Mechanical Behavior of FSP process in the Aluminum Alloy 6061-5052 and 7075

Mohsen Soori

Department of Aeronautical Engineering, University of Kyrenia, Kyrenia, North Cyprus, Via Mersin 10, Turkey

E-Mails: Mohsen.soori@gmail.com, Mohsen.soori@kyrenia.edu.tr

Abstract:

Recently a Friction Stir Processing (FSP) technique based on friction stir welding (FSW) is used for microstructural modification of metallic materials. A review of Friction stir processing in the aluminum alloy of 6061-5052 and 7075 is presented in the study to analyze the recent development in the Friction stir processing welding technology. Different topics of the research work related to the Friction Stir Processing (FSP) is reviewed and presented. Therefore, it hopes that new ideas can be introduced by reviewing and analyzing recent achievements from published papers to develop the welding technology.

Keywords: Friction stir processing, Aluminum Alloy

1- Introduction

Friction Stir Processing (FSP) is developed based on the basic principles of friction stir welding (FSW), a solid-state joining process originally developed for aluminum alloys, is an emerging metalworking technique that can provide localized modification and control of microstructures in near-surface layers of processed metallic components. The FSP causes intense plastic deformation, material mixing, and thermal exposure, resulting in significant microstructural refinement, densification, and homogeneity of the processed zone. The FSP technique has been successfully used for producing the fine-grained structure and surface composite, modifying the microstructure of materials, and synthesizing the composite and intermetallic compound in situ.
Schematic diagram of friction stir processing is shown in the figure 1 [1].

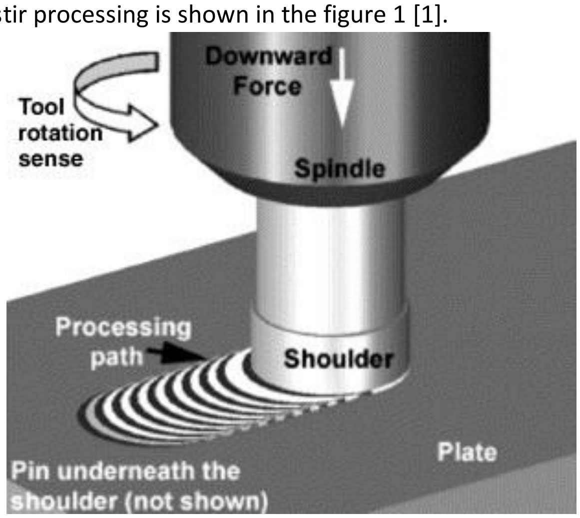

Fig. 1. Schematic diagram of friction stir processing [1].

Soori et al. provide virtual machining methodologies to assess and improve cnc machining in virtual worlds [2-5]. A review in advanced virtual machining systems is presented by Soori and Arezoo in order to increase the impacts of virtual simulation and analysis to efficiency enhancement of part production [6]. A review in machining induced residual stress in presented by Soori and Arezoo [7] in order to be analyzed and minimized. To minimize chord errors in 5-axis cnc milling operations of turbine blades, advanced NURBS interpolation algorithms is presented by Soori and Arezoo [8]. To analyse and modify the process of part production in virtual environments, virtual product development is presented by Soori [9]. Advances in Web-Based Decision Support Systems is presented by Dastres and Soori [10] to enhance the effects of web of data in decision support systems. A Review in Recent Development of Network Threats and Security Measures is presented by Dastres and Soori [11] in order to decrease the probability of accessing the secured data by the hackers. To analyze and modify the applications of the Artificial Neural Network Systems in different processing units, a review in recent development of Artificial Neural Network is presented by Dastres and Soori [12]. A review in advanced digital signal processing systems is presented by Dastres and Soori [13] to develop the capabilities and applications of signal processing in different industries.

Soori et al. provides a review of current developments in friction stir welding techniques in order to examine and improve efficiency in the process of component manufacturing employing welding procedures [14]. Soori and Asamel have explored implementations of virtual machining systems to reduce residual stress and deflection error throughout turbine blade five-axis milling processes [15]. Soori and Asmael created implementations of virtualized machining system in evaluating and decreasing the cutting temperature throughout milling operations of hard to cut components [16].

