Development of friction stir spot joints between similar metals

Students: Ziyad Abdullah Al-Sulaiman and Khalid Abdullah Al-Makawni

Supervisors: Prof. Mohamed Zaky Ahmed, Dr. Kamel Touileb, Eng. Joffine Jose and Eng. Abdejlil Hedhibi

1st Semester 2021/2022

Graduation Project 2

Abstract:

Friction stir welding (FSW) process was invented and experimentally tested by The Welding Institute (TWI) in Cambridge, UK, in 1991 for joining aluminum alloys. Friction stir spot welding (FSSW) is a variant of FSW for spot welding applications that has been gaining ground when compared to mechanical bonding. Friction stir spot welding (FSSW) is a subset of the FSW with this difference that there is no linear motion in this process and it is used to make point bonding in thin sheets FSSW is a single spot joining process, in which a solid-state joining is made between adjacent materials at overlap configuration.

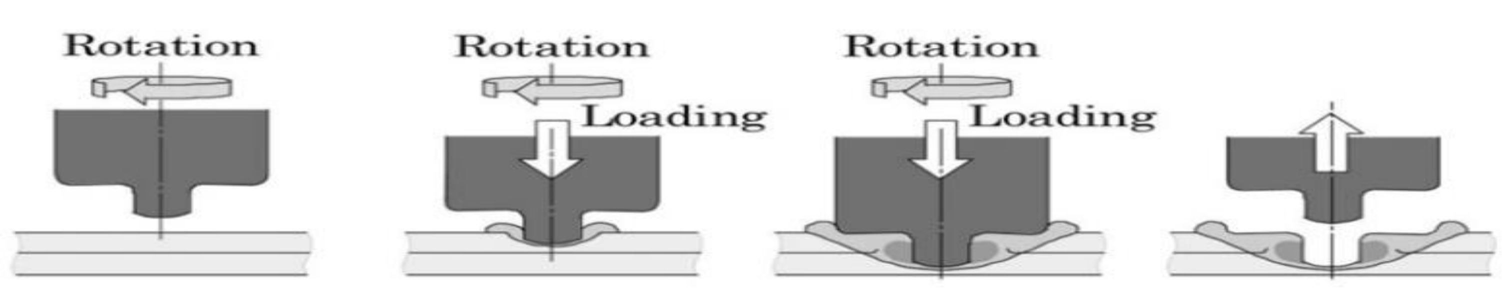
Objective:

In this project FSSW of similar aluminum was investigated in details using Taguchi approach. Analysis of variance was conducted to identify the effective parameters and their contributions on the mechanical performance. Tensile shear tensile strength, hardness measurement.

Principals of FSSW:

The method FSSW is divided into three steps: plunge, stir and retract.

The main process parameters are: rotational speed, plunge rate, plunge depth, dwell time.

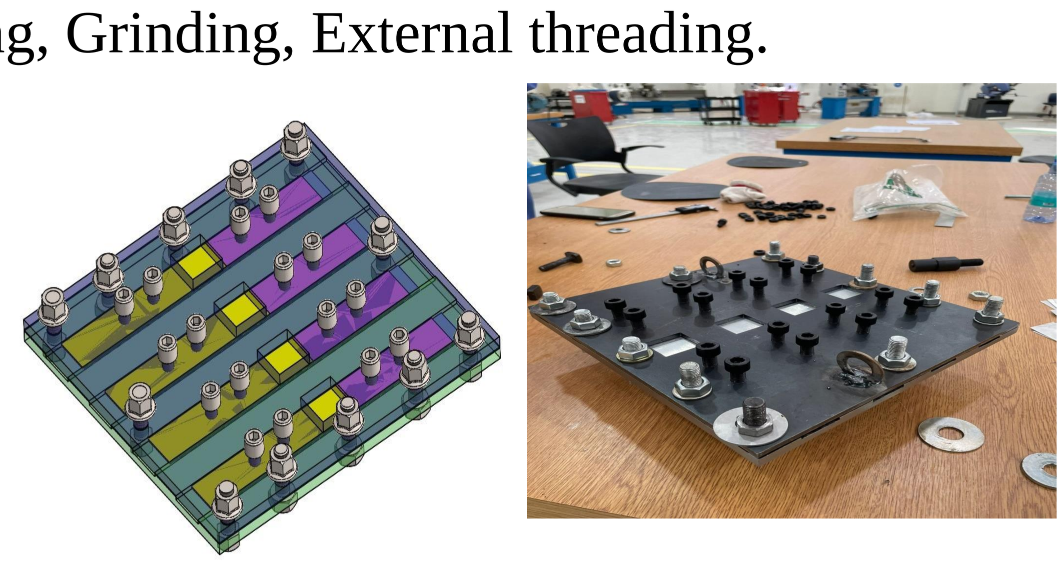


The FSSW process stages

Manufacturing FSSW tool and fixture:

