Effects on S690QL high strength steel and thermal conductivity

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ABSTRACT

The hardness, corrosion resistance and thermal conductivity of Metal Inert Gas (MIG) welded S690QL at various parameters are investigated in this study. The structural steel S690QL is used in ship building, high rise building, bridges, off-shore structures etc where the hard impact and explosion are possible. The specimens of 50mm X 50mm X 5mm thick are extracted from long plate. The parameters considered to perform the MIG welding are Voltage (20V, 21V, 22V and 24V), current (100A, 105A, 110A and 115A), Welding speed (18 m/min, 19m/min, 20m/min and 21m/min). The Vickers hardness test results shows that the maximum reduction of 4.98% in hardness of the welded plate as compared to non-welded sample. The electro-chemical corrosion test is performed to study the corrosion resistance and it is observed that the maximum corrosion resistance is increased of 0.9% in corrosion resistance as compared to non-welded sample. The Thermal conductivity test is performed to study the thermal conductivity and is observed that the maximum thermal conductivity is decreased to 3.2% in thermal conductivity compared to non-welded sample .Finally the test results says that hardness and thermal conductivity decreases by 4.98% and 3.2% and corrosion resistance increase by 0.9% after welding.

1. INTRODUCTION

The last decades, high-strength steels (HSS), steel grades with a yield strength between 460 and 700 MPa (e.g. Eurocode 3 Part 1-12), have been used in civil, ship and mechanical engineering due to their increased strength properties to normal steel. That implies a reduction in the thickness and therefore in the weight of elements with a decrease in raw materials and energy consumption. Being equal the number of structural components considered the amount of CO.emissions decreases, both during processing and transport. Despite their advantages, the main obstacles to the widespread diffusion of HSS are their high cost and the lack of detailed design codes which, in turn, depends on the lack of proper experimental data. However, specific experimental campaigns like the one described in this paper can be carried out to understand the mechanical behaviour of HSS under static and dynamic regimes to contribute to their widespread applications. Several experimental studies in the static regime were carried out on HSS structural elements such as columns and stiffened panels]. For instance, in the case of offshore structures thermal conductivity can vary for wave loading, for ship collisions collisions and up to thousands of s^{-1} for blast effects. The influence of material only on the mechanical response of these materials has been formed.

S = Structural Steel

690 = minimum yield strength (MPa) Q = Qunching & Tempering

L = Low notch toughness testing temperature

2.MATERIALS AND METHODOLOGY

Samples welded using MIG welding

In this work we used S690Ql material for the tensile test and for the process. S = Structural Steel

690 = minimum yield strength (MPa) Q = Qunching & Tempering

L = Low notch toughness testing temperature

S690QL material is to be cut into the given dimensions and maintaining ASTM standards and the cut piece is to be bevelled both sides and after mig welding takes place both sides and maintaining temperatures, velocity, speed, feed rate, current.
The material is done for quality check and maintaining the exact quality

Type of chemical composition of S690QL														
C	**SI**	**Mn**	**P**	**S**	**N**	**B**	**Cr**	**Cu**	**Mo**	**Nb**	**Ni**	**Ti**	**V**	**Zr**
0.2	0.8	1.7	0.025	0.015	0.015	0.005	1.5	0.5	0.7	0.06	2	0.05	0.12	0.15

SAMPLE 0

SAMPLE 1

SAMPLE 2

SAMPLE 3

SAMPLE 4

Parameter	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**
Current	115A	110A	105A	100A
Voltage	24V	22V	21 V	20V
Welding speed	21m/min	20/min	19 m/min	18m/min
Wire dia	1.2	1.2	1.2	1.2

Table **1**

Sample-1: current 115A, voltage 24V, welding speed 21m/min[1-2]
Sample 2: current reduced to 110A, voltage 22V and welding speed to 20/min[1-2] Sample 3: Current reduced to 105A,voltage 21V and welding speed to 19m/min[1-2] Sample 4: Current reduced to 100A and voltage to 20V and welding

speed to 18m/min[1-2]

3. Vickers Hardness Test

Hardness test is a mechanical test used to measure a material's resistance to deformation under a specific load. It's a common method in materials testing, especially for metals, and provides valuable information about material properties like strength.