Soori et al. proposed an improved virtual machining method to improve surface properties throughout five-axis milling operations of turbine blades [17]. Soori and Asmael devised virtual milling techniques to reduce deflection error during five-axis milling processes of impeller blades [18]. Soori and Asmael provided a summary of existing developments from published articles in order to examine and improve the parameter optimization technique of machining processes [19]. Dastres et al. give a study of Radio Frequency Identification (RFID) based wireless manufacturing systems to improve energy utilization efficiency, data quality and availability across the supply chain, and precision and dependability during the component production process[20].

To develop the decision support systems in the data warehouse management, advances in web-based decision support systems is studied by Dastres and Soori [21]. To develop the applications of the artificial neural networks in different areas such as risk analysis systems, drone control, welding quality analysis and computer quality analysis, a review in recent development and applications of the systems is presented by Dastres and Soori [12]. Applications of the information communication technology in the environmental protection is presented by Dastres and Soori [22] in order to decrease the effects of technology development to the natural disaster.

A review of Friction stir processing in the aluminum alloy of 6061-5052 and 7075 is presented in the study to analyze the recent development in the Friction stir processing welding technology. Therefore, it hopes that new ideas can be introduced by reviewing and analyzing recent achievements from published papers to develop the welding technology.
Section 2 presents a review from classified research works related to different topics of Friction stir processing technology.

2- Review of different topics in the Friction stir processing technology for Aluminum alloy 6061-5052 and 7075

To analyze and develop the FSP process, different issues in the process are investigated. In this section, the topics are classified and presented.

2-1- Friction stir processing technology for Aluminum alloy 6061

Wear and mechanical properties of 6061-T6 aluminum alloy surface hybrid composites [(SiC + Gr) and (SiC + Al_2O_3)] fabricated by friction stir processing is presented [23]. Influence of addition of Gr_p/Al_2O_{3p} with SiC_p on wear properties of aluminum alloy 6061-T6 hybrid composites via friction stir processing is presented [24]. Influence of reinforcements (SiC and Al_2O_3) and rotational speed on wear and mechanical properties of aluminum alloy 6061-T6 based surface hybrid composites produced via friction stir processing is developed [25]. Improving the tribological characteristics of aluminum 6061 alloy by surface compositing with sub-micro-size ceramic particles via friction stir processing is investigated [26]. Hardness mapping of the cross-section of an Al–Al_2O_3 composite surface is shown in the figure 2 [26].

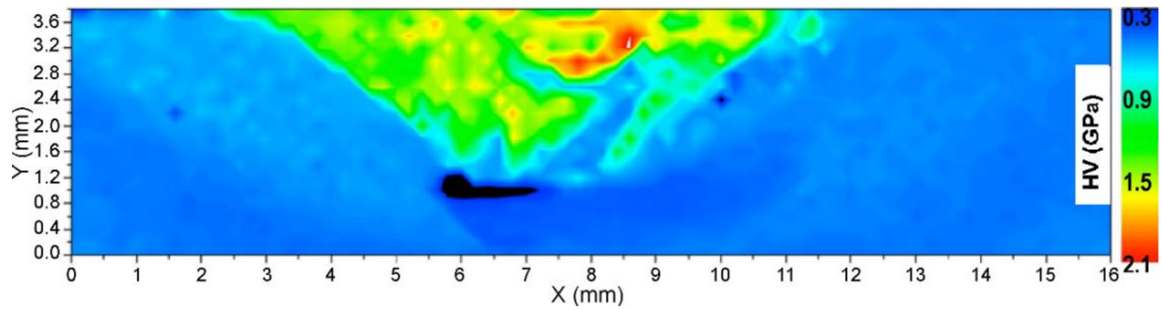

Fig. 2. Hardness mapping of the cross-section of an Al–Al_2O_3 composite surface [5].

