Design And Development of Seam Welding for Different Alloys

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Abstract: The aim of this project is to study and analysis various parameters which is involved in seam welding: The welding has mainly divided into two types one is fusion welding other one is pressure welding. In the pressure welding electrode is pressed against the weldment which has to be weld. The pressure welding furtherly divided in to resistance welding, smiths forge welding mechanical energy (Pressure) i.e., friction welding and chemical reaction welding. One of the most important welding are resistance spot, seam, percussion welding which are widely used in sheet metal industries. In this project we have concentrate on seam welding for different type of materials like AISI 1015 low carbon steel, nickel alloy and magnesium alloys, for analysis we have changed parameters like pressure of the electrode and welding time, whereas ANSYS have been used to determine the optimum process time

Keywords: Resistance welding, spot, seam welding, AISI 1015 low carbon steel, nickel alloy and magnesium alloys, Electrode, ANSYS

1.Introduction

Welding is the process of joining two metals by the action of heat and pressure, sometimes only the pressure and only heat, welding is an oldest method of joining process but there was a number of evaluations have been made in this technology day by day, from last two centuries scientists have put their effort on this technology to improve quality in different factors, which results different types of welding have been introduced which makes comfort and sound weld quality.

The welding has been divided in to two types one is pressurized welding and other is fusion (unpressurized) welding. In pressure welding electrode is pressed against the weldment which has to be weld. The common types of pressurized welding are Resistance welding, smiths welding, Mechanical energy (pressure) and chemical reaction welding. In resistance welding a non-consumable electrode is used to produce spark between faying surfaces of two dissimilar or similar metals or sheets

There are mainly four types of electric resistance welding:

1. Resistance spot welding
2. Resistance projection welding
3. Resistance butt welding
4. Resistance seam welding

Seam welding is the process of joining of two similar or dissimilar metal on continuous seam. Seam welding can be divided into two main techniques, friction seam welding and resistance seam welding.

2.Working Principle

The working principle of seam welding is similar to the working principle of resistance welding. According to the working principle of the seam welding, the heat required at the time of the welding is produced due to the resistance of the material. In a simple language, heat generation takes place due to the resistance of the material. The process of seam welding is similar to continuous spot welding. Two rollers have a shaped electrode. The electrodes are brought in contact with the work piece and then electric current is applied to them. Due to the high current supplied, the interface between the roller and the work piece melts and, as a result, a strong weld joint is formed. The rollers then begin to rotate on the surface of the work piece. As these rollers move, a generation of a continuous joint is formed. What is the welding speed for seam welding? In this welding technique, the speed is 60 in/min. This speed has been assumed to be standard but there have been practical instances when it may change increase or decrease

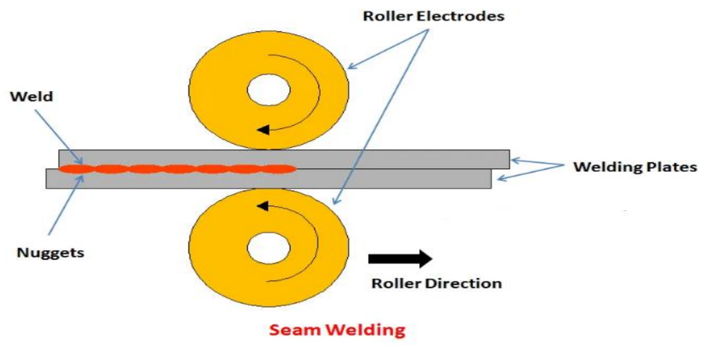

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Figure.1 showing the working principle of seam welding

Process Parameters

Major factors that controlling resistance welding are welding current, welding time, electrode pressure, electrode diameter and electrode geometry and dimension.