Principle is to indent a material with a precisely shaped diamond pyramid indenter and then measure the diagonals of the resulting square-shaped indentation[4] to calculate the Vickers hardness number (HV).

Surface is cleaned with the Emery paper (silicon carbide)

2kg load in this test allows deeper penetrations and tests on a wider range of material volumes, while lower loads are used for delicate, thin materials.[4]

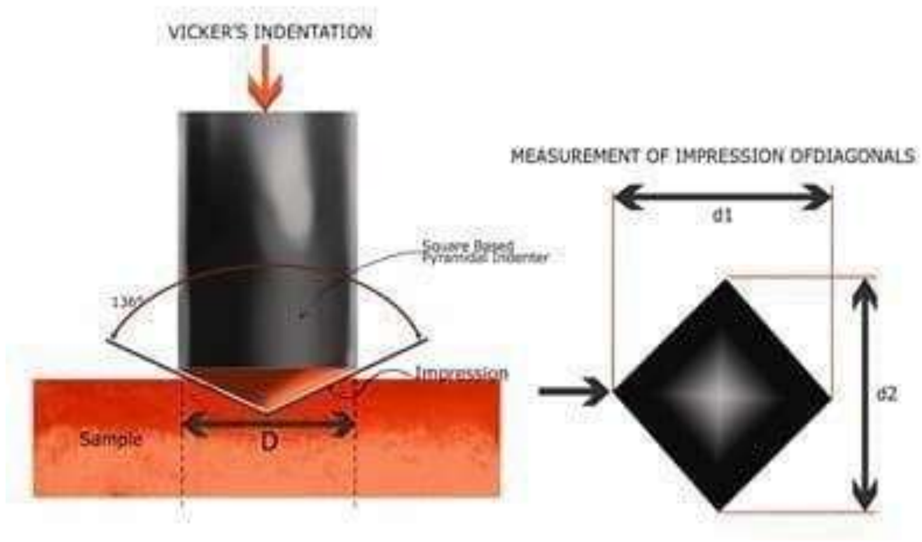
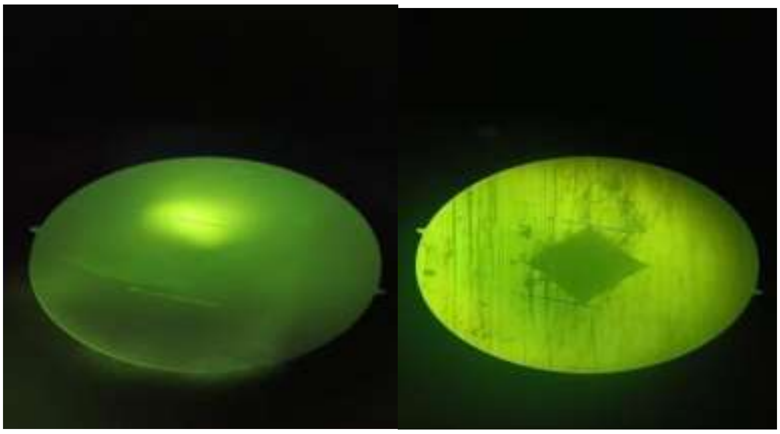


Fig a . Vickers Hardness Test specimen and measurement outlook



Figb. Diamond shape for the sample S690QL

3.1 Results

Before welding

Table 2

Sample	Load	Dwell Time	Value
0	2 kg	10 sec	301 VHN

After welding

Sample	Load	DwellTime	Value
1	2kg	10sec	293VHN
2	2kg	10sec	290VHN
3	2kg	10sec	288VHN
4	2kg	10sec	286VHN