Effect of friction stir processing with B_4C particles on the microstructure and mechanical properties of 6061 aluminum alloy is presented [27]. Angular distortion and through-thickness residual stress distribution in the friction-stir processed 6061-T6 aluminum alloy is presented [28]. Influence of the Tool Pin and Shoulder on Microstructure and Natural Aging Kinetics in a Friction-Stir-Processed 6061–T6 Aluminum Alloy is investigated by Woo et al. [29]. Influences of tool pin profile and axial force on the formation of friction stir processing zone in AA6061 aluminium alloy is presented by Elangovan et al. [30]. Internal defect and process parameter analysis during friction stir welding of Al 6061 sheets is presented by Ramulu et al. [31]. Texture analysis of a friction stir processed 6061-T6 aluminum alloy using neutron diffraction is presented by Woo et al. [32]. Process parameters optimization for enhanced microhardness of AA 6061/ SiC surface composites fabricated via Friction Stir Processing (FSP) is developed by Rathee et al. [33]. Effect of tool pin profiles and heat treatment process in the friction stir welding of AA 6061 aluminium alloy is presented by Prasanna et al. [34]. Preparation of nano surface layer composite $(TiB_2)_p$ on 6061-T6 Aluminum Alloy via Friction Stir Processing is developed by Kishan and Devaraju [35]. Optimization of process parameters for producing AA6061/SiC nanocomposites by friction stir processing is investigated by Salehi et al. [36]. Friction stir processing of Al6061-*SiC*-graphite hybrid surface composites is developed by Sharma et al. [37]. Surface layer modification of 6061 Al Alloy by friction stir processing and second phase hard particles for improved friction and wear performance is presented by Lorenzo-Martin and Ajayi [38]. Effects of Tool Rotating Rate and Pass Number on Pore Structure of A6061 Porous Aluminum Fabricated by Using Friction Stir Processing is presented by Utsunomiya et al. [39].

2-2- Friction stir processing technology for Aluminum alloy 5052

Reactive friction stir processing of AA 5052–TiO_2 nanocomposite for process–microstructure–mechanical characteristics is presented by Khodabakhshi et al. [40]. Pre-Treated Effect of Friction Stir Processing of Al Alloy 5052 on vibration fracture behavior under resonant vibration is presented by Huang et al. [41]. Microstructure and microtextural studies of friction stir welded aluminium alloy 5052 is developed by Kumbhar et al. [42]. Effect of

Dynamically Recrystallized Grain Size on the Tensile Properties and Vibration Fracture Resistance of Friction Stirred 5052 Alloy is developed by Huang et al. [43]. Effect of tool rotational speed on force generation, microstructure and mechanical properties of friction stir welded Al–Mg–Cr–Mn (AA 5052-O) alloy is presented by Moshwan et al. [44]. Friction stir welding procedure of 5052 aluminum alloy thin plate is presented by Guangchao et al. [45]. Friction stir welding of 5052 aluminum alloy plates is investigated by Kwon et al. [46]. Correlation between the Microstructure and Forces Generated during Friction Stir Processing of AA5052 is developed by Khraisheh et al. [47]. Effect of Prior Deformation on Tensile and Vibration Fracture Resistance of Friction Stirred 5052 Alloy is investigated by Huang et al. [48]. Correlation between the Microstructure and Forces Generated during Friction Stir Processing of AA5052 is investigated by Khraisheh et al. [49]. Effect of process parameters on microstructural and mechanical properties of friction stir diffusion cladded ASTM A516-70 steel using 5052 Al alloy is presented by Ibrahim et al. [50]. 3D profilometry images of the surface profile of cladded samples showing the effect of rotation speed is shown in the figure 3 [50].

