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A Comparative Approach on Replacement of Carbon Steel on Power Piping By Nickel Based Alloy

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ABSTRACT: In most of the power plants Carbon Steels are widely used in CRL and HRL in 500MW boilers (500°C). Since the carbon steels are being used in CRL and HRL the displacement over that piping area will be more. And the Carbon steel can with stand this temperature and the displacement. While moving for higher capacity boilers (800 MW boilers) CARBON STEEL cannot withstand the high temperature of 680°C and fails in thermal stress. Hence to overcome this problem we are introducing a nickel based alloy, INCONEL (75 Ni, 15 Cr, 10 Fe). Since inconel has creep strength and elongation property it is capable of withstanding such temperatures. Also due to good elongation property we can reduce the supports which helps to reduce the total operating cost of the piping.

I. INTRODUCTION

Piping is a system of pipe used to convey fluids from one location to another. Piping is used mainly over power plants, petro chemical industries, oil & gas industries. About two decades ago, in India, the design procedure for piping systems for refineries, petrochemicals and power plants, in magnitude, depth and complexities were not fully evolved. Only in the recent past, we were exposed in detail to this field. Now we are self sufficient in the field of piping technology and design.

II. LITERATURE REVIEW

Sanjay Koorse., studied about a typical high-energy piping systems consists of the main steam, reheat (hot and cold) and boiler feed pump (BFP). The initial design of the system is based on elastic analysis to ensure that the stresses and deflections fall within established code limits **Sanjeev kumar** attempted to explore the possibility for welding of higher thickness plates by TIG welding. Aluminium Plates (3-5mm thickness) were welded by Pulsed Tungsten Inert Gas Welding process with welding current in the range 48-112 A and gas flow rate 7 -15 l/min. Shear strength of weld metal (73MPa) was found less than parent metal (85 MPa). **Sivaprasad.**, had studied the performance of TIG welding of 2.5 mm thick Nickel based 718 alloy using welding current in the range of 44-115 A, voltage 13-15 V and welding speed 67 mm/min. the influence of magnetic arc oscillation on the fatigue behaviour of the TIG weldments in two different post-weld heat treatment conditions were studied.

Qinglei had studied analysed microstructure, element distribution, phase constituents and micro hardness for welding joint of Mo-Cu composite and 18-8 stainless steel plates of thickness 2.5 mm carried out by TIG welding process with Cr-Ni fillet wires. **Indira Rani** studied the mechanical properties of the weldments of AA6351 during the GTAW /TIG welding with non-pulsed and pulsed current at different frequencies. **Tseng** studied the effect of activated TIG process on weld morphology, angular distortion, delta ferrite content and hardness of 316 L stainless steel by using different flux like TiO₂, MnO₂, MoO₃, SiO₂ and Al₂O₃.

Karunakaran., had studied performance TIG welding of AISI 304L stainless steel and compare the weld bead profiles for constant current and pulsed current setting. Effect of welding current on tensile strength, hardness profiles, microstructure and residual stress distribution of welding zone of steel samples were reported. **Kumar and Sundarrajan** had studied pulsed TIG welding of 2.14 mm AA5456 Al alloy using welding current (40-90) A, welding

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speed (210-230) mm/min. Taguchi method was employed to optimize the pulsed TIG welding process parameters for increasing the mechanical properties and a Regression models were developed. **Ahmet durgutlu.**, investigated the effect of hydrogen in argon as shielding gas for TIG welding of 316L austenitic stainless steel.

Sivaprasad., studied the performance of TIG welding of 2.5 mm thick Nickel based 718 alloy using welding current in the range of 44-115 A, voltage 13-15 V and welding speed 67 mm/min. the influence of magnetic arc oscillation on the fatigue behaviour of the TIG weldments in two different post-weld heat treatment conditions were studied.

III. PROBLEM IDENTIFICATION

In future, super critical steam generators will be replacing the today's sub-critical boiler. In India the maximum capacity of boiler is 500MW. The operating temperature and pressure of the boiler will be 500^o C and pressure will be 200bar. While in supercritical steam generators the temperature will be 680^o C and the pressure will be above 280bar.

The materials used now-a-days such as carbon steel, stainless steel will not withstand this high temperature. Normally in a Power piping both creep and thermal stress are included into consideration.