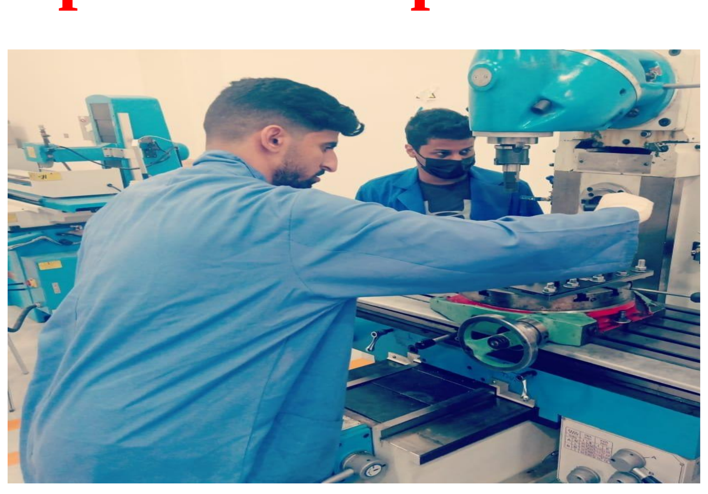
Major Machining Processes executed during realization of the bench test and tool are : Turning, Milling, Grinding, External threading.

FSSW Tool



Fixture system

Experimental procedure:



Fixing samples on machine

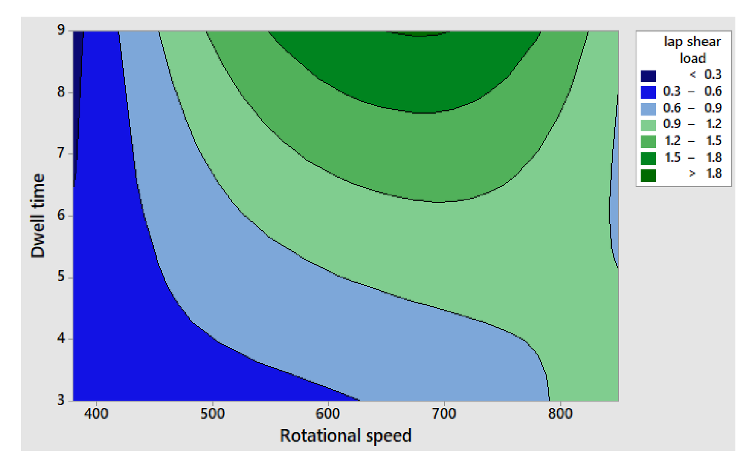
FSSW operation

FSSW specimen

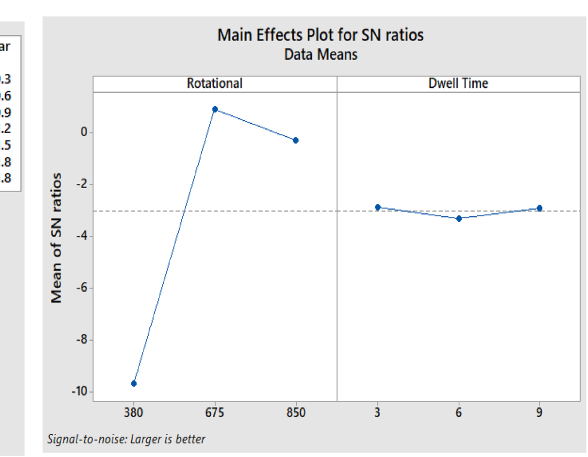
Results

Lap tensile shear load (LTSL)

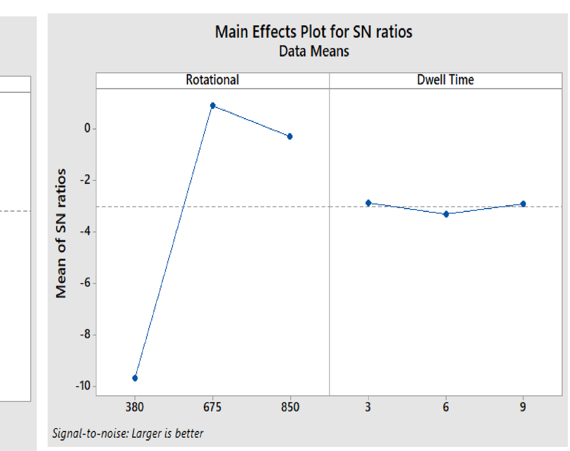
Level 2 for rotational speed (675 rpm) presents the highest value 0.9354.
Level 3 for dwell time (9 s) presents the highest value -2.8735.



