Journal of Advances and Scholarly Researches in Allied Education
Vol. 16, Issue No. 1, January-2019, ISSN 2230-7540

Analysis of Strength Parameter of Welded Joint Using ANSYS Workbench

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Abstract – Failure of welded systems or components causes various direct losses, such as repair costs, job costs to ensure that there is no imminent failure and insurance for injuries, and production loss. In any structure / machine, joints as the weakest element can first fail. We design welded joint in CAD software using Solid work and then import the joint assembly In ANSYS for analyses strength parameter of welded joint using mild steel and weld material is Al6061 and did Gas metal arc welding (GMAW) on them and perform fatigue testing so that, we applied the load conditions at which these joints having stress and deformation, fatigue life, and damage of joint by variation in weld bead thickness from 3 mm, 4mm and 5 mm. The whole analysis will be done with the help of 'ANSYS workbench' and will analyze their performance curves and results.

Keywords: Strength Parameter, Fatigue Testing, CAD, ANSYS, Mild Steel, Butt or T-Joints.

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I. INTRODUCTION

Steel structures include different joining strategies including welding, which is utilized for some reasons. This is identified with the necessary time for the procedure execution and furthermore identified with the moderate expense with great dependability. These structures are oppressed during their life cycle, to variable burden parts because of the outer condition, (for example, wave and wind sway). Presenting the welded joints in structures exposed to fatigue loads makes a test to safeguard the structural strength. This circumstance needs superior information on fatigue conduct of the welded joints. Evaluating this conduct utilizing the fatigue tests is the most solid strategy; in any case, it requires a huge interest in time and assets, which make this arrangement not reasonable for a vast dominant part of mechanical entertainers in steel construction. Welding is a process that combines materials by heating them at reasonable temperatures with or without weight utilization or by using weight alone, and using or without filler material. Welding is used for the creation of permanent joints. It is used for vehicles, ships, rail cars, structural works, tanks, furnishings, boilers, general fixed works and ship buildings. It also is used for assembling car bodies. Welding is manufacturing or sculptural technique, which blends materials regular metals or thermoplastic, for example brazing and patching that do not liquefy the base metal by a mixture that is unmistakable from lower-temperature metal connection systems. Regardless of softening the base metal, the joints are periodically filled with the filler material forms a layer of fluid material (the weld reservoir) that refreshes to create a joint that is as solid as the base material. Weight can also be used in warmth or without the input of anybody else to create a weld.

II. NEED FOR WELDING

The increasing demand for both high production rates and high accuracy has led to the provision of fully machined or automated welding processes. The pace at which automation is implemented in the soldering process is incredible and more automated machines than men in manufacturing units are expected to be found by the end of this century. Computers often play an important role in the operation of automated solder processes and the commands generated by the computer are derived from programs. Such programs require algorithms in the form of mathematical equations for the welding variables. To allow efficient use of the automated systems, a high degree of confidence is necessary for the prediction of soldering parameters in welded joints to achieve the required mechanical strength.

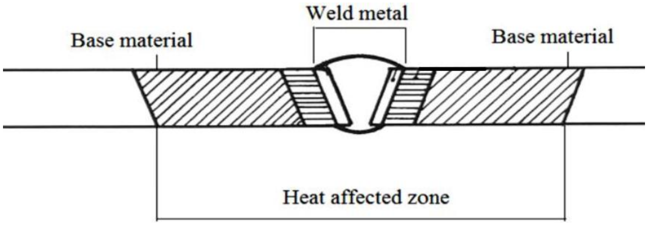


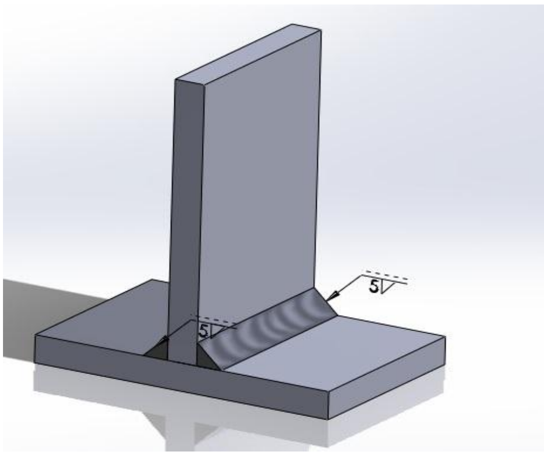
Figure 1: Weld Zones

- **Welding classes**

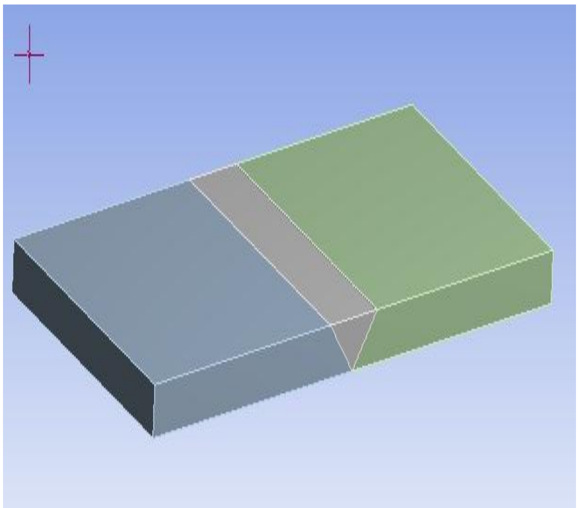
B, C and D are general grades of solder. The solder class shows how many errors the weld has and how the base material components both inside and outside have been misaligned. Welding class B is the lowest misalignment level which needs post-treatment in theory. Class B is used in high stresses of fatigue, high risk areas and fracture risk. Following welding Class C requires no post-treatment. It takes less time than class B. BT Products standard for welding class C. Class D is used in non-high load welds.