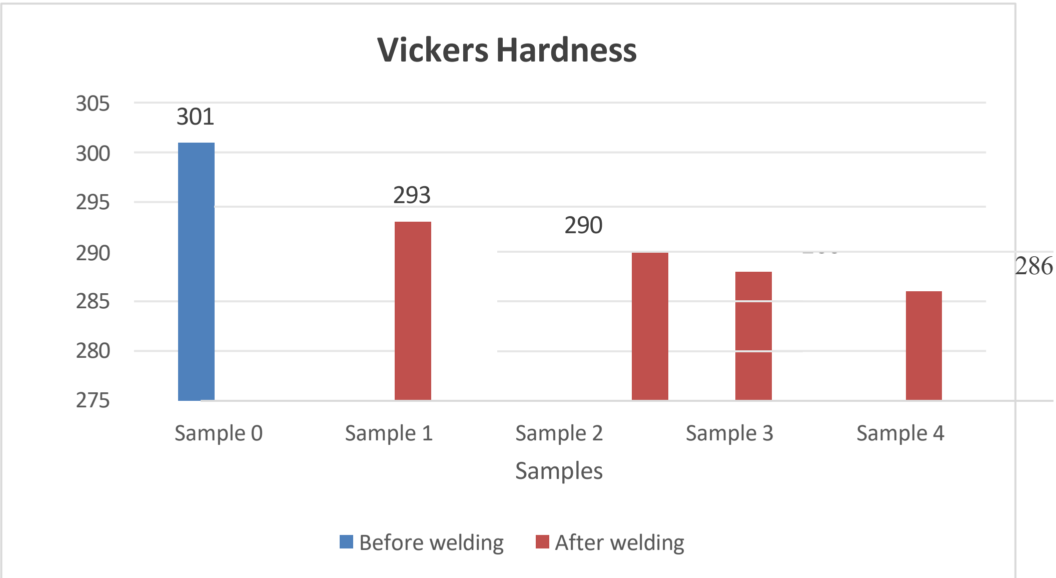


Fig.1 Vickers Hardness Number value variations

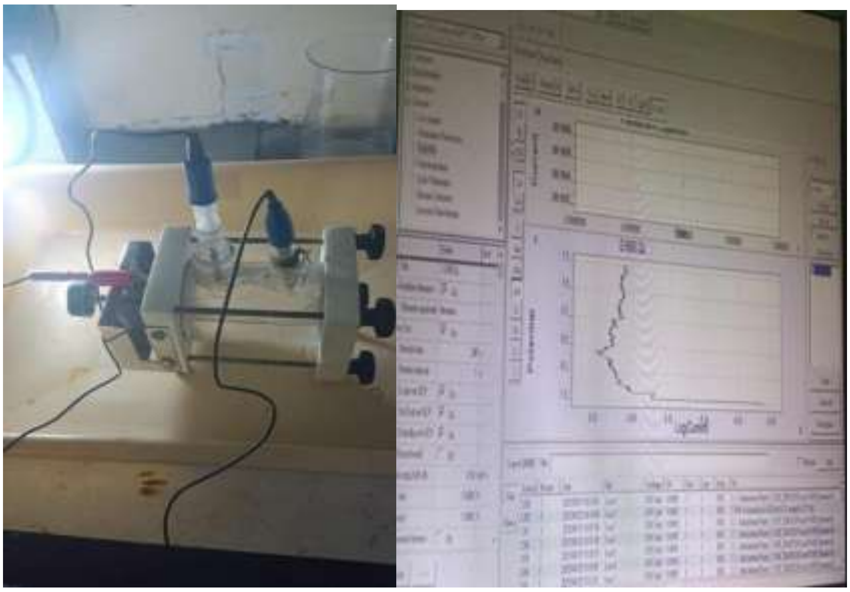
4. Electro chemical corrosion test

a. Electrochemical corrosion tests work by applying and measuring electrical current and potential between a test metal specimen (working electrode) and a reference electrode, immersed in an electrolyte solution

b. The metal sample (working electrode) is polished to a shiny, mirror-like finish using progressively finer grades of sandpaper to remove any oxides or rust.

d. The freshly polished sample is dried and should be used immediately for the electrochemical test to prevent re-contamination or re-passivation.

e. A corrosive electrolyte solution, such as a 3.5% sodium chloride (NaCl) solution, is prepared and allowed to stabilize before the test.
Make : IVIUM Model : VERTEX.C
Test : Gandhi Institute of Technology and Management (GITAM) (Deemed to be University) Visakhapatnam