Contour plot for Tensile shear



Main effects for Means



Main effects for S/N

ANOVA for LTSL

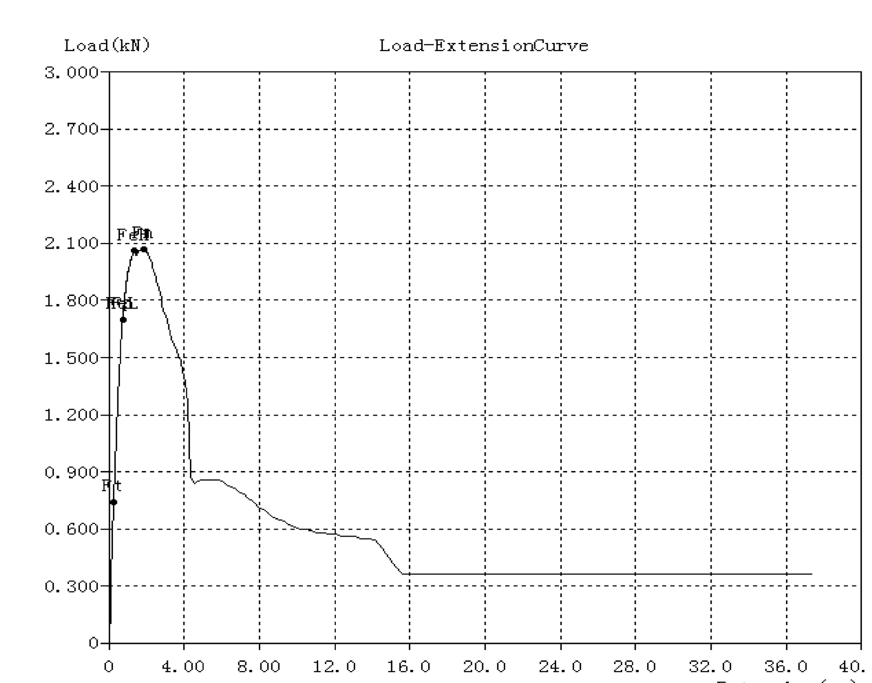
LTSL load is significantly influenced by rotational speed at level of 86.9%.

Confirmation test

The optimal condition was
R.T= 675 rpm, D.T= 9 s
The average **LTSL = 2000 N (2kN).**