III. MODELLING OF WELDED JOINTS

The first step in the simulation is to change the geometry so that a few bad parts are produced. Mild steel and weld Filler materials used Al 6061 were the actual material of the welding model used, the simulation material was chosen as a mild steel because it matches the most mechanical properties and is accurate enough. For the meshing process, the element type Hex dominant is used. It ensures that Hex elements but also other elements are preferably used for this approach to fill as well as possible the lack of geometry. The initial thickness size is fixed at 3 mm, 4 mm and 5 mm per part. The size of the elements is changed to verify the adequacy of the elements after the problem is solved. The present work has modeled various sets of geometrical assemblies. The first set is a simple' T' joint design, which is defined in the figure using the solid work and plate dimension. Secondly, assembly butt joint was designed. The thickness of the bead ranges between 3 mm, 4 mm and 5 mm.



(a) Welded 'T' joint



(b) Welded butt joint

Figure 2: Weld joints

- **Dimensions of joints**

Two plates are joined together by weld process. Plate size is 150 mm × 80 mm ×4 mm thick for butt joint. There is a chamfer provided by 45^{o}, chamfer of 4mm × 4mm & 4mm thick. Dimension of 'T' joint plate is 150 mm × 80 mm ×4 mm thick three plate joined by weld process to form a three shape. Weld bead having variations to its thickness.

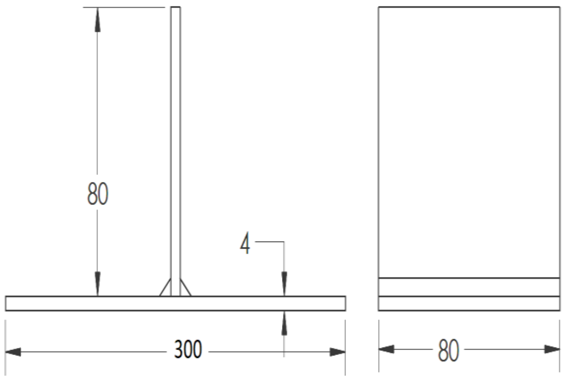


Figure 3: Dimensions of 'T' joint

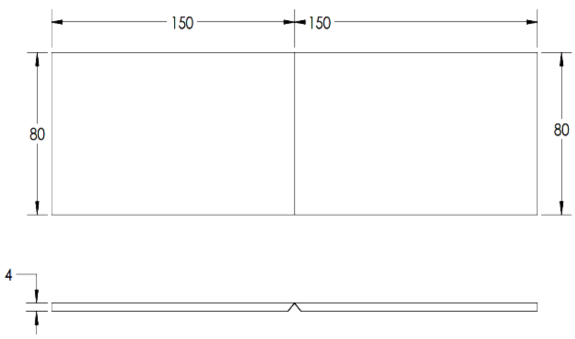


Figure 4: Dimensions of Butt joint

IV. MATERIALS AND METHODS

Mild steel and Aluminum 6061 considered as material in present study. Mild steel material considered for metal plates and Aluminum 6061 welding material considered for joining the plates by welding process. Properties of material are described below.

Table 1: Material properties

Parameters	Mild steel	Al6061
Density (Kg/m^3)	7860	2700
Young's Modulus (MPa)	2.1×10^5	69000
Poisson's Ratio	0.303	0.33
Bulk modulus (GPa)	177	67
Shear modulus (GPa)	80	25
Yield Strength (MPa)	370	55.15
Ultimate Tensile Strength (MPa)	440	124

The methodology adopted for static finite element analysis of the welded joints in ANSYS. Furthermore; boundary conditions, meshed models, and results of welded 'T' joint and butt joint are discussed. While welding has many distinct benefits over other joining processes, it suffers from several major drawbacks, such as residual stress evolution and solder distortions. The results of welding input conditions can be easily estimated by minimum experimental cost using simulation methods such as the Finite Element Method. A research was conducted to predict the complete transient temperature fields of a Mild steel plate's base, in a 3D finite element model.

V. RESULTS AND DISCUSSION

Results have been presented in the form of total deformation, stress and strain generated under the load value considered. Fatigue analysis performed on 'T' joint and butt joint and optimized factor of safety and fatigue life. Both joint having three type of model in variations of weld bead from 3mm, 4mm & 5mm. In present study two types of fatigue loading applied first one is fully reversed loading and secondly zero-based loading.

Weld joints deformation analysis performed by applying 1000N load on the top of surface of 'T' joint and horizontal plate fixed by both sides. Also, for butt joint one end of plate kept fixed and vertically downward load of 1000 N applied at the other end of plate. Then fatigue analysis formed for optimized stress and deformation of welded joint, after, results compare the data for optimization of welded joint strength.

Strength Analysis of Welded Butt joint in ANSYS

► Results of Welded Butt joint at 1000 N Fully reversed Cyclic load at 3 mm Thickness of Weld bead