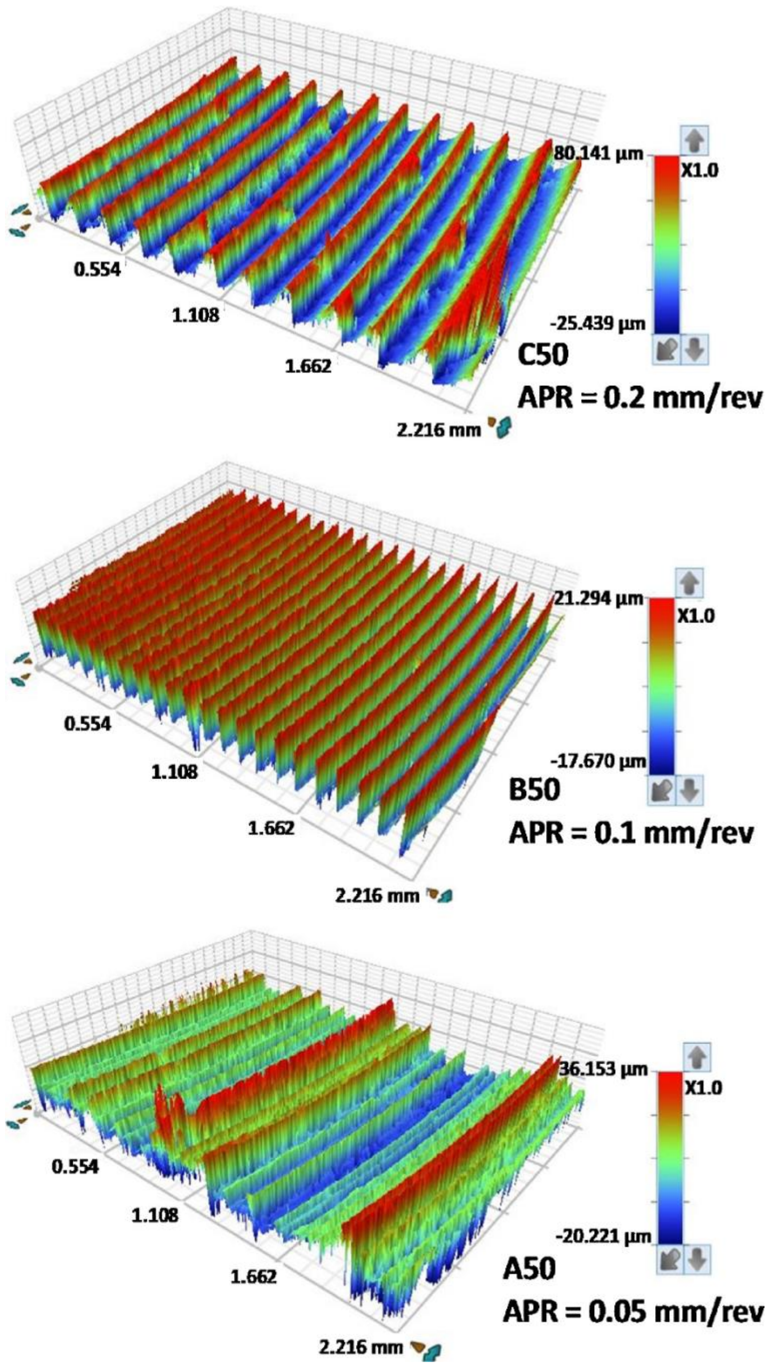

Fig 3. 3D profilometry images of the surface profile of cladded samples showing the effect of rotation speed [50].

Effects of process parameters on microstructural and mechanical properties of Al5052/SiC metal matrix composite fabricated via friction stir processing is investigated by Dolatkhah et al. [51]. The optimum combination of tool rotation rate and traveling speed for obtaining the preferable corrosion behavior and mechanical properties of friction stir welded AA5052 aluminum alloy is presented by Bagheri Hariri et al. [52]. Reinforcement of titanium dioxide nanoparticles in aluminium alloy AA 5052 through friction stir process is presented by Mathur et al. [53]. Influences of Tool Geometry on Metallurgical and Mechanical Properties of Friction Stir Welded Dissimilar AA 2024 and AA 5052 is investigated by Venkateshkannan et al. [54]. Neural network and genetic algorithm based modeling and optimization of tensile properties in fsw of AA 5052 to AISI 304 dissimilar joints is presented by Darzi Naghibi et al. [55]. A study on influence of underwater friction stir welding on microstructural, mechanical properties and formability in 5052-O Aluminium Alloys is presented by Babu et al. [56].

