressure and spray head pressure for nanoscale composite coatings on boiler applications were done [6]. Effect of spraying angle on various metallurgical and mechanical properties percentage of porosity, Vickers hardness, superficial hardness, and deposition efficiency. Graphs show that 60˚ is the most crucial angle for the increase or decrease of the properties.

But, the deposition rate tends to be stagnant. The morphology of aluminum coating was investigated in three different types of spraying which included electric arc spraying [7]. In this, both primary and secondary air pressure is amongst the control parameter and the results show that the reduction in roughness causes an increase in adhesion. Another study [8] reveals that by maintaining the pressure between 0.2 to 0.4 MPa, the focusing effect is remarkable and this effect is not dependent on the other parameters but this, along with current and voltage influence other parameters such as particle velocity, temperature, and droplet formation. Erosion of the sprayed material is also a factor that hugely affects the deposition and is dependent on impact angle [9],[10]. Microarc oxidation of the wire arc was done to observe the microstructures [11]. It shows that increasing gas pressure increases the hardness of the substrate and provides a thicker coated layer. The effects of gas pressure were deeply analyzed [12]. The gas pressure was released from the primary and secondary circuit to analyses the effects.

It was revealed that the coating increased and the constriction of the electric arc in determining the small atomized particles with low inertia was very much influenced by the secondary air pressure. Investigation on the parametric effects was done by keeping primary air, secondary air along with distance and arc current as the input parameters to determine the deposition efficiency, roughness etc [13].

It was observed that arc current is not significant and the increase of secondary air pressure decreases the mean particle size. Also, the particle sprayed at low-pressure results in rougher surface and secondary pressure does not affect porosity. Investigation on the effects of both primary and secondary air pressure on spray eccentricity, pattern, flatness etc. as secondary air pressure increases, pattern size decreases, and lower eccentricity and does not affect flatness [14]. Few other researchers [15] have also made conducted experiments using secondary air pressure.

CASE STUDY

Deposition efficiency is the most important parameter in the spraying process. It determines the effectiveness of the spraying process. Currently, in this industry, the deposition efficiency on the capacitor is roughly on an average of about 52% and this account for a loss of approximately 50 lakhs per month. The cost of 1 kg of zinc is around Rs 400/Kg and that of tin is Rs 700/Kg. Hence, the purpose is to increase the deposition efficiency such that deposition gets increased which will lead to the reduction in cost. The critical factors of the spraying process have to be analyzed deeply and also identify the other additional parameters that could be beneficial in increasing efficiency.

After performing an extensive study on this, few parameters has been put forth that could eventually increase efficiency. It is seen that the angle of the gun can be varied at certain angle from 45˚ to 90˚ to obtain higher deposition rates. Angles lesser than 90˚ will have low hardness and persists high adhesive strength. Also, increasing the angle will lead to the lesser deposition because of the normal component of the particle velocity [16]. Moreover, the angle spraying can be classified as no deposition region, transient region and maximum deposition region [17]. The spray distance if calculated from horizontal, vertical and radial distance from the spray jet Centre pertaining to the radial distance can also be considered and consequently, de-sign of experiments can be performed to find out the effect on deposition [18]. The gas flow rate also plays a vital role in the deposition. Maintenance of humidity up to 85% is desirable [19] and many more provisions are indicated. Amongst all these, the most feasible factor pertaining to this machine of electric arc spraying is the introduction of secondary air pressure that has the potential to increase the efficiency.

METHODOLOGY

The air caps are modified in its design by drilling hole in its outer core with a specified distance. Then, the normal process of spraying takes place. When the spray which is in the form of arc pressurized by air, passes though the main hole, these small holes will create back pressure. This back pressure will suck in the sprayed particles that deviate from its path and will be sent back to the desired main area where it is required. Also, a certain amount of dust spray will be reduced which eventually will account for more deposition. The deposition is measured by measuring the initial and final weights of the roller and also measuring the thickness using a micrometer. Fig 1 shows the existing design of the air caps whereas Fig 2 is the modified design with small holes on its outer core.