3.1 CREEP STRESS

Creep (sometimes called cold flow) is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. It can occur as a result of long term exposure to high levels of stress that are still below the yield strength of the material. Creeps are more severe in materials that are subjected to heat for long periods and generally increases as they near the melting point.

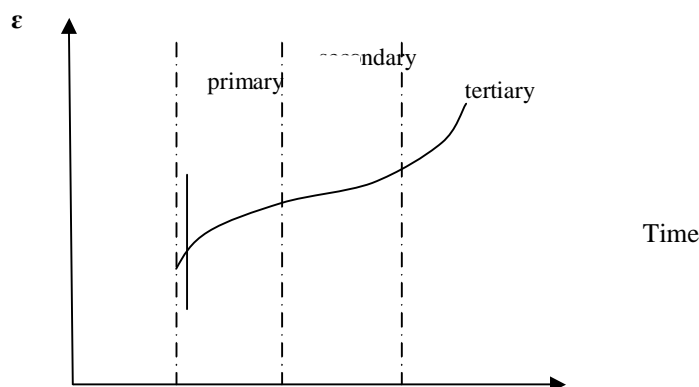


Fig 1.1 Strain as a function of time with respect to creep

In the initial stage, or primary creep, the strain rate is relatively high, but slows with increasing time. This is due to work hardening.

The strain rate eventually reaches the minimum and becomes near constant. This is due to balance between work hardening and annealing (thermal softening). This stage is known as secondary or steady creep. The characterised "creep strain rate" typically refers to the rate in the secondary stage. Stress dependences of this rate depend on the creep mechanism.

Tertiary creep, strain rate exponentially increases with stress because of necking phenomenon. Fracture occurs always at the tertiary stage. Creep is very important aspect of piping.

$$\text{CREEP RATE} = (\Delta \text{ strain} / \Delta \text{ time})$$

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$$= C \sigma^n \exp (Q_c / RT)$$

Where,

C = constant

Q_c = activation energy with respect to creep

R = gas constant

T = temperature.

3.2 THERMAL STRESS

Thermal stresses are the stress induced in a body due to change in temperature. Thermal stress is set up in the body, when the temperature of the body is raised or lowered and the body is not allowed to expand or contract freely. But, if the body is allowed to expand or contract freely, no stress will be set up in the body. But in piping mostly carbon steel, stainless steel P91 is used which has less strain capacity. Thermal stress is also known as temperature stress.

If the ends of the body are fixed to rigid supports, so that the expansion is prevented, then compressive stress and strain will be set up in the pipe. This stress and strain is called thermal stress and thermal strain.

$$\begin{aligned} \text{Thermal stress} &= \text{thermal strain} \times E \\ &= \alpha \cdot T \cdot E \end{aligned}$$

Where,

α is co-efficient of linear expansion,

T is rise in temperature

E is Young's modulus

3.3 CHANGES IN PROPERTIES OF MATERIAL

It is noted that the mechanical properties change with respect to the surrounding that is temperature and pressure. According to change in temperature the material tends to elongate or contract. Since then the mechanical property of that material also changes due to change in internal structure of the material.

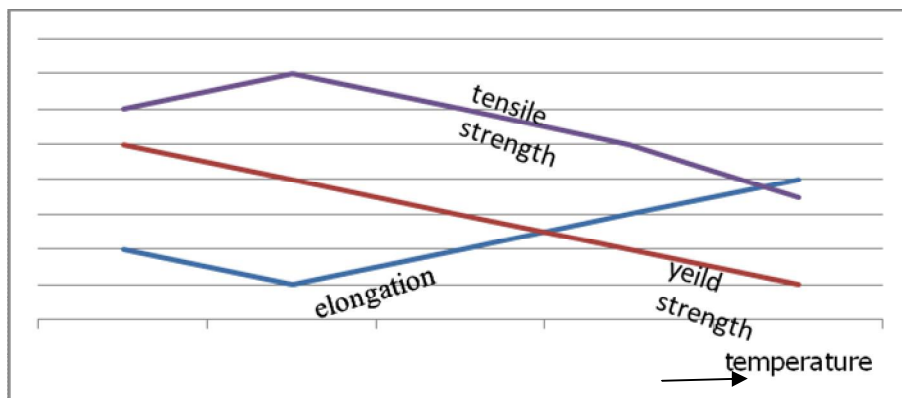


Fig 1.2 Change in mechanical properties with respect to temperature

But not only temperature pressure also has a great influence in changing the pressure. This pressure can be air pressure, water pressure or pressure from some other material surrounding the object. Obviously the pressure inside the power piping is due to super heated steam.