2-3- Friction stir processing technology for Aluminum alloy 7075

Multiple passes of friction stir processing for the creation of superplastic 7075 aluminum is presented by Johannes et al. [57]. High temperature deformation of friction stir processed 7075 aluminium alloy is developed by Cavaliere and Squillace [58]. High Strain Rate Superplasticity in a Friction Stir Processed 7075 Al Alloy is developed by Mishra et al. [59]. Friction stir processing of 7075 Al alloy and subsequent aging treatment is developed by Gholami et al. [60]. Deep cup forming by superplastic punch stretching of friction stir processed 7075 Al alloy is investigated by Dutta et al. [61]. Enhancement of wear and ballistic resistance of armour grade AA7075 aluminium alloy using friction stir processing is presented by Sudhakar et al. [62]. Fabrication of Al7075 / B4C Surface Composite by Novel Friction Stir Processing (FSP) and Investigation on Wear Properties is investigated by Rana et al. [63]. Friction Stir Welding of a Commercial 7075-T6 Aluminum Alloy is presented by Goloborodko et al. [64]. Formation of Al/B 4 C Al/B4C Surface Nano-composite Layers on 7075 Al Alloy Employing Friction Stir Processing is developed by Kashani-Bozorg and Jazayeri [65] to increase efficiency in process of part production. Effect of Friction Stir Processing on Pitting Corrosion and Intergranular Attack of 7075 Aluminum Alloy is investigated by Navaser and Atapour [66]. Superplasticity of a Friction Stir Processed 7075-T651 Aluminum Alloy is presented by Dieguez et al. [67]. Microstructure, surface chemistry and corrosion resistance in friction stir processing of aluminium alloy AA7075 is presented by Pang et al. [68]. Embrittlement Mechanism on Tensile Fracture of 7075 Al Alloy with Friction Stir Process (FSP) is presented by Ku et al. [69]. Dissimilar friction stir welding of 7075 aluminum alloy to AZ31 magnesium alloy using SiC nanoparticles is investigated by Tabasi et al. [70]. Experimental Investigation on Hybrid Friction Stir Processing using compressed air in Aluminum 7075 alloy is presented by Patel et al. [71]. Production and Characterization of Aluminium 7075 – T651 Alloy / B4C Surface Composite by Friction Stir Processing is presented by Ramesh and Murugan [72]. Characterization of the microstructure, texture and mechanical properties of 7075 aluminum alloy in early stage of severe plastic deformation is presented by Moghaddam et al. [73]. Friction stir modification of GTA 7075-T6 Al alloy weld joints: EBSD study and microstructural evolutions is investigated by Shamanian et al. [74]. Effect of microstructure on fatigue life and fracture morphology in 7075 aluminum alloy is presented by De et al. [75]. Microstructural evolution and mechanical properties during the friction stir welding of 7075-O aluminum alloy is presented by Dehghani et al. [76]. Influence of friction stir welding process and tool parameters on strength properties of AA7075-T_6 aluminium alloy joints is investigated by Rajakumar et al. [77]. Mechanical properties of 7075-t6 aluminium alloy surface hybrid composites synthesised by friction stir processing is investigated by Periasam et al. [78]. Grain refinement process in commercial 7075-T6 aluminum alloy under friction stir welding and superplasticity is studied by Motohashi et al. [79].

3- Conclusion

In the present research work, a review of Friction stir processing for the aluminum alloy of 6061-5052 and 7075 is presented. Different research works in the FSP process for the different aluminum alloy is presented to provide a review off resect achievement I in the research field. As a result, new ideas can be obtained from the reviewed paper in the study. The Non distractive Methods (NAT) can be applied to the welded parts using the FSP in order to increase quality of produced parts. Finite element analysis can also be applied to the simulated welding operation in order to increase performance of produced parts in actual working conditions. Also, the method can be combined to the other joining methods to crease a hybrid joining processes in order to increase efficiency in process of part production using the FSP. The ideas can be considered as future research works to develop the application of the FSP method in part manufacturing.

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