Welding current: Welding current is the most significant parameter that controls the heating at the joint of sheet-to-sheet interface and hence the weld nugget development and formation takes place. AC and DC currents possess different characteristics in total heating and heat input rate and their effect on weld quality and weld formation. Increase in the current increases the diameter of the weld, root penetration. It also increases strength of the weld. Excess current value gives rise to excessive indentation and burning of the weld nugget area. Where relation between the current and heat generation is given by the equation [1].

$$H = I^2 \times R \text{ ………. (1)}$$

Where H = heat, I^2 = Welding Current squared, R = resistance

Welding time: Resistance Welding relies on resistance base metals and the amount of current flowing to generate the heat needed to produce seams. Another important factor is time this is given by the equation [1].

$$H = I^2 \times R \times T \times K \text{……………….(2)}$$

Where T = Time, K = Heat losses

Electrode force: The force exerted by the electrodes on to the workpiece during welding cycle is called electrode force. The pressure excited on the workpiece has great effect on the weld bead (or) width of the bead and current flow.

Welding speed: The quality of weld is depending up on the speed of the electrode and orientation angle in SMAW (Shielded Metal Arc Welding) in similar way, seam welding quality also depends up on the speed and shape of the electrode. The speed of electrode or work piece is depending up on the parameters like thickness of the work piece, surface condition.

3.Literature Survey

For the analysis of the resistance welding process parameters and how they affect the response variables, a literature survey was conducted.

Tumuluru et al. [2] determined procedure development and practice considerations for seam welding process. Peel test and tensile tests was carried out to determine mechanical strength of weld. This paper gives information about seam welding of ferrous materials like low carbon steel, stainless steel. It also described about seam welding of nonferrous materials like Aluminium, Copper, and Bronze etc. They concluded that if the indentation is carefully controlled then tensile strength of 80 to 100% of the parent metal can be achieved of welded joint.

Robert Matteson [3] stated the concept of fundamentals of resistance seam welding. This Paper experimentally showed that if weld force increases under given electrode conditions, there is an improvement in the welding range in speed can be possible. It also leads to control cracking.

Khosravi et al. [5] experimented that when the current for low welding speeds increases it will leads in the decrease nugget size.When more current is used, it also increases joining zone thickness in each galvanized and electro galvanized sheet.Keeping welding current constant when welding speed increases, results in increase in joining zone thickness and nugget size decreases.

Kamble V. A. [8] investigated effect of process parameters on resistance spot welding shear strength using Taguchi method. They have taken welding current, welding time, electrode diameter and electrode force parameters for their study. ANOVA method showed that current and electrode force were the most dominating factors on welding process.

Kianersi et al. [9] They investigated the effect of optimized welding parameters on the properties and microstructure of AISI 316L austenitic stainless steel sheets.The analysis of effect of welding current by keeping constant welding time was considered on the weld properties such as weld nugget size, tensile–shear load bearing capacity of welded materials, failure modes, failure energy, ductility, and microstructure of weld nuggets. They concluded that tensile strength increases up to certain limit of current value and then decreases. Micro hardness studies showed that hardness of weld nugget was lower in comparison to HAZ and base metal.

Kamble Vijay Ananda. [8] have been studied about spot welding optimization parameter combination for the maximum tensile shear strength was obtained by using Taguchi method for enhancing the welding performance and optimization.

4.Materials and Methods

Selection of material is an important factor while studying different parameters in welding. Material selections includes electrode and weldment, there are different alloys are largely used in industries. Some of them are

- **Low-Carbon Steels 1015**
- **Nickel alloy**
- **Magnesium alloys**

Low –carbon steels 1015 : These are general purpose low-carbon steels that may be case-hardened by carburizing and other methods, and may be easily machined and welded.

Nickel alloy

Nickel is a versatile metal that is found in abundance in the earth's crust and core. First discovered and isolated by Axel Fredrik Cronstedt, a Swedish chemist and mineralogist, nickel exhibits several desirable properties that render it useful in industrial applications. For one, nickel is highly ductile and is valuable as an alloying element to alter the properties of other metals. For example, grades of stainless steel can be created by the addition of nickel to produce alloys that offer corrosion resistance and high-temperature endurance, making them ideal for uses in chemical plants where exposure to caustic substances may be expected.

