Application of thermal spraying process in advancement of welding Technology

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Abstract: In the contemporary world, with the incubation of advanced technologies and tremendous outbursts of research works, simplification of large cumbersome tasks with assets to saving time and money is perhaps one of the most crucial aspects in the current scenario. This paper focuses primarily on advancing welding technology using thermal spraying as the major tool for improving the cost, labor and time associated with some of the common welding processes. The analysis has been carried out on mild steel plates having the thickness of 3 mm & 4 mm thick. This has indeed provided multifaceted benefits such as weldability of similar and dissimilar metals keeping in mind the quality of welded joint, cost of operation and minimizing time for achieving optimum results etc. The study has also compared different welding processes to that of thermal spraying for achieving the same results based on well-defined parameters, as discussed in further sections. Ultimately, now with thermal spraying a plethora of processes can be accompanied such as coating, cladding etc, in addition to welding technology as well.

Keywords: Thermal Spraying; Oxy-acetylene Welding; BronzoChrome-10185; SEM; Microstructure

1. Introduction:
The primary factors influencing the credentials of any welding technology depends entirely on cost, time and labor associated with the particular processes. Although in some cases this may seem to be a herculean task to be accomplished, keeping the feasibility of the process in mind. However, with the incorporation of thermal spraying technology, welding of a variable material type has been made easier compared with the past processes such as Gas Metal Arc Welding, Shield Metal Arc Welding etc.[1-3]. Thermal spraying is a group of processes in which finely divided metallic and nonmetallic materials are deposited in a molten or semi molten state on a prepared substrate [4,5]. Among the various types of thermal spraying processes, major emphasis has been laid on the usability of flame spray process in our experimental research and analysis. The temperature of the flame spray varies around till 3200°C with a low particle velocity of around 110 m/s. The coating thickness varies from 5 mm- 10mm, keeping the spraying distance constant in the process.
For successful completion of the research project, a plethora of papers were comprehended in a detailed manner. Herman et al. tried to analyze the strength and variations of coating thicknesses of various thermal spraying cladded plates and sheets [6]. Similarly, Planche et al. tried to innovate the thermal spraying incorporating the plasma, flame and HVOF process [7].

2. Methodology and Experimentation
The major advantage of using Thermal Spraying for welding processes is that the application of heat input incurred on base metal can be optimized using thermal spraying. In more simple words, being low heat input process compared to other processes, resulting in low HAZ (Heat Affected Zone), this will inhibit grain coarsening leading to a higher strength of welded material [8,9].

The foremost step incubated in the process was majorly related to investigating the weld ability of the plates in this regard. However, as coating was not our aim here, hence we tried to optimize the spraying distance with major modifications for incurring a well-defined weld bead. The powder used for thermal spraying was mainly ‘bronzo chrom 10185’, a eutalloy of N-B-Si, suitable for metal-to-metal friction and corrosion resistance [10]. The above shows the concentration of Ni-B-Si-Al-Fe present on reaction with low Carbon steel on thermal spraying.

First, the bead profile using mild steel plates (4mm thick) was majorly obtained for 3 different samples with different spraying distances for optimizing our research work.

| SAMPLE TYPE | SPRAYING DISTANCE |
|-------------|--------------------|
| Sample 1    | 3-4 mm             |
| Sample 2    | 1-2 mm             |
| Sample 3    | 50 mm              |

By optimizing the spraying distance, the quality of weld bead was improved. Moreover, it was observed that at large spraying distances from weld bead, such as 50 mm or so, the thickness as well as width of weld bead was significantly increased. Figure 1 represent the microstructure of 3 different samples obtained on 100 X magnification.
For microstructure, etching was mainly done using NITAL (2% HNO₃ and 98% C₂H₅OH). Nital develops ferrite grain boundaries in low carbon steels (here mild steel) and thus produces contrast between pearlite and cementite or ferrite network ultimately helping us to further clearly observe grain boundaries under transformation.

Since the weld beads obtained with different samples helped us to examine the feasibility of the process. Hence, we accelerated our approach with obtaining welded joints using Mild steel and stainless steel plates. The mild steel plate used was low Carbon Steel 3mm thick plate and with stainless steel majorly 316-L was used for research analysis. Our major objectives included welding of two mild steel plates followed by two stainless steel plates and finally we had dissimilar plates for investigating the feasibility of the process.

Etching of mild steel in all the cases incurred was carried about using Nital as the major etchant and with stainless steel, predominantly two etchants that is, Carpenter and Picral was used for obtaining the microstructure.

**Designing of hopper for thermal spraying**

A metallic hopper suitable for regulating the powder flow, improving the durability and powder-output etc, were some prominent reasons for designing of hopper as shown in figure 2. Since low heat input is
incurred in Thermal Spraying, there is no possibility of melting of metallic hopper. The designing of metallic hopper was majorly done using the following:

1. Kitchen Storage steel jar (cylindrical with 3.42 cm radius)

2. Copper ring attached to the periphery and then welded to find support inside the torch.

3. Storage jar cap for optimizing, storing and mixing of different powders responsible for welding (if available)

![Figure 2. Designed Hopper attached with thermal spraying.](image)

3. Results and Discussions

Weldability of two mild steel plates was determined using thermal spraying as our broad objective (refer figure 3). 4 mm mild steel plate has been welded through thermal spraying by keeping the distance between the welded plates was kept to be 4 mm and spraying distance of around 10 mm for best optimization.

![Figure 3. Welding of 2 mild steel plates with a dominated weld zone](image)
For obtaining microstructure, mainly Nital was preferred, and 3 major surfaces were analyzed using Optical Microscope. This included the Weld joint-reinforcement, root enforcement and interface, HAZ (Heat affected Zone) and finally the base metal. The following figures depict the microstructure obtained for varied surfaces of the same specimen.

Microstructure Analysis

![Heat Affected Zone Mild Steel (M-200X)](image1)
![Weld Zone of Mild Steel (M-200X)](image2)

**Figure 4.** Microstructure of successful welded samples at different locations.

As evident from the microstructure, a lot of porosity has been found in the welded portions especially the interface and welded zone of mild steel plates. As evident from the figure 4, this may be due to several reasons such as high gas flow to cause O$_2$ or H$_2$ molecules to easily interact with the weld pool. Powder moisture or loose fittings in the gas hose from gas cylinders to the power house welding torch, gun etc. Figure 5 represent the Interface Zone of the welded sample.

![Interface Zone of Mild Steel (M-200X)](image3)

**Figure 5.** Interface Zone of Mild Steel (M-200X)
4. Conclusion

Welding using thermal spraying is entirely a new concept embedded with the newness and feasibility of the process compared to many other processes at stake. In simple words, as clear from Results and Discussions section, a significant amount of research strategies can be impregnated using thermal spraying, adding to the advantage of welding dissimilar plates is also very important in this regard. However, we must realize that there are many unturned objectives in the coming future which mainly includes: use of trolley or torch-fixer cart for keeping the spraying distance fixed, determining and advancing the compatibility of a powder with similar characteristics as to Bronzo Chrom (10185), optimizing the flame/gas velocity for getting well defined weld bead etc. These are some of the future endeavors that can be realized by scrutinizing more efforts with detailed research analysis in this context. Undoubtedly, a lot has been achieved especially combating to the very innovative idea of Welding – using Thermal Spraying.

5. References

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