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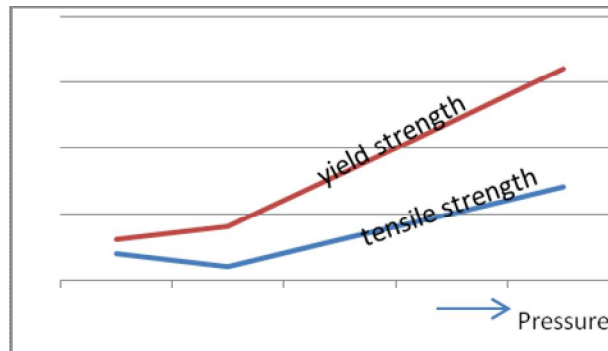


Fig 1.3 Change in properties of a material with respect to pressure

3.4 ELONGATION

Elongation is the property of the material to change in its dimensions freely. The property of the material to retain its original position after an external force is applied is elasticity. Since, deformation in the piping undergoes change in its position, the material which has high elongation properties will have less stress intensity factor and stress induced in that piping is less. It helps in piping material to retain its stress value.

3.5 MATERIAL SELECTION

By introducing Ni alloy, it not only withstands high temperature but also we can reduce the support to be given to the piping (since it has high strain). It has high thermal conductivity, and also withstands high pressure due to its high strain.

3.6 INCONEL 600

- INCONEL (nickel-chromium-iron) alloy 600 is a standard engineering material for applications which require resistance to corrosion and heat. The alloy also has excellent mechanical properties and presents the desirable combination of high strength and good workability.
- The limiting chemical composition of INCONEL alloy 600 is shown in table 1.1. The high nickel content gives the alloy resistance to corrosion by many organic and inorganic compounds and also makes it virtually immune to chloride-ion stress-corrosion cracking.

Table 1.1 - Limiting Chemical Composition, % of INCONEL 600

Nickel (plus Cobalt)	72.0 min
Chromium	14.0 -17.0
Iron	6.00 – 10.00
Carbon	0.15 max
Manganese	1.00 max
Sulfur	.015 max
Silicon	.50 max
Copper	.50 max

3.7 COMPARISON OF MATERIALS WITH RESPECT TO CREEP

In material science, creep is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. It can occur as a result of long term exposure to high levels of stress that are still below the yield strength of the material. Creep is more severe in materials that are subjected to heat for long periods and generally increases as they near the melting point.

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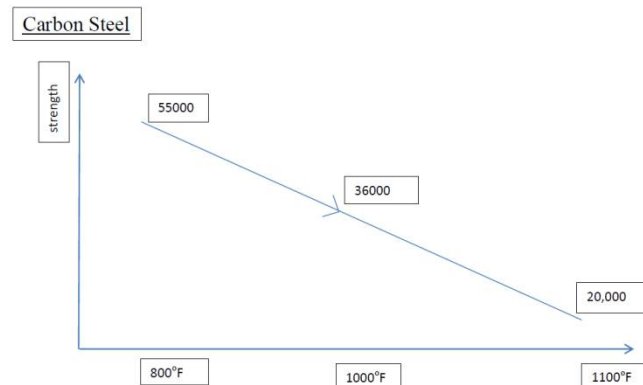