The experiment was performed on a roll diameter of 500 mm with a pressure of 3 kg. the wire used was zinc and the weight of wire is 0.2045 kg. The specification of the capacitor stands out to be 10 mm. The weight of the wire must be

multiplied by 4 since there are four passes of Two positive and two negative electrodes. Thus, it becomes 0.818 Kg. Therefore, the percentage of deposition efficiency is calculated as the difference divided by the length of the wire. This will give the ratio as to how much is the deposition made from the total wire that was used.

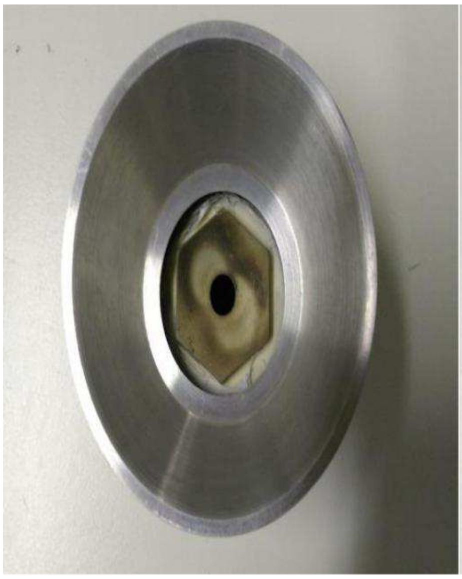

Figure 1: Existing Design

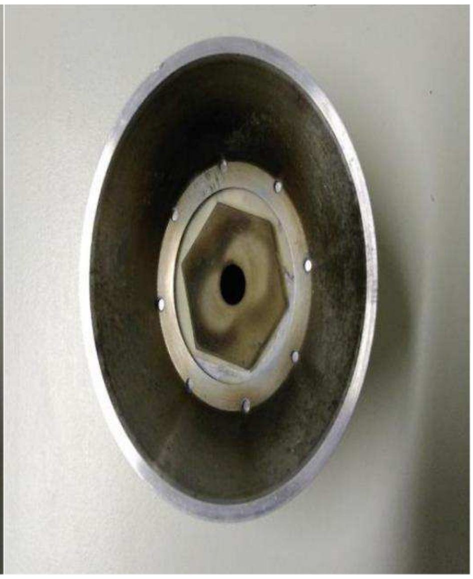

Figure 2: Modified Design

Results

Table 1: Trial 1 for the Existing Design

Terminologies	Values
Initial Weight	1.272 Kg
Final Weight	1.770 Kg
Difference	0.498
Thickness	0.333-0.363 m
Deposition Efficiency	60.8802 %

Table 2: Trial 2 for the Existing Design

Terminologies	Values
Initial Weight	1.256 Kg
Final Weight	1.782 Kg
Difference	0.476
Temperature	90˚
Deposition Efficiency	58.19071%

Table 3: Trial 1 for the Modified Design

Terminologies	Values
Initial Weight	1.300 Kg
Final Weight	1.850 Kg
Difference	0.550
Thickness	0.38-0.479 m
Deposition Efficiency	67.23716 %

Table 4

Terminologies	Values
Initial Weight	1.304 Kg
Final Weight	1.829 Kg
Difference	0.525
Temperature	85˚
Deposition Efficiency	64.18093%

CONCLUSIONS

It is evident from the results that the modified design shows higher deposition efficiency than the existing design in all the trials. Also, the temperature has dropped down to about 5˚ and the increase in deposition efficiency of about 5-10%. Speaking on the financial aspects, this reduces approximately 20% of the loss that is obtained currently. Thus, the method is successful and can be implemented in the near future which will lead to the overall equipment efficiency.