Magnesium alloys

These are well-known for being the lightest structural alloys. They are made of magnesium, the lightest structural metal, mixed with other metal elements to improve the physical properties. These elements include manganese, Aluminium, zinc, silicon, copper, zirconium, and rare-earth metals. Some of magnesium's favourable properties include low specific gravity and a high strength-to-weight ratio. As a result, the material lends itself to a range of automotive, aerospace, industrial, electronic, biomedical, and commercial applications. Here, you can learn about the various types of magnesium alloys and their designations, the physical properties of magnesium alloys, and the applications in which magnesium alloys are used.

5. Modeling and Analysis

In this paper we have used one software for modelling and one software for analysis.

CATIA – stands for **C**omputer **A**ided **T**hree -dimensional **I**nteractive **A**pplication used for design three dimensional parts. CATIA is a multi-platform 3D software suite developed by Dassault Systems, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modelling tool that unites the 3D parametric features with 2D tools and also addresses every design-to-manufacturing process. In addition to creating solid models and assemblies, CATIA also provides generating orthographic, section, auxiliary, isometric or detailed 2D drawing views. It is also possible to generate model dimensions and create reference dimensions in the drawing views. The bi-directionally associative property of CATIA ensures that the modifications made in the model are reflected in the drawing views and vice-versa.

The first release of CATIA was way back in 1977, and the software suite is still going strong more than 30 years later. While CATIA V6 is just being released, the most popular version of CATIA is V5 which was introduced in 1998. That said, it is important to note that each version of CATIA introduces considerable additional functionality. For example, V4 (introduced in 1992) offered enhancements to the Assembly Modelling Product including easy-to-use graphical tree-based assembly management. V5 and V6 saw changes in the way data is handled. Dassault

Systems typically offers new updates, releases and bug fixes for each version. The CATIA software is written in C++. It runs on both UNIX and Windows.

ANSYS - ANSYS is a general-purpose finite element analysis program used in the field of static, dynamics, nonlinear, thermal, optimization and a macros program containing over one million lines of code. ANSYS is a general-purpose finite element analysis program used in the field of static, dynamics, nonlinear, thermal, optimization and a macros program containing over one million lines of code. ANSYS is consisted of bunch of building block called module and a module is a collection of subroutines designed to perform specific task processing model geometry, assembling matrix, applying boundary conditions, solving matrix, calculating output quantities, printing, so on. The modules are controlled by DAMP program called Direct Matrix Abstraction. Each type of analysis consisted of a collection of hundreds and thousands of DAMP commands. Once a type of analysis is chosen, its DAMP command sends instruction to the module that is needed to perform the requested solution. ANSYS can quickly solve a large size of problem with small amount of disk space by using the Sparse Matrix Algorithms.

- Solution Flow Chart.
- Formulate element stiffness matrices from element properties, material properties, and geometry.
- Assemble all element stiffness matrices into global stiffness matrix.
- Apply boundary conditions to constrain model.
- Apply loads to model.
- Calculate displacements of nodes.
- Calculate stresses from the displacements

6.Structural And Thermal Analysis

ANSYS workbench is a new generation solution from ANSYS that provides powerful methods for interacting with the ANSYS solver functionality. This environment provides a unique integration with CAD systems, and design process, enabling the best CAE results.

