EFFECT OF NOTCH GEOMETRY ON THE FATIGUE LIFE OF UNS S32760 SUPER DUPLEX STEEL TIG WELDED JOINTS

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Abstract - *The objective of this activity is to evaluate the fatigue lifespan of parent material ('UNS S32760 Super Duplex stainless steel') and their TIG welded joints. And it is TIG welded joints' is evaluated on Nano Universal Testing Machine. The possibility of the plan also comprises comparison of the 'Fatigue life of the parent material and the TIG welded joints. The scope further includes performing Taguchi analysis on the results to obtain optimal parameters and finding the equivalent elastic loading for the obtained experimental life of parent material based on the finite element method approach using ANSYS*

***Key Words*: Fatigue Life, Notch, TIG (Tungsten Inert Gas) Welding, Nano UTS (Universal Testing Machine)**

1. INTRODUCTION

Machines are mechanical structures that use power to apply forces to control the movement and other components which we use in daily life, are often subjected to several forces encircled. The stresses and strains developed are sometimes periodic depending on the direction of forces. Though the magnitude of strain is below their yield limit but they cause failure when they are applied several times periodically. "If a material stays subjected to repeated series of stress or strain, failure occurs and that may lead the cracking on weak points and this type of a failure is termed as Fatigue".

1.1 Aim of the Activity

The aims are summarized as follows:

To perform TIG welding on raw material pieces, to perform LCF test runs on notch less S32760 specimen and analyse its behavior upon fatigue load conditions, to perform LCF test runs on notched specimens with various notch central angles (120°, 240° and 360°) and analyse its behavior upon fatigue load conditions, the scope also includes the prediction of UNS S32760 material fatigue life in ANSYS.

2. MATERIAL SELECTION

Super Duplex Stainless Steel of grade UNS 32760 has been selected for the present project. The material was procured from the market in the form of rectangular plate measuring (200*250*300) mm. The raw material was then made to undergo several cutting and machining processes before TIG welding was performed on the machined material. After the material was welded, it was sent for fabrication in CNC lathe. The material was then fabricated into ten specimens, of which nine were with notches and one without notch. All ten specimens were made of equal dimension i.e. 6mm diameter and 12.5mm gauge length so that these specimens can be embedded in the hub of Nano UTM easily

Fig-2.1 Pre welding

Fig-2.2 post welding

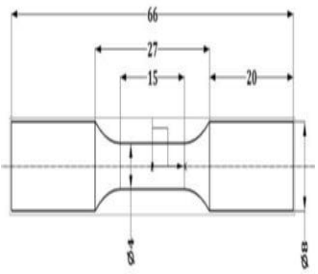

Fig-2.3 Specimen geometry

Fig-2.4post fabricated

Table- 2.1 Composition of UNS S32760 Super Duplex Stainless Steel in percentage (%)

Chemical analysis i	Cr	Mo	Ni	N	W
observed values	24	3	6	0.3	0.8
Minimum	24	3	6	0.2	0.5
maximum	26	4	8	0.3	1.0

Table- 2.2 mechanical properties

Mechanical properties	Metric
Yield point, Mpa	300
Tensile strength, Mpa	730-930

Bulk modulus, Gpa	166
Modulus of elasticity, Gpa	200
Strength at break, Mpa	425
Elongation at break, mm	25%
Poisson's ratio	0.3
Hardness (Brinell)	290Hb

3. FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) is a computer-based numerical technique for calculating the strength and the behavior of components, structures in various conditions. FEA is also used to find the stress, deflection, buckling behavior, vibration and various other phenomena ANSYS performed analysis is observed in the below pictures displaying the boundary conditions of the specimen tested on the fatigue machine to have its fatigue life. The pictures shown below give a clear idea of the Equivalent stress and the fatigue life of the specimen without notch and with notches