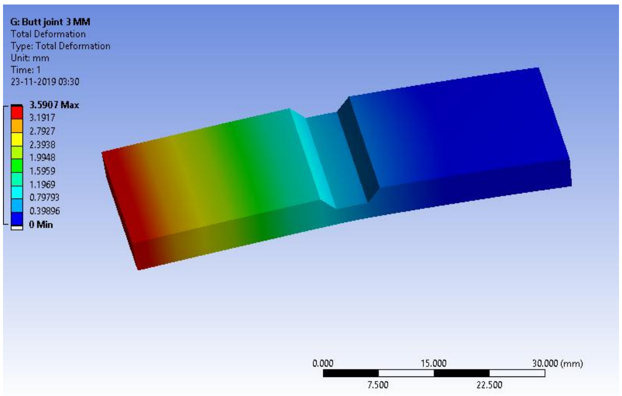


Figure 5: Total Deformation of Butt joint at 3mm thickness

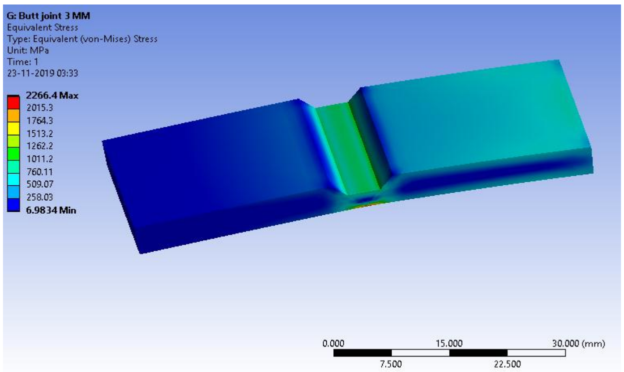


Figure 6: Equivalent Stress of welded plate at 3 mm thickness

► Results of Welded Butt joint at 1000 N Fully reversed Cyclic load at 4 mm Thickness of Weld bead

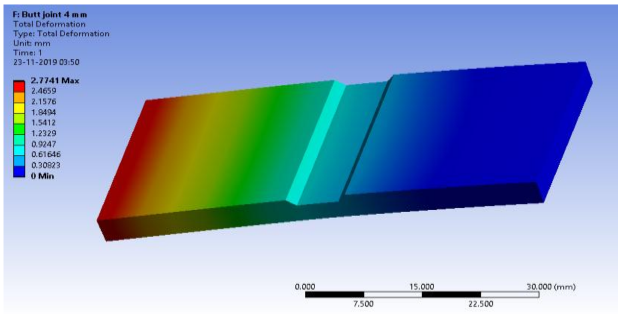


Figure 7: Total Deformation of Butt joint at 4 mm thickness

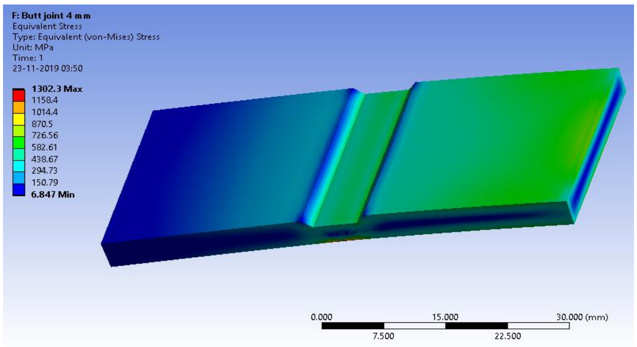


Figure 8: Equivalent Stress of welded plate at 4mm thickness

► **Results of Welded Butt joint at 1000 N Fully reversed Cyclic load at 5 mm Thickness**

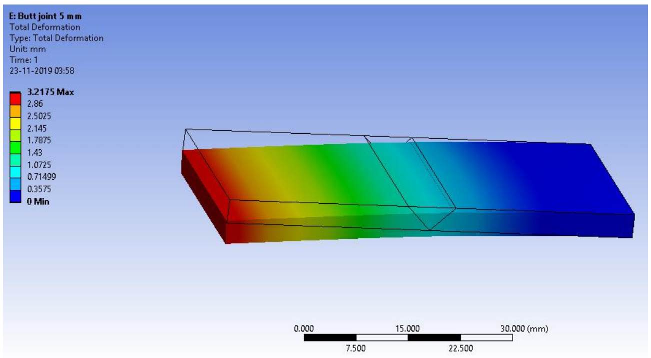


Figure 9: Total Deformation of Butt joint at 5 mm thickness

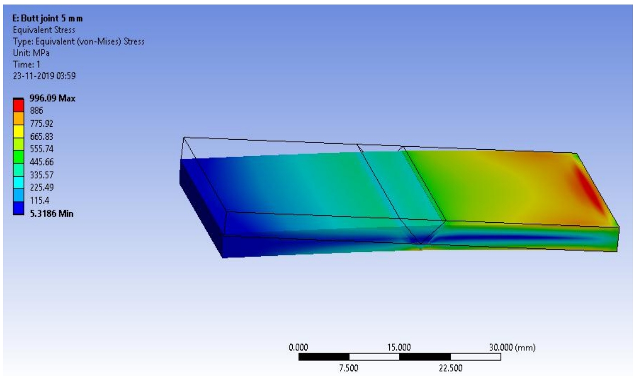


Figure 10: Equivalent Stress of welded plate at 5 mm thickness

7.1.2. Strength Analysis of Welded 'T' joint in ANSYS

► **Results of Welded 'T' joint at 1000 N Fully reversed Cyclic load at 3 mm Thickness of Weld bead**

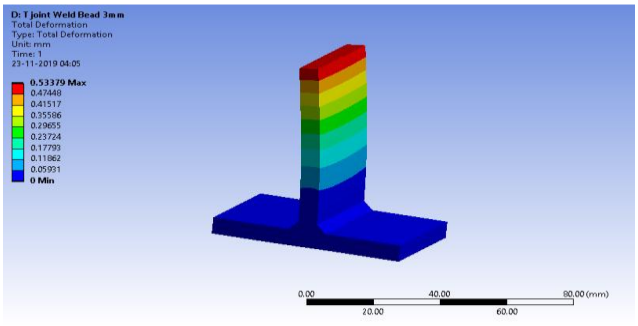


Figure 11: Total Deformation of 'T' joint at 3 mm thickness

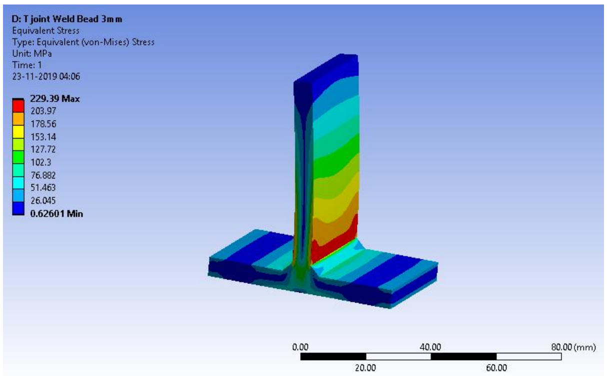


Figure 12: Equivalent Stress of welded 'T' joint at 3 mm thickness

► **Results of Welded 'T' joint at 1000 N Fully reversed Cyclic load at 4 mm Thickness of Weld bead**