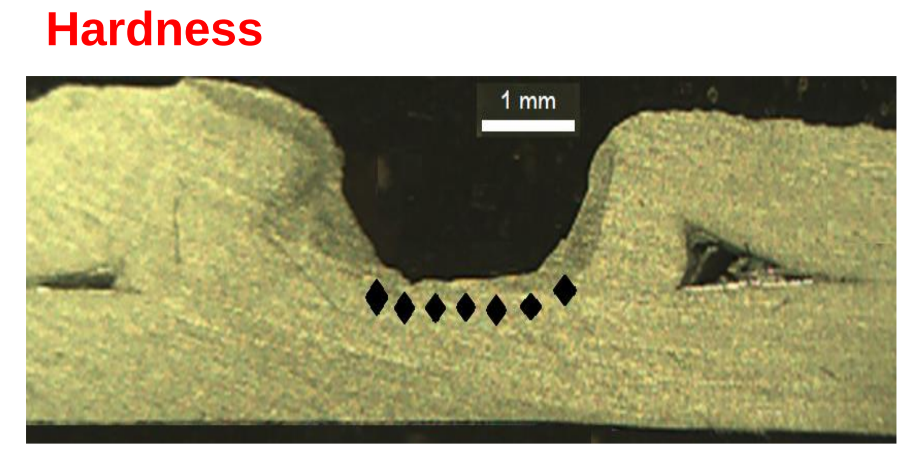
Before tensile shear test

After tensile shear test



Tensile shear test curve

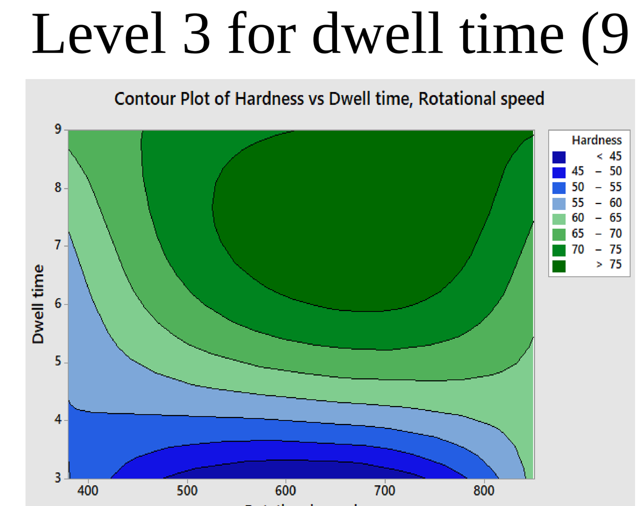
Hardness



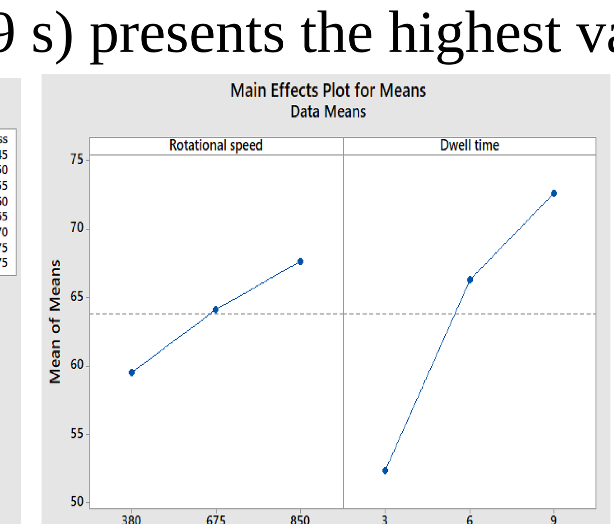
Hardness test zone

Microhardness test machine

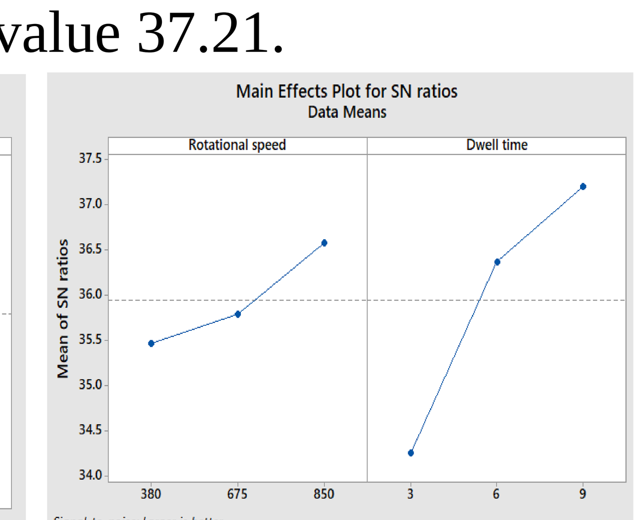
Level 3 for rotational speed (850 rpm) presents the highest value 36.58.
Level 3 for dwell time (9 s) presents the highest value 37.21.



Contour plot for Hardness



Main effects for Means



Main effects for S/N

ANOVA for hardness

The hardness is significantly influenced by D.T at a level of 73.84%.

Conclusions

- The Analysis of Variance for the tensile shear result concludes that rotational speed is the most significant parameter with a percentage of 86.9 %, followed by the dwell time of 13.1% while optimizing the lap tensile shear load.
- The Analysis of Variance for the hardness result concludes that the dwell time was the most dominant welding parameter with a contribution of 73.84 %. However, the influence of rotational speed is up to 26.16 %.
- The Taguchi method successfully maximized the response in LTSL to up 2000 N with R.T = 675 rpm and D.T= 9 s and hardness up to 76 HV with R.T=850rpm and D.T= 9s.
- It is recommended to widen the range of speeds to find out the best parameter combination and maximize the response.

Kingdom of Saudi Arabia, Prince Sattam bin Abdulaziz University, College of Engineering, Mechanical Engineering Department