A REVIEW – OPTIMIZE THE PROCESS PARAMETER FOR RAW MATERIAL CONSUMPTION FOR SPECIFIED DRY FILM THICKNESS IN FLAME SPRAY COATING ON EXTRUDER SCREW.

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ABSTRACT

Flame spray coating is a coating technique used extensively in industrial application to enhance the performance of engineering component like extruder screw, shafts & plunger ring set. Improved resistance to wear can be achieved, which eventually extend the life of component. Due to its simplicity in process and low initial cost of setup Flame spray coating techniques are widely used for coating on extruder screw. The deposition efficiency then becomes a vital output to survive in today's competitive market. The deposition efficiency i.e. the raw material consumption depends upon the spraying process parameters. This paper focuses on tracing out various process parameters which has influence on deposition efficiency, coating thickness and quality of coating in thermal spray coating processes. Design of experiment such as Taguchi's experimental design can be used for the optimizing these process parameters. Analysis of variance can then be useful to identify significant process parameters.

Keywords: - *Flame Spray coating, Extruder screw, Taguchi's orthogonal array, Analysis of variance.*

1. INTRODUCTION

To withstand the today's competitive market it is important to produce surfaces that are resistant to wear & corrosion over a long period. Thermal spray coating technique is a process that improves the overall performance of component by adding functionality to the surface of component [1]. Thermal spray is a very versatile technology that can be used in many types of applications and virtually almost on any component. This is why it has grown to become a large worldwide market of several billion dollars since the first produced coatings in the early years of the twentieth century [1]. Its versatility makes this technology suitable for use against wear, corrosion and aggressive and high-temperature environments and for repair and restoration of components.

The flame spray process uses the combustion of fuel to create a flame and thus the heat source and accelerating force for the deposition process term as a thermal spray technique [2]. Flame temperature is controlled by the mix of fuel gasses and oxygen. The pressure regulator is given on flame gun or torch to control pressure of oxy-acetylene. In flame spraying coating process the fuel is mixed with oxygen in a combustion chamber, the mix is ignited and the combustion gasses are accelerated down a long convergent divergent nozzle. The nozzle design creates a supersonic combustion jet into which powder can be injected efficiently. The benefits of this process are that the particle velocity on impact is very high.

Extruder screws are thermally flame sprayed in order to achieve higher wear life. Flame spray coating being one of the simplest coating processes is extensively used for coating on extruder screw. Extruder screw is widely used in plastic industries for manufacturing of plastic component. Extruder screws (when used in pair) basically inject plastic into mould and are subjected to abrasive wear once in operation. Hence to achieve higher wear life the screw is thermally coated with thermal spray coating technique with suitable raw material term as feedstock. A more detailed overview pertaining to Extruder screw (substrate) and Feed stock (raw material) is explained in the subsequent section.

2. LITRETAURE REVIEW

G. Montavon et al has studied the effect of various spray angle i.e. 90, 75, 60, 45, and 30 degree on splat morphology during the thermal spraying process. On investigating it is observed that the spray angle had a strong effect on the geometric properties, in particular on elongation factor of the shape. At lower spray angle the deposit is build from more narrow size particle and thus the deposition efficiency decreases [3].

J. R. Fincke et al has investigated the process variations that limit the process repeatability and coating performance. The development of close loop processor controllers can help to control the process from trial and error approach to a more specific approach leading to intelligent, real time sensor and model based control which will help users and developers to ensure the consistent production of those coatings [4].

Ming-Der Jean et al has design a fuzzy logic approach for optimization reinforced zirconia deposition using plasma sprayings. Taguchi orthogonal array was use for the design of experiment. From the experiment conducted and Analysis of variance the factors that affect the coating thickness most are Standoff distance, Powder feed rate and accelerating voltage which accounts for almost 78.57 % of the experimental variance [5].

W.-Y. Li et al has done the investigation of effect of standoff distance on coating deposition characteristics in cold spraying. The standoff distance was increased from 10 mm to 110 mm. It was found that the maximum deposition efficiency for Cu powder was obtained at the standoff distance of 30 mm, and then the deposition efficiency decreased with further increasing the standoff distance to 110 mm. it was also found that the surface of substrate or previously deposited coating could be exposed to a relatively high gas temperature at a short standoff distance [6].

Alexander Kout et al has reveal that the position of gun that is standoff distance and spray time has direct influence on response characteristics in spray coating process. Hence this makes the position of the gun a parameter to be optimized. Also the quality of desired coating, the computing time and insights into the distribution of the spray time and the distance of the guns are of major concern for the evaluation [7].

Z. Bergant et al in the study has investigated that the adhesion strength is responsible for coating quality and its deposition efficiency. The four chosen influential factors, that is, surface roughness, preheat temperature of the substrate, distance of flame torch, and type of oxyacetylene flame, were optimized to maximize the adhesion strength, using the Taguchi parametric method. The confirmation experiment showed that the developed experimental model is suitable for optimization of flame spraying deposition process [8].