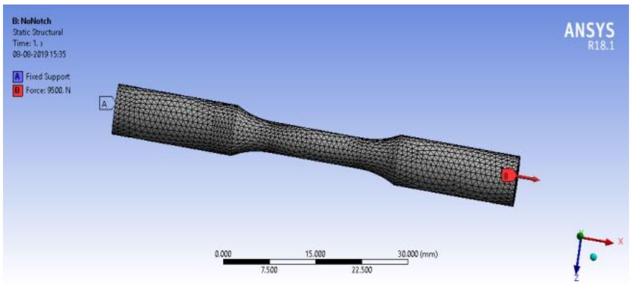

Fig 3.1 No notch specimen-1

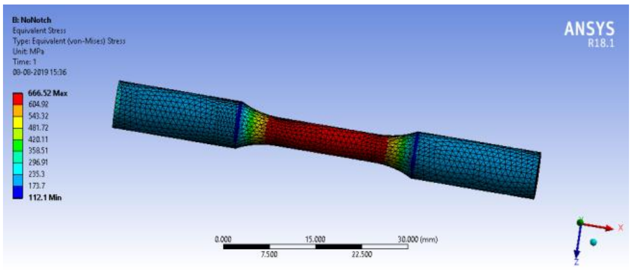

Fig 3.2 No notch specimen -1 Equivalent (von-Mises) stress

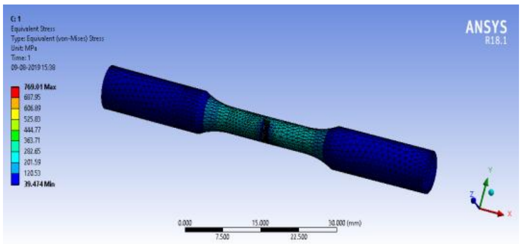

Fig 3.3 Specimen-1 with 120 notch Equivalent (von-Mises) stress

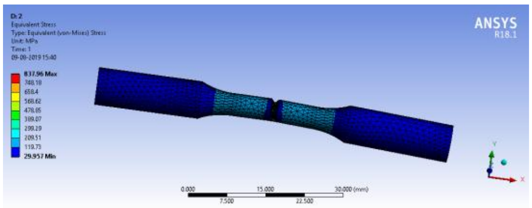

Fig 3.4 Specimen 2 with 240 notch Equivalent (von-Mises) stress

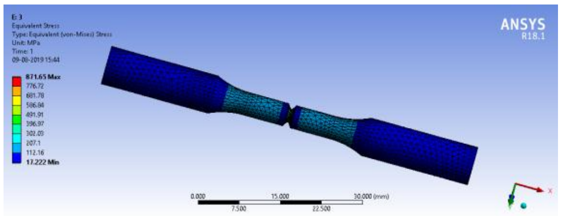

Fig 3.5 Specimen 3 with 360 notch Equivalent (von -Mises) stress

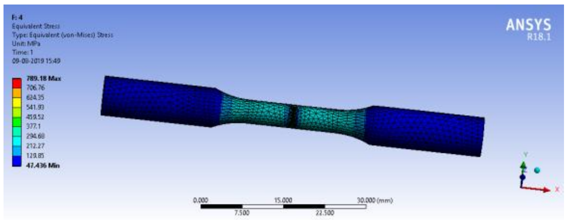

Fig 3.6 Specimen 4 with 240 notch Equivalent (von-Mises) stress

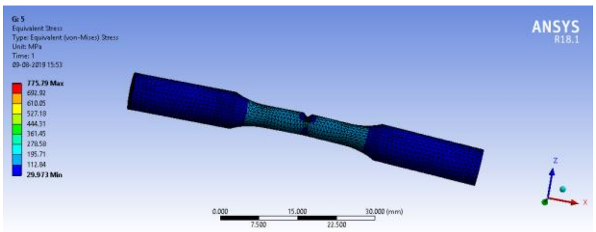

Fig 3.7 Specimen 5 with 120 notch Equivalent (von-Mises) stress

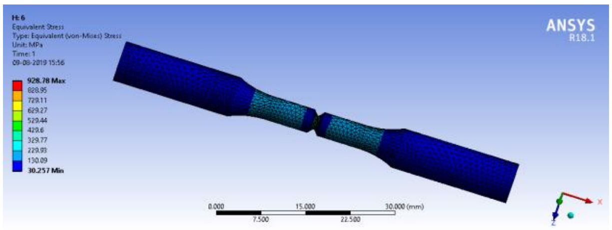

Fig 3.8 Specimen 6 with 360 notch Equivalent (von-Mises) Stress

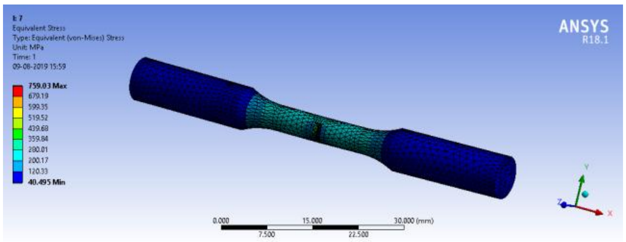

Fig 3.9 Specimen 7 with 120 notch Equivalent (von-Mises) stress

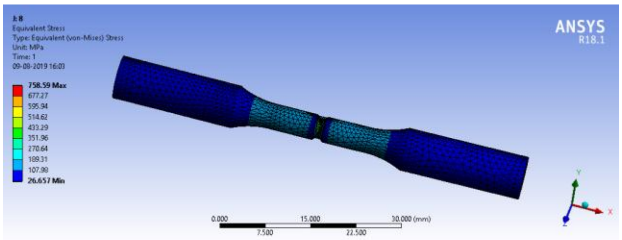

Fig 3.10 Specimen 8 with 240 notch Equivalent (von-Mises) stress

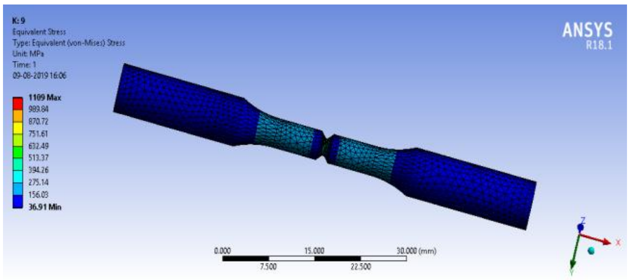

Fig 3.11 Specimen 9 with360 notch Equivalent Stress

4. EXPERIMENTAL REUSLT

The life cycles range 1≤ N ≤ 10^3, it is classified as "Low cycle Fatigue" and if it ranges N≥10^3 then it is considered as "High cycle Fatigue". Let us have an open study on Strain life method. To have a strain life prediction and to predict the tiredness lifecycle of a specimen we have a method called as ϵN method. ϵN method is a fatigue design method to estimate the amount of cycles to begin the tiredness crack using a rate of strain amplitude under "cyclic loading". The Fatigue test method uses "strain range instead of stress range" to have a tiredness lifespan of material. Mostly, it is used to model the "low cycle fatigue" when plastic strain range $\Delta\epsilon\rho$ and Elastic range $\Delta\epsilon e$ at critical are under seismic loads. This method is useful for estimation of crack initiation and propagation life of material. Through ϵN system, the "strain range" $\Delta\epsilon$ at critical location and its initiation life (N) is associated by "Coffin- Mansons" appearance presented in 1910, given below

