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INFLUENCE OF FRICTION STIR PROCESSING ON MICROSTRUCTURAL PROPERTIES OF MATERIAL: A REVIEW

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Abstract-Friction stir processing is the noval and efficient technique to obtain homogeneous and fine structure. A cylindrical tool is used for the Friction stir processing without or with a pin. The tool rotates along with transverse speed and produces local heat on the surface of material under processing. Local heat produced by the tool motion, recrystallized grains of the material on surface. Rapid cooling along with processing decreased the growth of grains due to recrystallization which improves the microstructural properties. The microstructure produced by the processing is mainly equiaxed in stir zone resulting increase in microhardness. Resistance to erosion, corrosion, wear and other material degradation improves with refinement in the microstructure by friction stir processing. This paper summarizes recent research work which has been carried out to characterize microstructural behaviour produced by friction stir processing.
Keywords: Friction stir processing, microstructure, mechanical properties, wear.

1. INTRODUCTION

The degradation of materials, metallic or non metallic parts of the equipments used in various industries, i.e. transportation industries, aero space, process industries like coal burners nozzles, compressor blades, steam and gas turbines, boiler parts etc is big problem[1]. The research is carried out since long for the resistance to degradation of materials used in various industries as this increases the part as well as production cost. [1-5].

Wear between mating parts, abrasive and cavitation erosion, erosion-corrosion, solid particle erosion are the main processes due to which the machinery parts get degraded. This type of degradation is due to the friction between the mating parts and the low strength of the parent material surface. Surface modification by various methods is preferred to attain high the wear resistance [2, 6-9].

There are many surface modification techniques that used to enhance the wear resistance properties of material under process i.e. Hardfacing , Thermal spray coatings, Heat treatments, Friction stir processing [6, 10-12].

In this paper a detailed study of the friction stir processing has reviewed as this is a surface modification technique. Dynamic recrystallization of the surface of material under processing occurred due to local heating produced by rotating motion and transverse motion of tool along with downward force[13]. Grains of the processed zone are greatly affected by heating the surface. The refinement in the grain size improves mechanical and microstructural properties [14]. These properties greatly affect the resistance to degradation of machinery parts [15].

2. FRICTION STIR PROCESSING (FSP)

Friction stir processing is a newly immerged solid-state processing technique that has significant attraction for surface hardening through microstructural modification. FSP involves the use of a rotating tool having a shoulder with a pin inserted into a single piece of material and traversed along the desired path to cover the region of interest as shown in Fig: 1. [6, 16].

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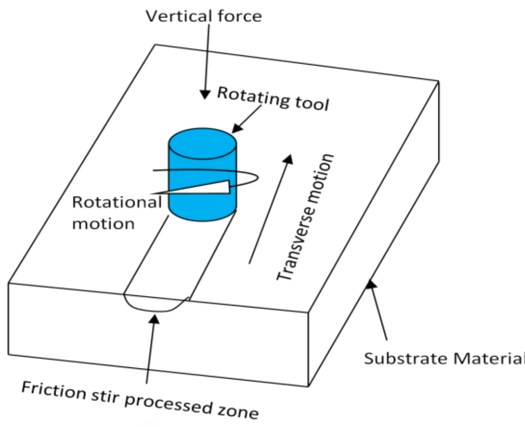

Fig: 1 Friction stir processing

The tool rotation and traveling speed produces friction between workpiece and tool pin accomplished by generation of localized heat. The heat produced by tool movement is capable of producing dynamically recrystallized fine microstructure. For improvement in the strength, ductility, hardness and fracture toughness properties, microstructural refinement is a unique technique which can be attained by friction stir processing [10, 17]. Friction stir zone and thermal cycles are influenced by the stiring parameters e.g. rotational speed and transverse speed [3, 10]. Increased rotational speed refines the microstructure at high extent. Heat input and strain rate are the factors that affected by rotational speed if transverse speed kept constant. With increase in rotational speed both heat flow and strain rate are increased. Increased in heat and strain rate promotes the grain refinement [18-20].