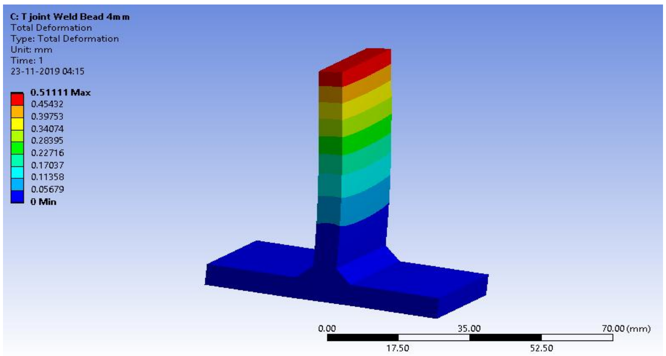


Figure 13: Total Deformation of 'T' joint at 4 mm thickness

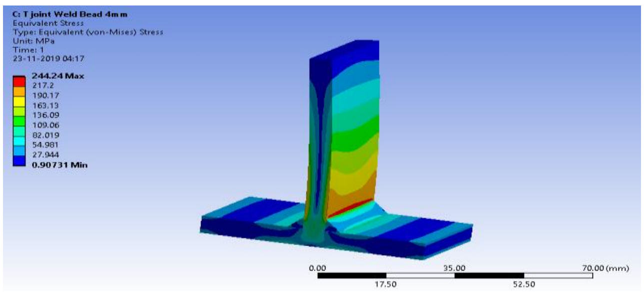


Figure 14: Equivalent Stress of welded 'T' joint at 4 mm thickness

► Results of Welded 'T' joint at 1000 N Fully reversed Cyclic load at 5 mm Thickness of Weld bead

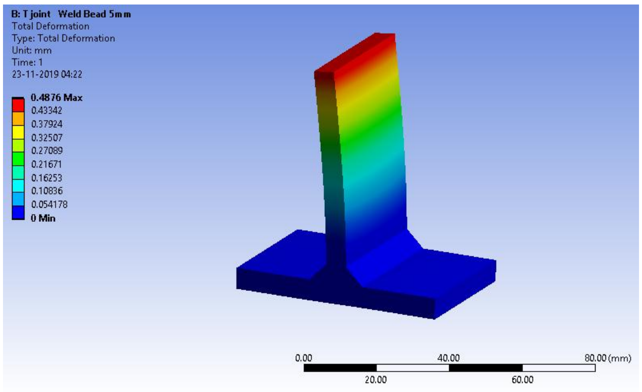


Figure 15: Total Deformation of 'T' joint at 5 mm thickness

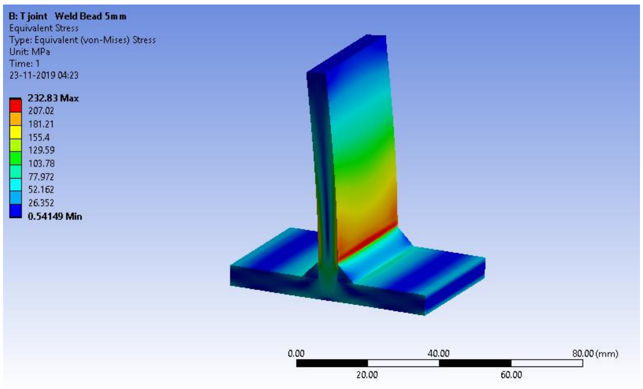


Figure 16: Equivalent Stress of welded 'T' joint at 5 mm thickness

7.1.3. Comparison of Strength parameter of Butt joint as per thickness of weld bead variations

Table 2: Total Deformation of Butt joint in mm at 1000 N load

S. No.	Force (N)	Weld Bead Thickness (mm)	Total Deformation (mm)
1	1000 N	3	3.5907
2	1000 N	4	2.7741
3	1000 N	5	3.2175

Table 7.2: Maximum Stress of Butt joint in MPa at 1000 N load

S. No	Force (N)	Weld Bead Thickness (mm)	Max Stress (MPa)
1	1000 N	3	2266.4
2	1000 N	4	1302.3
3	1000 N	5	996.09

Table 7.3: Maximum Weld Bead Stress in MPa at 1000 N load

S. No	Force (N)	Weld Bead Thickness (mm)	Weld Bead Stress (Max) MPa
1	1000 N	3	1455
2	1000 N	4	795.95
3	1000 N	5	583.4

Table 7.4: Strain of Butt joint in mm at 1000 N load

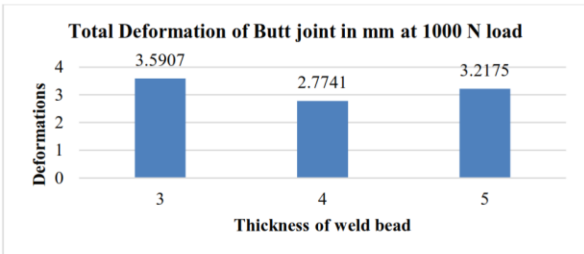
S. No.	Force (N)	Weld Bead Thickness (mm)	Strain
1	1000 N	3	0.02108
2	1000 N	4	0.01153
3	1000 N	5	0.00845