Step –By-Step Procedure of Analysis

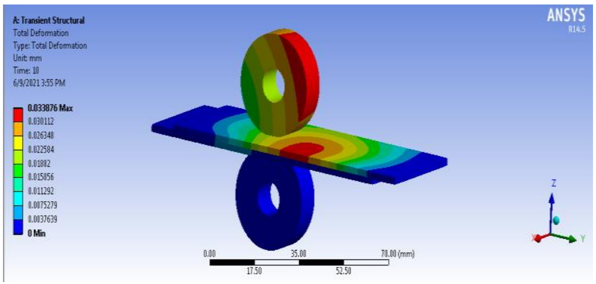
- Preliminary decisions→ Preprocessor → Solve the modal → Post processor

In analysis we have chosen three materials at different conditions of loads and time. Which are generally used in sheet material industries

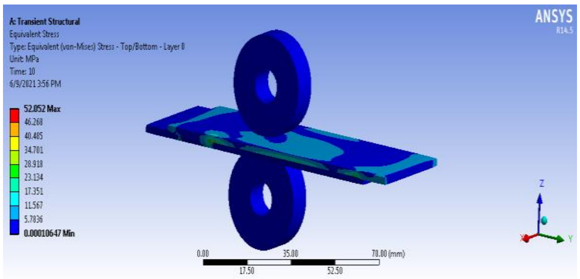
AISI 1015 Low Carbon Steel

At 10sec time and load 3kg/cm^2

Total deformation **Equivalent Stress**

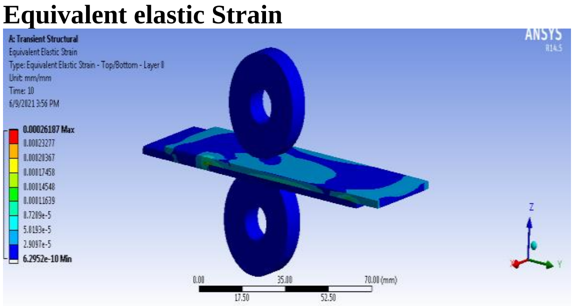


(a)



(b)

Equivalent elastic Strain



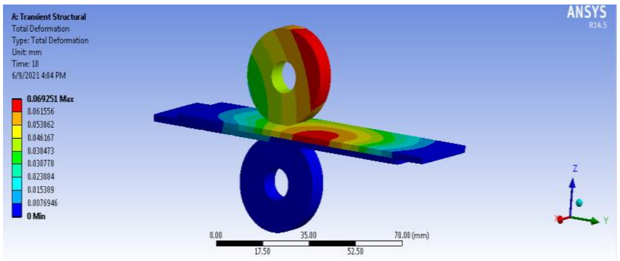
(c)

Figure.2: Shows (a) Total deformation (b) Equivalent stress (c) Equivalent elastic Strain of AISI 1015 low carbon steel

In similar manner we have conducted the 2 other parameters; like time at 20sec and 5 Kg/cm^2 and time 30 sec and 7 Kg/cm^2

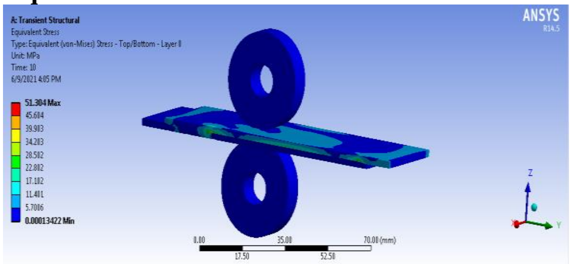
Nickel Alloy
At time-10s and load 3kg/cm^2

Total deformation



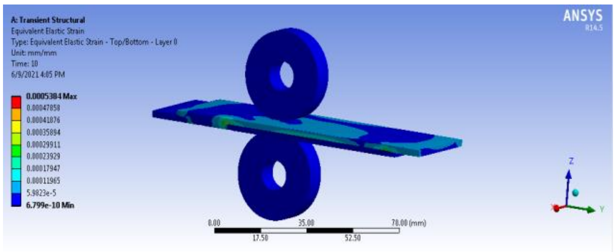
(a)

Equivalent Stress



(b)