Figb. Nacl chemical solution and apparatus

4.1 Corrosion Test results Before welding

Sample	E\V(Corrosion potential in volts)	1/UA(Corrosion rate in amperes)
0	-1	-0.1

After welding

Sample	E\V(Corrosion potential in volts)	1/UA(Corrosion rate in amperes)
1	-1	-0.103
2	-1	-0.105
3	-1	-0.107
4	-1	-0.109

Table 3

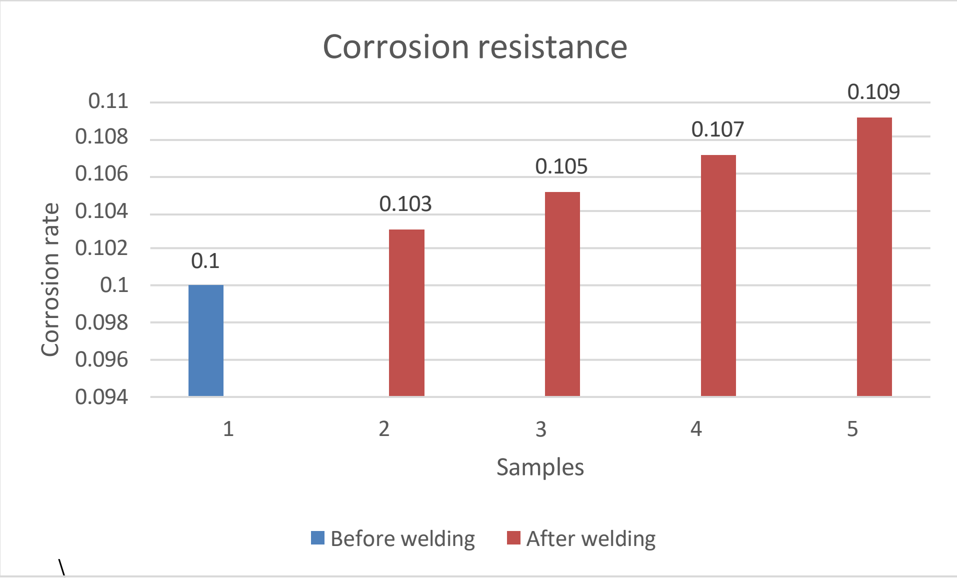


Fig2 .Corrosion resistance variations before and after welding

5. Thermal conductivity test

1.A thermal conductivity test measures a material's ability to transfer heat by applying a controlled temperature gradient across a sample and measuring the heat flow through it.

1. Placing a material sample between a heat source and a heat sink to establish a temperature gradient, then measuring the heat flow and temperature change over time until a steady state is reached.[6-7] C- THERM
Model : TRIDENT-920000
Test : Gandhi Institute of Technology and Management (GITAM) (Deemed to be University) Visakhapatnam

Fig.C Trident – 920000 C.Therm Equipment

5.1 Results

Before welding

Valid k(w/mk)	R^2 (coff of deremination)	Effusivity	1/m (per meter)	Temp
50.0	0.9896	22,937.9	386.2	26.7

After welding

Samples	Valid k(w/mk)	R^2 (coff of deremination)	Effusivity	1/m (per meter)	Temp
Sample 1	46.8	0.9565	18,526.2	324.4	26.7
Sample 2	46.3	0.9522	16,425.5	329.2	26.9
Sample 3	45.9	0.9541	15,525.7	325.2	26.6
Sample 4	45.6	0.9625	14,526.6	324.8	27.2