Table 7.5: Factor of Safety of Butt joint in mm at 1000 N load

S. No.	Force (N)	Weld Bead Thickness (mm)	Factor of Safety
1	1000 N	3	3.5814
2	1000 N	4	3.7577
3	1000 N	5	4.2052

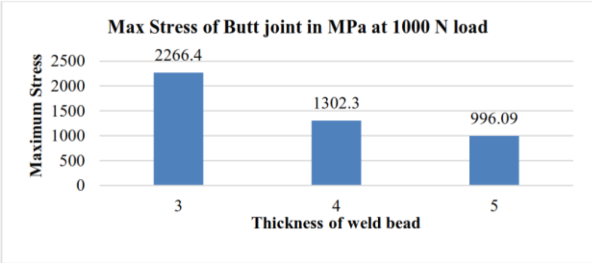
Table 7.6: Fatigue Life Cycles and damages of Butt joint

S. No.	Force (N)	Weld Bead Thickness (mm)	Fatigue Life Max (Cycles)	Damage (Max)
1	1000 N	3	1.00E+08	1.00E+32
2	1000 N	4	1.00E+08	1.00E+32
3	1000 N	5	1.00E+08	1.00E+32

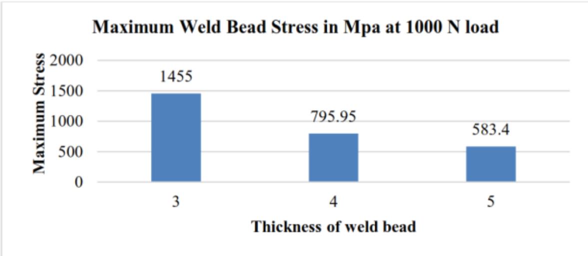


Graph 17: Total Deformation of Butt joint in mm at 1000 N load

As per graph we found the maximum deformation in butt weld joint at 3mm thickness. Minimum deformation found on 4 mm weld bead thickness. When using weld bead of 5 mm thickness deformation found 3.2175 which is lower from 3 mm thick weld and higher than 4 mm thickness of weld bead. Minimum deformation found on 4 mm thickness of weld bead joint.

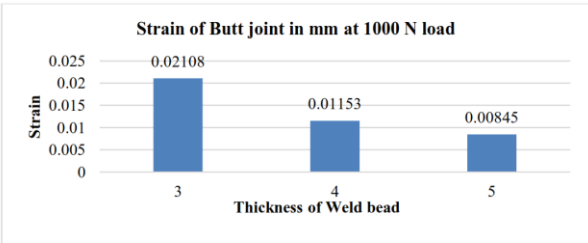


Graph 18: Max Stress of Butt joint in MPa at 1000 N load

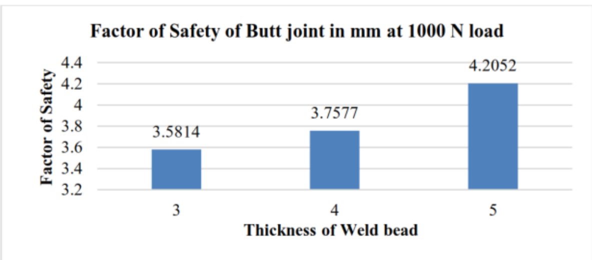


Graph 19: Maximum Weld Bead Stress in MPa at 1000 N load

As per graph maximum stress found on 3 mm thickness of weld bead and minimum stress found on 5 mm thickness of weld bead joint.

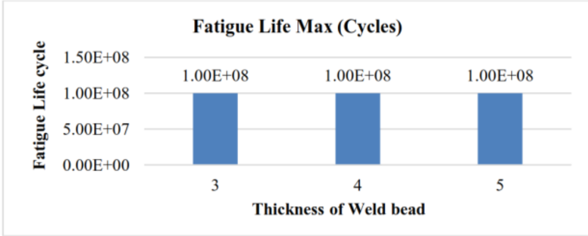


Graph 20: Strain of Butt joint in mm at 1000 N load

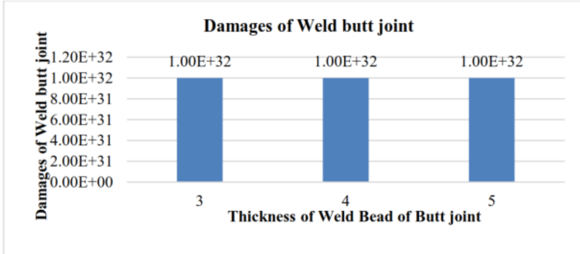


Graph 21: Factor of Safety of Butt joint in mm at 1000 N load

As per graph higher factor of safety found on 5 mm thickness of weld bead in welded joint and minimum FOS found on 3 mm thickness weld bead joint which is lower than as compared to other.



Graph 7.6: Fatigue Life Max (Cycles) of Butt joint



Graph 7.7: Damages of Weld butt joint

7.1.4. Comparison of Strength parameter of 'T' joint as per thickness of weld bead variations.

Table 7.7: Total Deformation of 'T' joint in mm at 1000 N load

S. No	Forces (N)	Weld Bead Thickness (mm)	Total Deformation (mm)
1	1000 N	3	0.5337
2	1000 N	4	0.5111
3	1000 N	5	0.4876

Table 7.8: Maximum Stress of 'T' joint in MPa at 1000 N load

S. No.	Forces (N)	Weld Bead Thickness (mm)	Max Stress (MPa)
1	1000 N	3	229.39
2	1000 N	4	244.24
3	1000 N	5	232.83

Table 7.9: Maximum Weld Bead Stress of 'T' in MPa at 1000 N load

S. No.	Forces (N)	Weld Bead Thickness (mm)	Weld Bead Stress (Max) MPa
1	1000 N	3	149.65
2	1000 N	4	140.11
3	1000 N	5	135.44