Equivalent elastic Strain

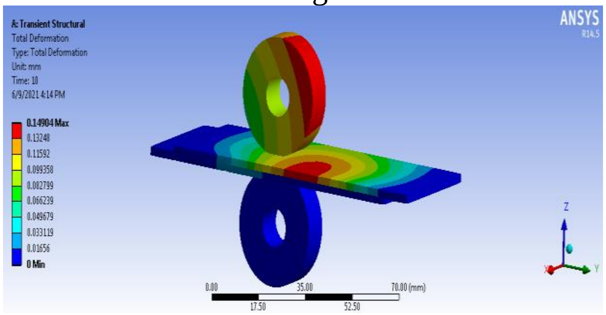


(c)

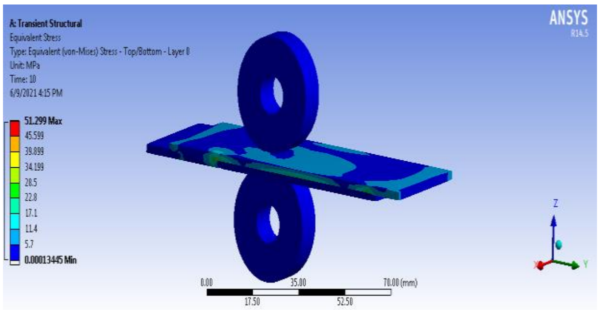
Figure.3: Shows (a) Total deformation (b) Equivalent stress (c) Equivalent elastic Strain of Nickel alloy

In similar manner we have conducted the 2 other parameters; like time at 20sec and 5 Kg/cm^2 and time 30 sec and 7 Kg/cm^2

Magnesium Alloy:
At time-10s and load 3kg/cm^2



(a)



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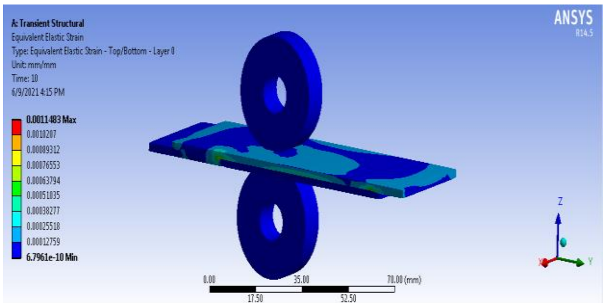


(c)

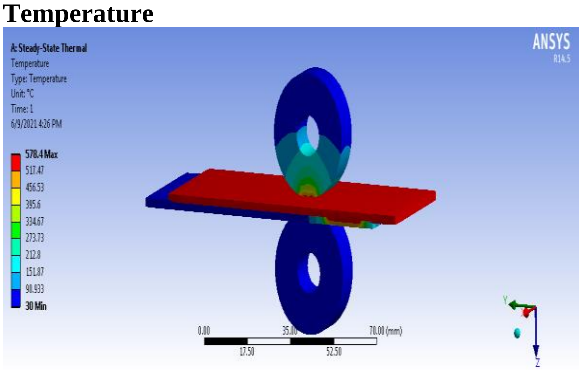
Figure.3: Shows (a) Total deformation (b) Equivalent stress (c) Equivalent elastic Strain of Magnesium alloy

In similar manner we have conducted the 2 other parameters; like time at 20sec and 5 Kg/cm^{2}and time 30 sec and 7 Kg/cm^2

Thermal Analysis

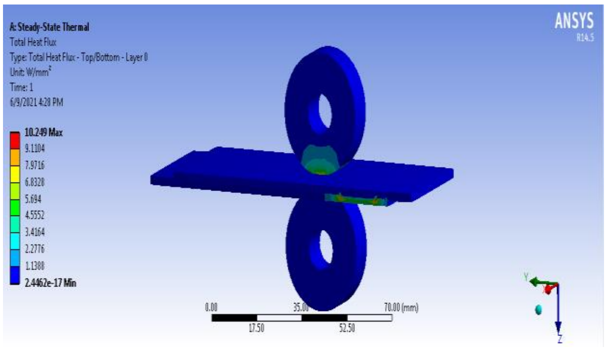
AISI 1015 Low carbon steel:

Temperature



(a)

Heat Flux

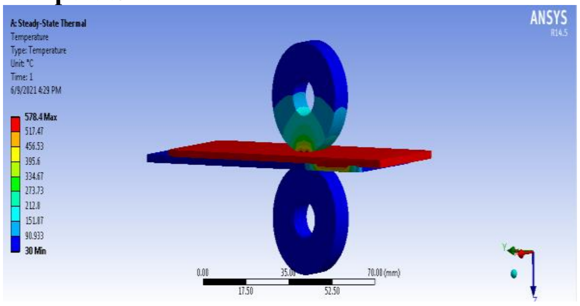


(b)

Figure.4: (a) Shows temperature Analysis and (b) shows heat flux analysis for AISI 1015 Low Carbon Steel

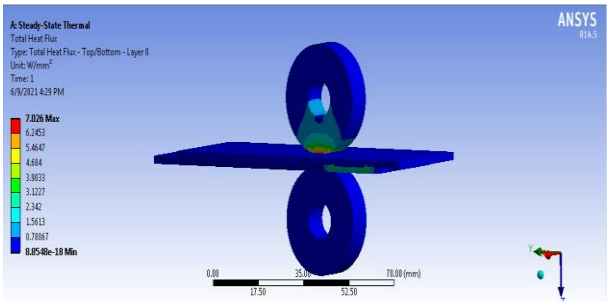
Nickel Alloy:

Temperature



(a)

Heat Flux

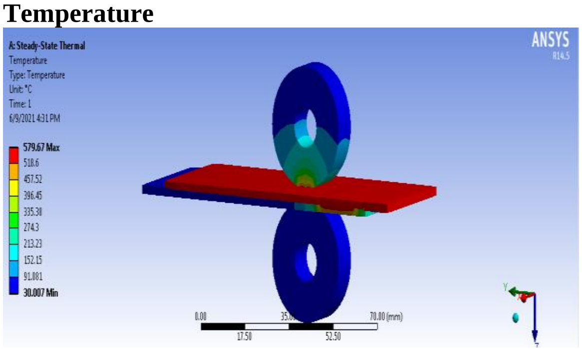


(b)

Figure.5: (a) Shows temperature Analysis and (b) shows heat flux analysis for Nickel Alloy

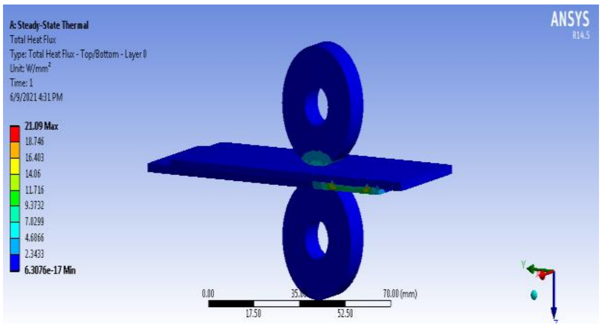
Magnesium Alloy

Temperature



(a)

Heat Flux



(b)

Figure.6: (a) Shows temperature Analysis and (b) shows heat flux analysis for Magnesium Alloy

7. Results And Discussions

Table.1: Transient structural analysis results

Materials	Time(sec)	Force(kg/cm^2)	Deformation (mm)	Stress (N/mm^2)	Strain
AISI 1015 Low carbon steel	10	3	0.03386	52.052	0.0002818
	20	5	0.07086	106.71	0.00536
	30	7	0.10808	161.32	0.00811
Nickel alloy	10	3	0.069251	51.304	0.00058
	20	5	0.14501	104.98	00.00110
	30	7	0.22125	158.21	0.001660
Magnesium alloy	10	3	0.14904	51.299	0.00114
	20	5	0.31198	104.09	0.0023
	30	7	0.4789	154.61	0.0034619

Interpretation of table-1.