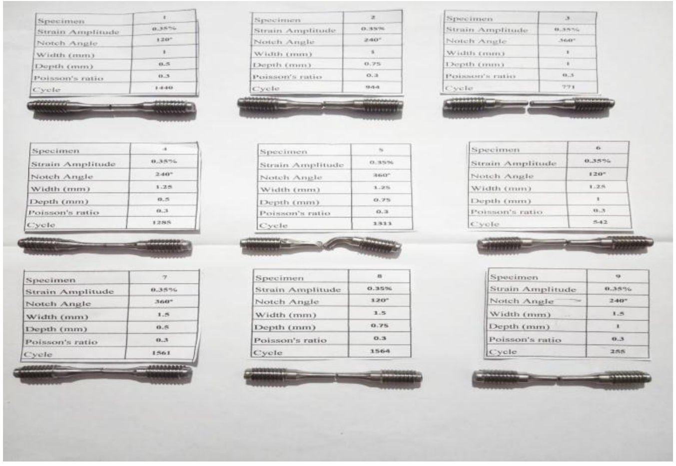

Fig4.1 Broken specimens with their life cycles

Table 4.1 Taguchi Orthogonal Array (L9) without Notches

Specimen with no Notch	Fatigue Life (cycles)		
	Trial 1	Trial 2	Average
	5918	5451	5685

Table 4.2 Taguchi Orthogonal Array (L9) with Notches and corresponding fatigue life cycles of parent material

S.no	Width mm	Depth mm	Notch angle	Trial 1	Trial 2	Avg
1	1	0.5	120^0	1440	1482	1461
2	1	0.75	240^0	944	1011	977
3	1	1	360^0	771	811	791
4	1.25	0.5	240^0	1285	1290	1288
5	1.25	0.75	360^0	1311	1507	1409
6	1.25	1	120^0	542	666	604
7	1.5	0.5	360^0	1561	1589	1575
8	1.5	0.75	120^0	1564	1581	1572
9	1.5	1	240^0	255	308	281

5. TAGUCHI DESIGN

To Create Taguchi Design and to create a robust parameter design to identify controllable factors in this research process that can minimize variation and make the product insensitive to alter in the factors. Taguchi design includes control factors, which are factors that one cannot control when the product or process is in use. Minitab provides two types of Taguchi designs. When you create a design, Minitab stores the design information in the worksheet and they are Static and Dynamic design data. The Taguchi results of the runs are depicted with the help of a graph below.

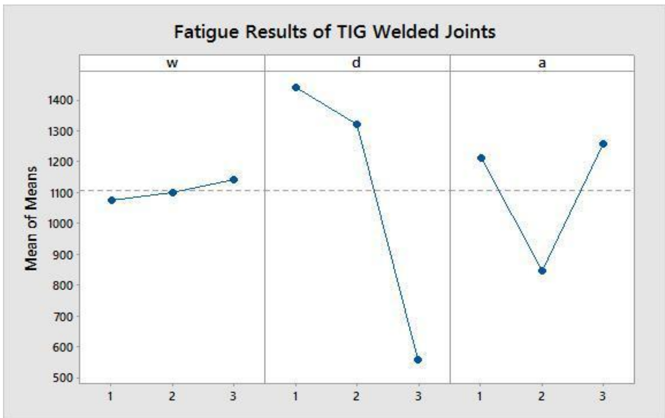

Fig 5.1 Taguchi result of TIG welded joints

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

From the experimental work undertaken and subsequent Taguchi analysis, it can be concluded that

1. Fatigue life drastically reduces with the introduction of notch on the specimen. The maximum fall was to the tune of around 84%.
2. Fatigue life of notched members of UNS S32760 Super Duplex steel increases as the width of the notch increases, depth of the notch decreases and notch central angle increases.
3. Width and notch central angle have marginal impact on the fatigue life reduction. However, when the angle was 360˚ irrespective of the depth and width of the notch, there was considerable reduction in the fatigue life.
4. For a given fatigue life cycles, Murlidhar- Manson's method gives higher strain amplitude when compared to the experimental runs.

6.2 Scope for Future Research

1. This scope of experiments on UNS S32760 can be increased by selecting higher order Taguchi designs for the notch geometry. One can arrive at accurate conclusions if full factorial design is selected.
2. The scope of research can be expanded by selecting other types of welding apart from TIG welding like Metal Inert Gas Welding, Plasma Arc welding etc.

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