R. Gadow et al purpose of this study was to implement an advanced computer aided robot path planning approach for thermal spraying operations which allows the generation, simulation and implementation of the robot trajectory. The process parameters such as the trajectory, the relative distance, velocity profile and the angle between the spraying torch and substrate, have a major influence on the heat and mass transfer to the component during the process, and therefore on the coating microstructure, physical and chemical properties and their quality [9].

Shuo Yin et al The effect of injection gas pressure on particle acceleration, dispersion and deposition in cold spray process was investigated by both numerical and experimental methods. A computational fluid dynamics (CFD) model was developed which exactly matches the real nozzle in experiment to predict the supersonic gas flow field and particle velocity prior to the impact. Based on the simulation results, it is found that injection pressure significantly affects the flow field of the driving gas. Higher injection pressure leads to higher injection flow rate as well as powder injection rate, producing thicker coating on the substrate. Besides, the particle footprints on the substrate surface at different injection pressures were predicted and compared with the experimental measurements of the single track coating width [10].

S. Luangkularb et al this paper presents the influences of supplying pressure, spray time and nozzle size of spray gun on the weight of material used per shot and the dry film thickness obtained. A high volume low pressure type spray gun was used to atomize and deliver a liquid solution of Teflon depositing on a flat work surface. The experimental results showed that low spray time, large nozzle size and low spray pressure were responsible for the increased material consumption and dry film thickness. The optimization was performed, where the material consumption was minimized and the dry film thickness was set within a specified standard. Based on the geometric interaction between the spray gun and work-piece, a spray coating model in this application, which is considered unique was also developed and discussed in this paper. Factorial experimental design and ANOVA methods are used for Design of experiment and statistic analysis [11].

3. EXISTING PROCESS

In existing process the thermal spray torch, nickel based as well as tungsten carbide based carbide powder and Extruder screw is required.

3.1 Thermal spray equipment

For thermal spray nickel based as well as tungsten carbide based coating, Superjet Ewac torch require. Using this torch we can produce 800˚C to 1600˚C. In addition to this we also need Oxygen and Acetylene gas for producing the flame.

Fig – 1: Superjet Ewac Flame spray torch

3.2 Tungsten carbide coating powder (feedstock)

WALLCOLMONOY 88 – Hard surfacing alloy: Colmonoy 88 is a unique alloy containing fine, multiple hard phase which are uniformly distributed a Ni-Cr-B matrix. These hard phases comprised of complex bi- and tri- metallic borides and carbides, are precipitated during manufacturing, and are therefore an inherent part of the microstructure and not added externally as in conventional composite powders. The hard phases remain uniformly distributed shipping, spraying and fusing to ensure consistent performance throughout the coating. They are an intimate part of the matrix and will not erode prematurely. Their fine size contributes to better finishing characteristics. The hard phases along with the high-hardness Ni-Cr-B matrix, resist extreme abrasion and corrosion. The table below shows the chemical composition of the Colmonoy 88 coating powder.

Table - 1 Chemical composition of Colmonoy 88

Chemical	Composition
Boron, B	3 %
Carbon, C	0.80 %
Chromium, Cr	15 %
Iron, Fe	3.5%
Nickle, Ni	56.4 %
Silicon, Si	4.0%
Tungsten, W	17.3 %

3.3 Extruder screw

Extruder screw is widely used in plastic industries for manufacturing of plastic component. Extruder screws basically inject plastic into mould and are subjected to abrasive wear once in operation. Hence to achieve higher wear life the screw is thermally coated with thermal spray coating technique.

3.4 Flame spray coating on extruder screw

Surface preparation: Operators clean the surface of the work-piece to remove greases, soils, oxides and other materials in preparation for application of the surface treatment. The operator typically uses solvents to clean the surface.

Surface Treatment: This stage involves actual modification of the work-piece surface including coating. Next, applying paint (paste) excluding coating area to prevent the metal striking on screw root in the case of screws. Further next, with the help of dissolved acetylene and oxygen gas we can achieve require high temperature for the heat treatment process. After achieving required temperature for heat treatment process, applying heat treatment to the coating area step for surface treatment process is to strike the metal on the object by the metal flame coating specialized by operator. Remove paste which applied earlier to prevent screw root surface.