Table 7.10: Strain of ‘T’ joint in mm at 1000 N load

S. No	Forces (N)	Weld Bead Thickness (mm)	Strain
1	1000 N	3	0.00217
2	1000 N	4	0.00208
3	1000 N	5	0.00196

Table 7.11: Factor of Safety of ‘T’ joint in mm at 1000 N load

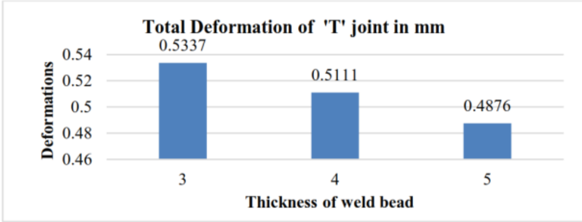
S. No	Forces (N)	Weld Bead Thickness (mm)	Factor of Safety
1	1000 N	3	2.0308
2	1000 N	4	3.0807
3	1000 N	5	4.0025

Table 7.12: Fatigue Life Cycles of ‘T’ joint

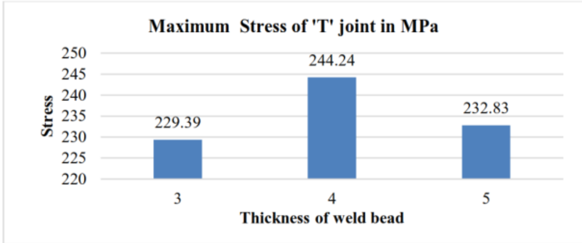
S. No	Forces (N)	Weld Bead Thickness (mm)	Fatigue Life (Cycles)
1	1000 N	3	16793
2	1000 N	4	13700
3	1000 N	5	16076

Table 7.13: Damages of ‘T’ joint

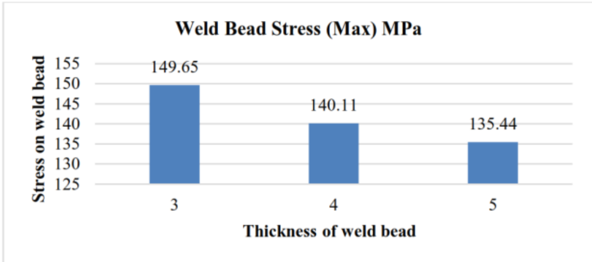
S. No	Forces (N)	Weld Bead Thickness (mm)	Damage (Max)
1	1000 N	3	59548
2	1000 N	4	72994
3	1000 N	5	62203



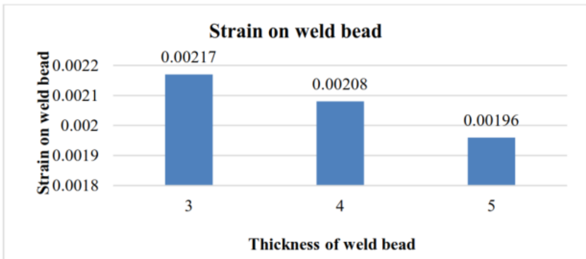
Graph 7.8: Total Deformation of ‘T’ joint in mm at 1000 N load



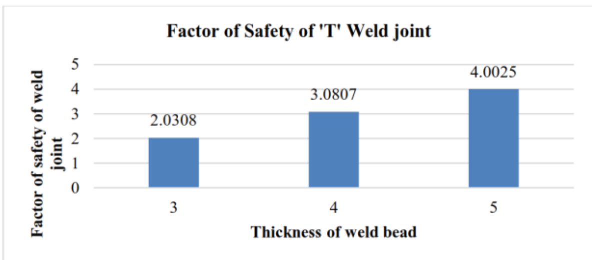
Graph 7.9: Max Stress of ‘T’ joint in MPa at 1000 N load



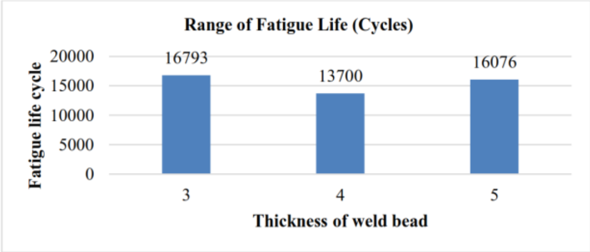
Graph 7.10: Maximum Weld Bead Stress of ‘T’ joint in MPa at 1000 N load



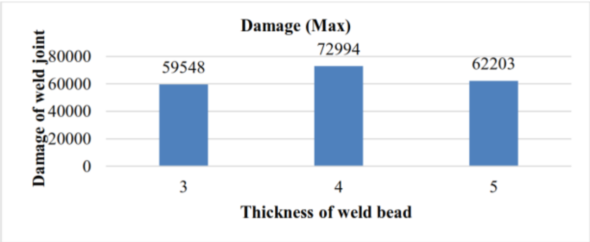
Graph 7.11: Strain of ‘T’ joint in mm at 1000 N load



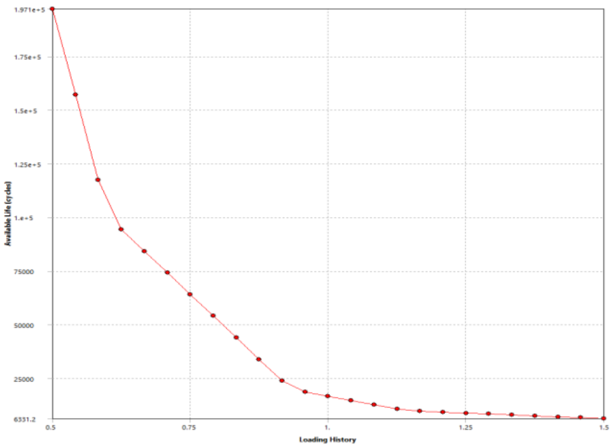
Graph 7.12: Factor of Safety of ‘T’ joint in mm at 1000 N load