There is significant difference between AISI 1015 Low carbon steel, Nickel alloy and Magnesium alloy

In this analysis of the transient structural the analysis is carried out to determine the deformation, stress, and strain of different alloys at different loads and time (3,5,7 kg/cm2 and 10, 20, 30 sec).

Table.1. Shows different material properties as a function of load variation in seam welding.

Table.2: Thermal analysis

Materials	Temperature (^{0}C)	Heat flux(W/mm^2)
AISI 1015Low carbon steel	578.4	10.249
Nickel alloy	578.9	7.024
Magnesium alloy	579.4	21.09

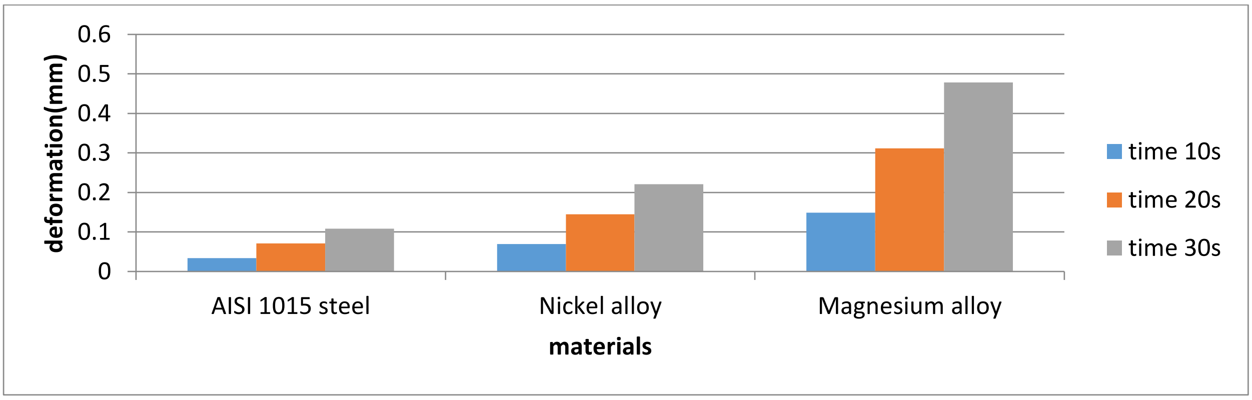
Interpretation of table-2.

There is significant difference between AISI 1015 Low carbon steel, Nickel alloy and Magnesium alloy

Based on the table above, the heat flux and temperature distribution can be determined. 578.9 ^{0} C has a low heat flux for nickel alloys

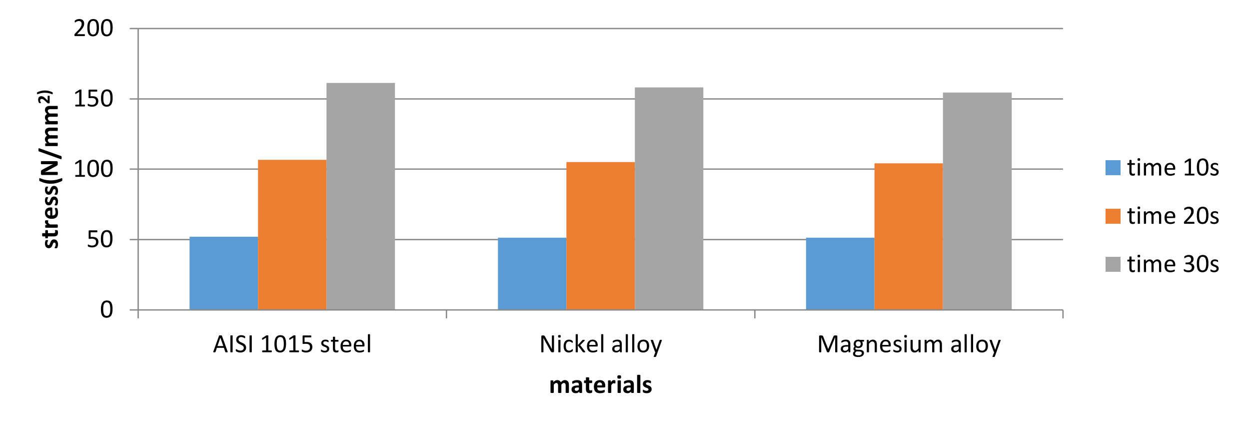
Table.2. Thermal variation of different materials is shown in the table

