SHORT ABSTRACT

The Cold Metal Transfer (CMT) process is a specialized welding technique used for cladding and coating, which involves applying a layer of metal onto a base material. In fact, CMT cladding is an efficient additive manufacturing technology that finds application in the automotive, defence, and power plant sectors. As Additive Manufacturing evolves, new welding methods have emerged, including CMT, an advanced version of Metal Inert Gas (MIG) welding known for reduced spatter and low heat input. CMT-based cladding processes have gained attention for improved aesthetics and lower heat input. Utilizing a wire as feedstock and a robotic arm for deposition enables precise material placement in complex shapes, with heat input determined by process parameters like voltage, current, wire feed speed, and stand-off distance.

In this thesis, the motivation is implementing the cost-effective method of surface modification of AA 6061-T6 aluminum alloy. For this, CMT process was used. The CMT cladding was conducted by depositing filler material to the aluminum substrate. Fe-based ER70S6 filler material was selected due to automatic welding, stable arc, low sputter, cost-effectiveness, and high deposition efficiency. In order to investigate the proper deposition different cladding bead was deposited and the best was selected on the basis of visual inspection. The formation of good metallurgical bond was observed between the former and latter. The formation of good bonding of added materials with aluminum substrate played a great role in improving surface properties such as microhardness, wear, tensile and shear strength.

The cladding layer corrosion behavior was studied through longer-duration immersion tests in 2.0% of H_2SO_4 acid solution, revealing considerable surface damage caused primarily by localized pitting corrosion. The pits grew more rapidly laterally than in the depth direction. Moreover, the corrosion test led to a decrease in the average micro-hardness due to the removal of hard materials and the introduction of porosity, resulting in a reduced load-bearing area at specific locations.

The impact of heat treatment on the cladded layer was investigated using four distinct methods. The first method involved heating the sample to 600°C for 1 h holding time followed by furnace cooling. The second method utilized water quenching after heating the sample to 600°C with a one-hour hold. The third approach entailed artificial age hardening, which included heating the sample to 175°C, holding it for 24 hours, and slowly cooling it in a furnace over six hours. Lastly, the deep cryo-treatment in liquid nitrogen (–196°C) for one hour. The cryogenic treatment exhibited the most significant improvement in the properties of the steel cladded parts manufactured using CMT technology. Water quenching came in second in terms of effectiveness, while furnace cooling demonstrated enhanced ductility but had a detrimental impact on tribological properties.

To study the effectiveness of layer thickness, cladding layers of 1.5 mm, 2.5 mm, and 3.5 mm were deposited on the substrate. Among these thicknesses, the 1 mm cladding layer yielded the most favourable results in terms of bead quality, exhibiting minimal dilution, reduced porosity, a low bead contact angle, and a relatively smoother surface. The 1 mm cladding layer also provided a fine grain structure, featuring enhanced low angle grain boundaries. The presence of a higher

number of such boundaries in the 1 mm cladding layer led to a higher dislocation density, which, in turn, contributed to improved mechanical properties such as hardness and wear resistance.

Overall, this research highlights the potential of CMT-based cladding processes for surface modification and the importance of selecting appropriate heat treatment methods to enhance the properties of cladded materials for various industrial applications.