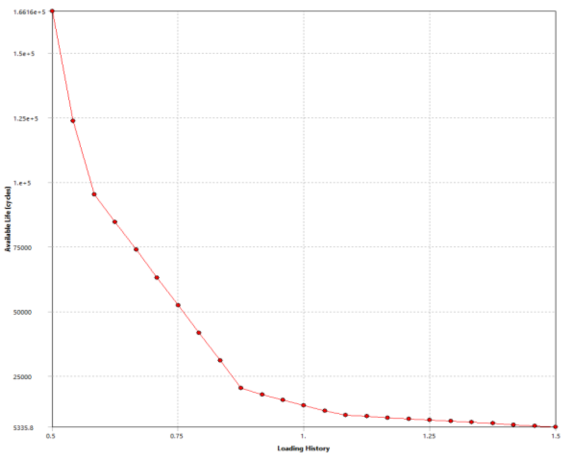
Graph 7.13: Fatigue Life Max (Cycles) of 'T' joint



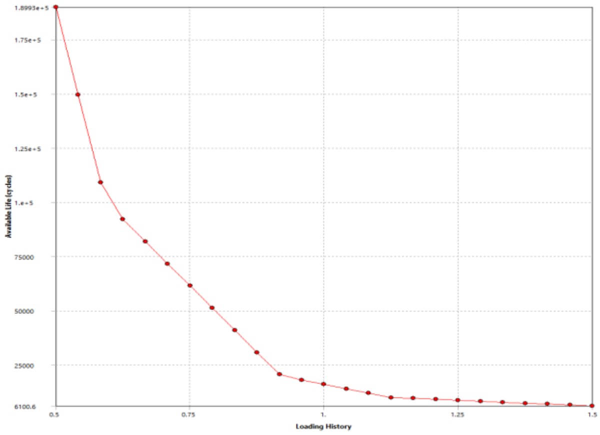
Graph 7.14: Damages of Weld 'T' joint



Graph 7.15: Fatigue Sensitivity graph of 3 mm of 'T' Joint



Graph 7.16: Fatigue Sensitivity graph of 4 mm of 'T' joint



Graph 7.17: Fatigue Sensitivity graph of 5 mm of 'T' joint

IV. CONCLUSION

A number of the structural components are made of welded joints in containers, pressurized vessels, transport vehicles, earthmoving equipment, spacecraft, etc. In the manufacturing and construction of several structures, butt welds and' T ' joints are the most common. The extensive application of butt welds in different structures, including offshore and nuclear, offers scientists wide scope for analyzing the actions under different loading conditions [8]. Failure analysis of the elements shows that the principal cause of most destructive failures is fatigue alone [14]. Even if the fatigue of the sold metal is fine, there are problems. There is an abrupt change in the section which is caused by excessive solder regeneration, undercutting, layer inclusion and insufficient penetration. [7]

The structural use of aluminum alloys in applications like automobiles and trains, bridges, overland structures and high-speed ships is becoming more and more significant. Sweating is the primary method of joining in all cases and fatigue is an important design criterion. It is, however, considered to have weak fatigue properties in weakened joints. Clear design guidelines are therefore needed to prevent fatigue failures in the welded structures of aluminum alloys. In addition to the basic design of new structures, the methods to evaluate the remaining lives of existing structures are also of increased interest. 24] This study suggested that the strength parameters of the butt-type welded joint were strongest as far as the mechanical properties of the weld joint were concerned.

Results output for Butt welded Joint

- As per deformation study by graph we found maximum deformation in butt weld joint at 3mm thickness. Minimum deformation found on 4 mm weld bead thickness. When using weld bead of 5 mm thickness deformation found 3.2175 which is lower from 3 mm thick weld and higher than 4 mm thickness of weld bead.

- Stress optimization in butt weld joint at 3 mm thickness found maximum as compared to other two. also, for 5 mm thickness of weld bead gives lower deformation is 996.09 mm. so as per study of deformation and stress we found 5 mm thickness of weld joint gives better strength parameters.

- Strain found in welded joints is maximum at 3 mm thickness of weld bead and minimum strain found on 5 mm thickness of weld bead.

- As per study minimum factor of safety found on 3 mm thickness of weld joint and maximum factor of safety found on 5 mm thickness of weld bead joint.

- In fatigue life analysis using S-N curve analysis in ANSYS we found similar life of all weld joint that is 1x 10 8 at 1000 N load.

- In butt joint we found satisfactory results at 5 mm thickness of weld bead.

Results output for 'T' type Welded Joint

- As per deformation study by graph we found maximum deformation in T weld joint at 3mm thickness. Minimum deformation found on 5 mm weld bead thickness. When using weld bead of 5 mm thickness deformation found 0.4876 which is lower from 4 mm and 5 mm thick weld.

- Stress optimization in T weld joint at 4 mm thickness found maximum as compared to other two. also, for 3 mm thickness of weld bead gives lower stress is 229.39 mm. so as per study of deformation and stress we found 5 mm thickness of weld joint gives better strength parameters.

- Strain found in welded joints is maximum at 3 mm thickness of weld bead is 0.00217 mm and minimum strain found on 5 mm thickness of weld bead is 0.00196 mm.

- As per study minimum factor of safety found on 3 mm thickness of weld joint is 2.0308 and maximum factor of safety found on 5 mm thickness of weld bead joint is 4.0025 mm.

- In Factor of safety analysis using S-N curve analysis found maximum FOS on 5 mm thickness of weld bead T joint and minimum FOS found 3 mm thickness of weld joint.

- Fatigue life cycle found maximum on 3 mm thickness of weld joint and minimum found on 4 mm thickness of weld bead joint, so as fatigue failure we can say that 3 mm thickness of weld bead T joint having higher number of life cycle during cyclic loading.

- In butt joint we found satisfactory results at 5 mm thickness of weld bead.