Graph7.1: Deformation in Different materials



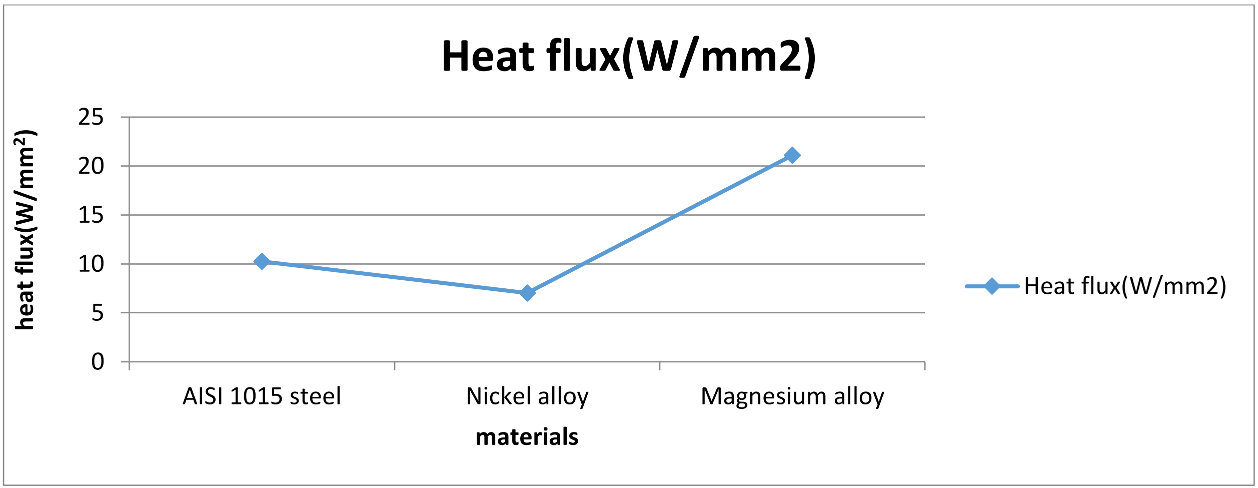
Graph.7.1: The graph illustrates the deformation of different materials under various conditions.

Graph7.2: Equivalent stress in Different Materials



Graph.7.2. The graph illustrates the Equivalent stress of different materials under various conditions.

Graph7.3: Heat flux in Different Materials



Graph.7.3. The graph illustrates the heat flux of different materials under various conditions.

8. Conclusion

To investigate effect of process parameters on stress and temperatures for seam welded at different alloys such as AISI 1015 low carbon steel, Nickel alloy and magnesium alloys. The study parameters considered in the experiments are electrode pressure and welding time. ANSYS has been used for optimization to determine optimum process parameters.

In this project the Transient structural analysis is to determine the deformation, stress and strain at different loads and times (3,5,7 kg/cm^2 and 10, 20, 30 Ms) of different alloys. And thermal analysis is to determine the heat flux and temperature distribution.

By observing the Transient structural analysis results, the stress values less at magnesium alloy with load of 3kg/cm^2 when we compared to other materials and loads.

By observing the Thermal analysis results, the heat flux value more at magnesium alloy when we compared to other materials.

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