3. MICROSTRUCTURAL AFFECTS OF FSP

The stirring action generated by thermal and mechanical effects of rotating tool during FSP refines as cast microstructure by breaking up and refining the coarse grains to fine along with uniform distribution of each phases by the severe plastic deformation. Form the observations it reveals that stir zone has microstructure with fine equiaxed grains. This modifications result in improvement of mechanical properties of parent material surface [21, 22].

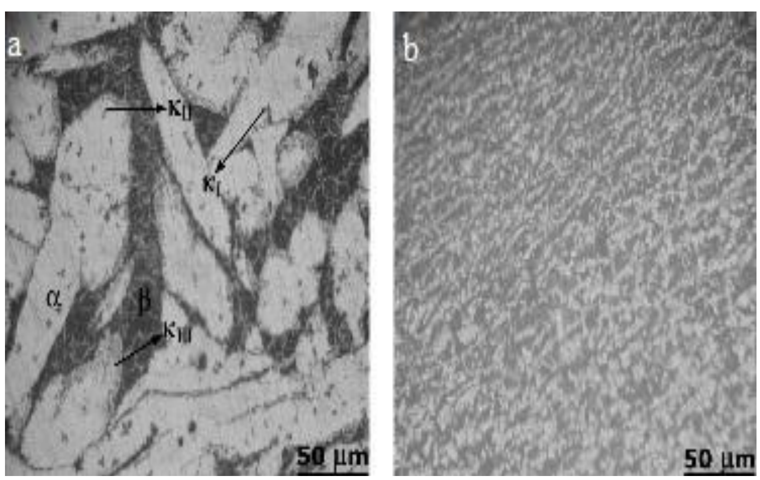

Fig: 2 Microstructure of a) As cast NAB alloy, b) FSPed NAB alloy. [21].

As in Fig: 2 show the nickel, aluminium and bronze (NAB) alloy with friction stir processed and as cast surface. It has observed that the microstructure of as cast NAB includes α, β and fine κ type structure. After friction stir processing the microstructure of surface gets deformed and recrystallized with fine microstructure. Homogeneous structure has produced with FSP as shown in Fig: 2 [21].

It also revealed from various researches that FSP increases microhardness of the surface as compared to as-cast surface of material as it constitutes of refined grained structure [3, 22].

4. EFFECT ON MECHANICAL PROPERTIES

The literature reveals that, at low tool rotational speed, the hardness in the regions near the surface in FSP sample increases five times as high as the hardness of the base metal [23, 24]. The hardness near the surface of FSPed sample is increased due

to the high degree of grain refinement [25, 26]. Martensitic structure produced in friction stir zone improves the microhardness value [27].
Tensile strength of the specimens reveals same as of base metal when tested by Chen, Y. C (2009) because fracture of all specimens takes from the base metal side due to higher hardness to the FSPed side [27].

5. WEAR BEHAVIOUR OF FSP

The effect of FSP on material loss can be observed by comparing the as cast and FSPed samples. The volume loss during wear testing is inversely proportional to the hardness of the surface [28]. The resistance to sliding wear reduces by increased hardness of the material surface [23, 29]. The hardness increased with decreasing the tool rotation speed during FSP [30].
Investigators find that grain refinement increases hardness along with ductility of the material [26] [22]. As a rule of thumb, wear resistance increased with increase in hardness. It seems from literature that reduction in grain size with FSP leads to increase in hardness of the material surface which improves the cavitation erosion resistance of the surface [23]. Mass loss of duplex stainless steel (DSS) through cavitation erosion observed 3.6 times higher than that of FSPed DSS as the incubation period for FSPed sample also increased by 200% as compare to BM and time for reaching maximum erosion rate was 16h as compare to 6h for BM [31].

6. CONCLUSION

1. Friction stir processing is a technique to improve mechanical and microstructural properties of material under processing without additional material alloys.
2. Refinement in grain size obtained by recrystallization through local heating of surface under friction stiring.
3. Grain refinement improves the microstructural and mechanical properties of the surface under processing.
4. Increase in hardness improves cavitation erosion resistance by increasing incubation time.

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