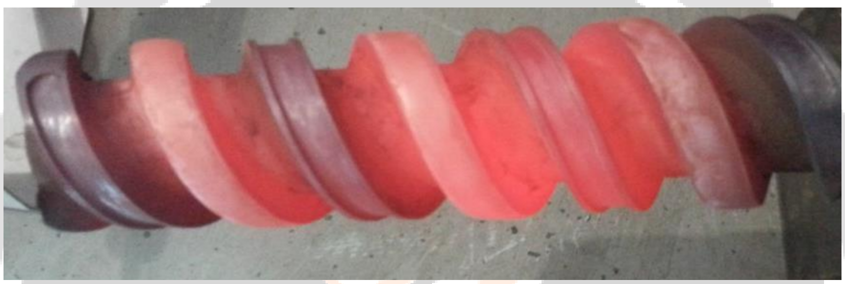

Fig – 2: Coating on extruder screw.

The following were the deposition prameters observed during the coating process.

Table – 2 Deposition parameters

Parameters	Value
Thermal spray gun	EWAC Superjet eutlloy
Spray distance	50 mm
Spray angle	90˚
Powder feed rate	63 g/min
Particle size	80-120 µm
Oxygen flux	1.5 bar, 22 psi
Acetylene flux	0.5 bar, 7.5 psi
Nozzle bore size	1.7 mm
Velocity	24 m/min
Normal force	10 N
Pre heat temperature of Substrate	600 Deg. C

The following were the result obtained

Table – 3 Results

Extruder screw detail	Unit
Screw Material	EN41B
Screw size	Dia. 52 mm
Screw length	1470 mm
Coating length	170 mm
Weight of Extruder screw before coating	26.000 Kg

Weight of Extruder screw after coating	26.240Kg
Weight of feedstock consumed during coating	500 grams
Dry film thickness	2 mm
Deposition efficiency	48 %
Time taken for coating	1 hr.

4. DESIGN OF EXPERIMENT

Taguchi has envisaged a new method of conducting the design of experiments which are based on well defined guidelines. This method uses a special set of arrays called orthogonal arrays. These standard arrays stipulate the way of conducting the minimal number of experiments which could give the full information of all the factors that affect the performance parameters. Which orthogonal array we choose is the most important factor in this desings of experiment.

4.1 S/N ratio and Analysis of variance

In Taguchi's technique a loss function was used to calculate the deviation between the experimental valu e and the desired value. This function further transformed into signal to noise ratio. Taguchi's philosophy includes three general ways to evaluate the relationship between quality and variability. They are: 'Nominal is better approach', 'Smaller is better approach', 'Larger is better approach'.

5. CONCLUSION

Form the extensive literature review the parameters which has influence on coating quality i.e. deposition efficiency, coating thickness & adhesive strength are identified. Some of these parameters are as follows.

- Standoff distance
- Substrate pre heat temperature
- Nozzle size (diameter of nozzle)
- Pressure
- Powder feed rate
- Spray angle

6. REFERENCES

[1] Introduction to thermal spray coatings by N. Espallargas.

[2] Current status and future directions of thermal spray coatings and techniques By P. Fauchais.

[3] G. Montavon, S. Sampath C.C. Berndt, H. Herman, C. Coddet, Effects of the spray angle on splat morphology during thermal spraying. Elsevier – Surface and coating technology 91 (1997) 107-115.

[4] J.R. Fincke, W.D. Swank, R.L. Bewley, D.C. Haggard, M. Gevelber, D. Wroblewski, Diagnostics and control in the thermal spray process, Elsevier – Surface and coating technology 146-147 (2001) 537-543

[5] Ming-Der Jean, Bor-Tsuen Lin, Jyh-Horng Chou. Design a fuzzy logic approach for optimization reinforced Zirconia depositions using plasma sprayings, Elsevier – Surface and coating technology 201 (2006) 3129-3138

[6] W.-Y. Li, C. Zhang, X.P. Guo, G. Zhang, H.L. Liao, C.-J. Li, C. Coddet. Effect of Standoff distance on coating deposition characteristics in cold spraying. Elsevier – Materials and Design 29 (2008) 297-304

[7] Alexander Kout, Heinrich Müller. Parameter optimization for spray coating. Elsevier – Advances in Engineering Software 40 (2009) 1078-1086.

[8] Z. Bergant and J. Grum, Quality Improvement of Flame Sprayed, Heat Treated, and re-melted NiCrBSi Coatings, Journal of Thermal spray technology – Springer 2008 JTTEE5 18: 380 – 391.

[9] R. Gadow, A. Candel, M. Floristan. Optimized robot trajectory generation for thermal spraying operations and high quality coatings on free-form surfaces. Elsevier – Surface and Coating Technology 205 (2010) 1074-1079.

[10] Shuo Yin, Qi Liu, Hanlin Liao, Xiaofang Wang. Effect of injection pressure on particle acceleration, dispersion and deposition in cold spray. Elsevier – Computational Material science 90 92014) 7-15.

[11] S. Luangkularb, S. prombanpong, V. Tangwarodomnukun. Material consumption and dry film thickness in spray coating process. Elsevier – Procedia CIRP 17 (2014) 789-794.