V. FUTURE SCOPE

The scope of the present study was limited to the mechanical properties and microstructure of the welded joint and three other dissimilar joints involving various metals. Further studies can focus on the corrosion behavior of these four dissimilar metal weld joints as it is more susceptible to corrosion. Also fatigue analysis of the welded joints can be attempted and the results can be compared. Also, further experimental work can focus on Post heat treatment on welded joints to increase the austenite content which can help to obtain satisfactory corrosion resistance and mechanical properties on the dissimilar welded joints. More studies can focus on welding joint process with different dissimilar metals considering the scope of new development projects in especially in aerospace industries.

REFERENCES

1. Subramanian J, Supriyo Ganguly, Wojciech Suder (2019). Influence of welding processes on weld bead geometry, International *Research Journal of Engineering and Technology*, Volume: 06, Issue: 01.

2. Manabendra Saha, S. S. Dhami (2019). Effect of TIG Welding Parameter of Welded Joint of Stainless Steel SS304 by TIG Welding, *Trends in Mechanical Engineering & Technology*, Volume 8, Issue 3.

3. M.M. Alam, Z. Barsoum, P. Jonse´n (2010). A.F.H. Kaplan, The influence of surface geometry and topography on the fatigue cracking behavior of laser hybrid welded eccentric fillet joints, *Applied surface science*, Elsevier.

4. Vikas Chauhan, Dr. R. S. Jadoun (2015). Parametric Optimization of Mig Welding for Stainless Steel (Ss-304) And Low Carbon Steel Using Taguchi Design Method, *International Journal of Recent Scientific Research*, Vol. 6, Issue, 2, pp.2662-2666.

5. N. Farabi,D.L. Chen, J. Li, Y. Zhou, S.J. Dong (2010). "Microstructure and mechanical properties of laser welded

DP600 steel joints", *Materials Science and Engineering*, Elsevier.

6. R. Megavarnan, G. Rajamurugan, R. Shanmuga Prakash (2017). Comparative Study on Mechanical Properties of GMA Welded IRSM41 Mild Steel Plate Based on Grain Flow Direction, *Applied Mechanics and Materials*, ISSN: 1662-7482, Vol. 854, pp. 38-44.

7. Muhammad ABID, Muhammad Jawad QARNI (2009). 3D thermal finite element analysis of single pass girth welded low carbon steel pipe-flange joints", *Turkish Journal Engineering Environment Science*, 2009.

8. Rajashekhar S. Sharma, Pal Molian (2009). Yb: YAG laser welding of TRIP780 steel with dual phase and mild steels for use in tailor welded blanks, *Material and design*, Elsevier.

9. Hongtao Zhang, Qing Chang, Jihou Liu, Hao Lu (2014). A novel rotating wire GMAW process to change fusion zone shape and microstructure of mild steel, Elsevier.

10. Sengupta, Susil K. Putatunda (1993). Application of a new model for fatigue threshold in a structural steel weldment, *Engineering fractures mechanics*, Vol. 45, No. 4, pp. 463-477.

11. V. Caccesea, P.A. Blomquist, K.A. Berube (2006). Effect of weld geometric profile on fatigue life of cruciform welds made by laser/GMAW processes, Elsevier.

12. Uygur, B. Gulenc (2009). The effect of shielding gas compositions for MIG welding process on mechanical behavior of low carbon steel, Metabk 43, pp. 35-40.

13. Subhajit Bhattacharya, Santanu Das (2013). Selection of Appropriate process parameters for Gas Metal arc welding of medium carbon steel specimens, *International Journal of the Analytic Hierarchy Process*, Vol. 5, Issue 2,ISSN 1936-6744.

14. Fidelis Rutendo Mashiri, Xiao-Ling Zhao, Paul Grundy (2002). Fatigue Tests and Design of Welded T Connections in Thin Cold-Formed Square Hollow Sections Under In-Plane Bending, *Journal of Structural Engineering*, Vol. 128, No. 11.

15. V. Caccesea, P.A. Blomquist, K.A. Berube (2006). Effect of weld geometric profile on fatigue life of cruciform welds made by laser/GMAW processes, Elsevier.

16. C. V. Vijaykumar, DR. Deshpande S.V., Valsange P.S. (2016). Tensile strength analysis of lap welded joint of similar plates with F.E.A., *International journal of innovations in engineering research and technology* [IJIERT] ISSN: 2394-3696, volume 3, issue 8.

17. V. Sastry, S. srinivasan (2015). Fatigue Analysis of Welded Joint by Varying Weld Bead Size, *International Journal & Magazine of Engineering*, Technology, Management and Research, Volume No. 2, Issue No.12 , pp. 35-38.

18. Nuri Akkas, Durmu G Karayel, Sinan Serdar Ozkan (2013). Modeling and Analysis of the Weld Bead Geometry in Submerged Arc Welding by Using Adaptive Neuro fuzzy Inference System, *Mathematical Problems in Engineering*, Volume 2013, Article ID 473495.

19. P. J. Mistry (2016). Effect of Process Parameters on Bead Geometry and Shape Relationship of Gas Metal Arc Weldments, *International Journal of Advanced Research in Mechanical Engineering* & Technology (IJARMET), Volume 2, Issue 2.

20. H. Yajima, E. Watanabe, Z.M. Jia, K. Yoshimotoj (2011). Study on fracture toughness of welded joints for heavy-thick steel plates by centre-notched small size specimen, Vol. 55.

21. Rajashekhar S. Sharma, Pal Molian (2009). "Yb: YAG laser welding of TRIP780 steel with dual phase and mild steels for use in tailor welded blanks", *Material and design*, Elsevier.

22. Hongtao Zhang, QingChang, JihouLiu, HaoLu (2014). A novel rotating wire GMAW process to change fusion zone shape and microstructure of mild steel", Elsevier.

23. M Nagy, M Behúlová (2017). "Design of welding parameters for laser welding of thin-walled stainless steel tubes using numerical simulation", *Materials Science and Engineering*, 266.

24. P. D. Chaudhari, Nitin N. More (2014). Effect of Welding Process Parameters on Tensile Strength, Vol. 04, Issue 05.

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