REFERENCES

1. *Newbery A P, Grant P S and Neiser R A.: The velocity and temperature of steel droplets during electric arc spraying. Surface and Coatings Technology 195, 91-101 (2005).*
2. *Bardal E, Molde P and Eggen T G.: Arc and flame sprayed aluminium and zinc coatings on mild steel: bond strength, surface roughness, structure and hardness. British Corrosion Journal 8, 15-19 (1973).*
3. *Varacalle Jr D J, Wilson G C, Lundberg L B, Hale D L, Zanchuck V, Kratochvil W and Hodum A.: An SDE study of twin-wire electric arc sprayed nickel-aluminum coatings (1995)*
4. *Jandin G, Liao H, Feng Z Q and Coddet C.: Correlations between operating conditions, microstructure and mechanical properties of twin wire arc sprayed steel coatings. Materials Science and Engineering: A 349, 298-305 (2003).*
5. *Gedzevičius I and Valiulis A V. Influence of the particles velocity on the arc spraying coating adhesion. Material Science 9(4), 334-337 (2003).*
6. *Branagan D J, Breitsameter M, Meacham B E and Belashchenko V.: High-performance nanoscale composite coatings for boiler applications. Journal of thermal spray technolo-gy 14, 196-204 (2005).*
7. *Paredes R S C, Amico S C and d'Oliveira A S C M.: The effect of roughness and pre-heating of the substrate on the morphology of aluminium coatings deposited by thermal spraying. Surface and Coatings Technology 200, 3049-55 (2006).*
8. *Wilden J, Bergmann J P, Jahn S, Knapp S, Rodijnen F V and Fischer G.: Investigation about the chrome steel wire arc spray process and the resulting coating properties. J. of Thermal Spray Technology 16, 759-67 (2007).*
9. *Dallaire Sege.: Hard arc-sprayed coating with enhanced erosion and abrasion wear re-sistance. J. of thermal spray technology 10, 511-19 (2001).*
10. *Luo L M, Liu S G, Yu J, Luo J and Li J.: Effect of Al content on high temperature erosion properties of arc-sprayed FeMnCrAl/Cr3C2 coatings. Transactions of Nonferrous Metals Society of China 20, 201-06 (2010).*
11. *Kumruoglu L C, Ustel F, A Ozel A and Mimaroglu A.: Micro Arc Oxidation of Wire Arc Sprayed Al-Mg6, Al-Si12, Al Coatings on Low Alloyed Steel. Engineering 3, 680-90 (2011).*
12. *Toma S L, Bejinariu C, Baciu R and Radu, S.: The effect of frontal nozzle geometry and gas pressure on the steel coating properties obtained by wire arc spraying. Surface and Coatings Technology 220, 266-70 (2013).*

13. *Johnston A L, Hall A C and McCloskey J F.:Effect of process inputs on coating properties in the twin-wire arc zinc process. Journal of thermal spray technology 22, 856-63 (2013).*

14. *Horner A., Hall A C and McCloskey J F.: The effect of process parameters on Twin Wire Arc spray pattern shape. Coatings 115-23 (2015).*

15. *Tillmann W, Vogli E and Abdulgader M.:Influence of Atomisation Gas on the Particle Formation During Arc Spraying with Cored Wires. Thermal Spray 837-42 (2007).*

16. *Kim D Y, Lee J B, Jeong C H, Park S S, Jung, J Y, Choi H J and Lee S H.: Effects of Cur-vature on the Flow Characteristics and Particle Behavior in the Flame Spray Pro-cess. Materials transactions 56(12)**,** 2070-77 (2015).*

17. *Li C J, Li W Y, Wang Y Y and Fukanuma H.: Effect of spray angle on deposition charac- teristics in cold spraying. Thermal Spray 2003: Advancing the Science and Applying the Technology 5-8 (2003).*

18. *Planche M P, Liao H and C. Coddet.: Relationships between in-flight particle characteris-tics and coating microstructure with a twin wire arc spray process and different working conditions. Surface and Coatings Technology 182, 215-26 (2004).*

19. *Malek M H A, Saad N R, Abas S K A and Shah N M.: Thermal arc spray overview IOP Conference Series: Materials Science and Engineering. 46, 1-10 (2013)**.***