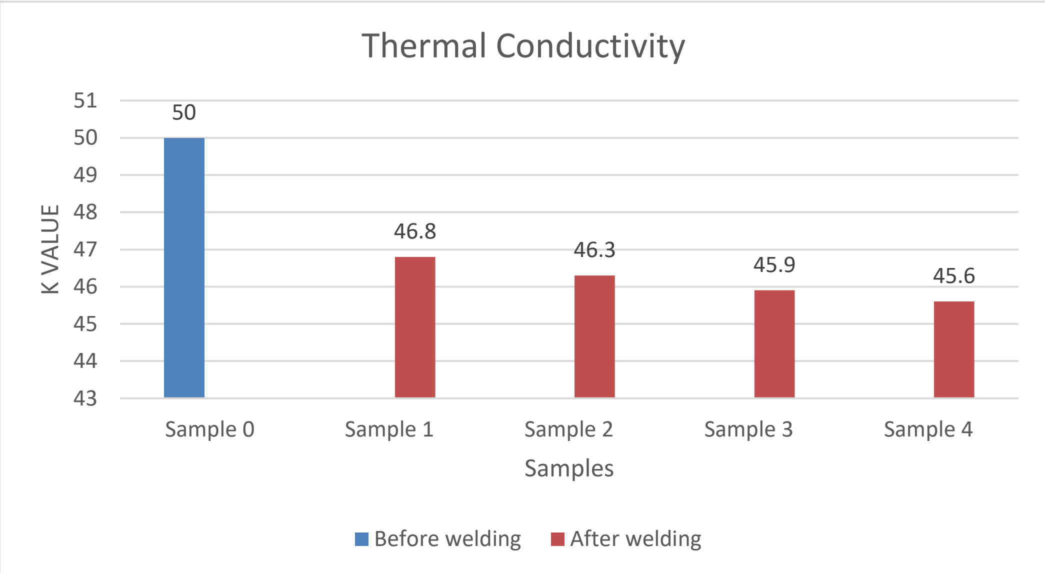


Fig 3. Thermal conductivity K value variations

6.CONCLUSIONS

Based on the findings from the tests the following conclusions can be drawn:

1. Hardness of the material decreased compared to before(301VHN) and after welding (289.25) by 4.98% due to the formation of a heat-affected zone (HAZ), which experiences changes in its microstructure and properties from the heat of the weld.

2. When less current is given to sample it gives more corrosion resistance to the material due to a low current density is a factor in maintaining a protective passive oxide layer on a metal surface.

3.Low thermal conductivity after welding is caused by changes to the material's microstructure, such as the formation of new phases, increased grain size, or structural defects like cracks and cavities within the weld joint and heat-affected zone

4.Thermal conductivity is low after welding the joints it reduces the transmission of heat or current fastly through the material and hence it reduces the effect.

5.In the context of submarines, S690QL steel, known for its high strength and weldability, would ideally be used for its low thermal conductivity. This property helps in maintaining a stable internal temperature within the submarine, especially when operating in varying external temperatures.

The findings demonstrate the potential of using S690QL material for welding purpose and the characteristics of the material pre and post weld treatment.

7.REFERENCES

[1] M. Jovanović, V. Lazić: Instructions for welding of high strength steel WELDOX 700, Faculty of Mechanical Engineering in Kragujevac, Belgrade/Kragujevac, 2008.

[2] D. Arsić: Estimates of weldability and selection of optimal welding technology for welding high strength steel class S690QL, MSc Thesis, Faculty of Engineering in Kragujevac, Kragujevac

[3] D. Arsić, M. Djordjević, V. Lazić, S. Aleksandrović, R. Nikolić: In Proc. of 19th International PhD. students' seminar SEMDOK 2014, Ed: P. Palcek, EDIS Zilina 2014, pp. 5-9

[4] Bandara,c,Siriwardane , S,Dissanayake,u,Dissanayake R,2016.Full range S-N curves for fatigue life evaluation of steels using hardness measurements. International Jornal of Fatigue 82,325- 331 doi-https://rddoi.org/10.1016/j.ijfatigue.

[5] Zhang, Chuntao, Hongjie Zhu, and Li Zhu. "Effect of inter- action between corrosion and high temperature on mechan- ical properties of Q355 structural steel." Construction and Building Materials 271 (2021): 12160

[6] Lu L, Yi W and Zhang D L 2001 3ωmethod for speci c heat and thermal conductivity measurements Rev. Sci. In

[7] B. Young, J. Chen, B. Uy, Behaviour of High Strength Structural Steel at Elevated Temperatures, Journal of structural engineering 132 (2006), 1948–1954