Fig 1.4 Creep strength for carbon steel

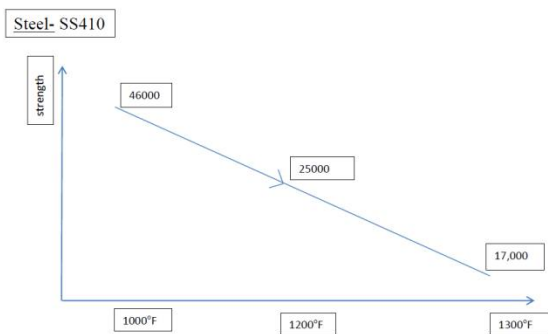


Fig 1.5 Creep strength for SS 410

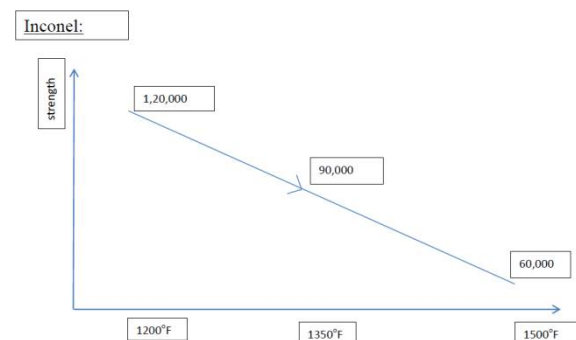


Fig 1.6 Creep strength for INCONEL

Thus from the above graph, the creep strength of a INCONEL material is more than the existing materials. Thus, replacing the existing material with INCONEL can be done.

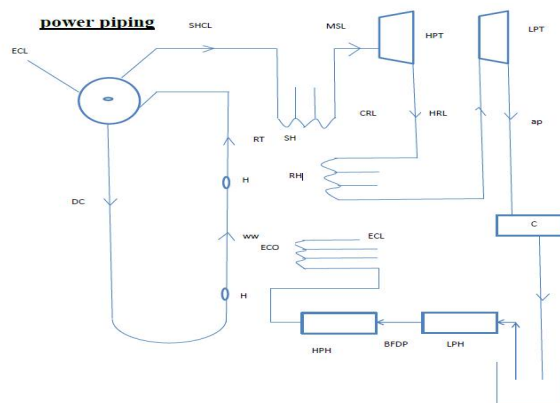


Fig 1.7 Power piping system

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4. METHODOLOGY

The main work of this project is to change the material of the piping for its prolonged life and to reduce the total operating cost of the boiler. Before implementing or changing the material we have to cross check whether it is correct to change the material is possible or not.

4.1 TESTING OF MATERIAL

The material selected should be checked for its property. The mechanical property of a material can be tested with various destructive testing. We did hardness test on purchased INCONEL 600. From this we can convert to find the tensile strength of the material by direct conversion.

Table 1.2 Hardness of material

MATERIAL	HRB
INCONEL 600	95

4.2 ANALYSIS THROUGH SOFTWARE

CAESAR II evaluates the structural responses and stresses of piping systems to international codes and standards. CAESAR II is a pipe stress analysis standard against which all others are measured. CAESAR II is a complete pipe stress analysis software program that allows quick and accurate analysis of piping systems subjected to weight, pressure, thermal, seismic and other static and dynamic loads. It can analyze piping systems of any size or complexity. CAESAR II is unique, incorporating calculation methods and analysis options not found in any other program.

By comparing two routings with two different materials i.e CARBON STEEL and INCONEL, the output result is taken. Designing of carbon steel is easy since the material is available in the package. Carbon steel routing is shown below with attachments.



Fig 1.7 CAESAR II routing of Carbon steel material

4.3 INSERTING INCONEL IN CAESAR II

The nickel alloy which we selected is not available in CAESAR II package. So we are adding this new material into the material database. Steps to insert a new material in CAESAR II are shown below as images.

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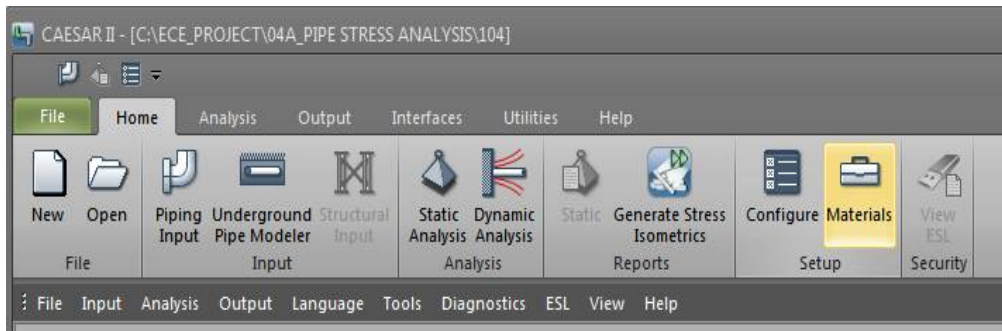


Fig 1.8 Inserting new material to the package

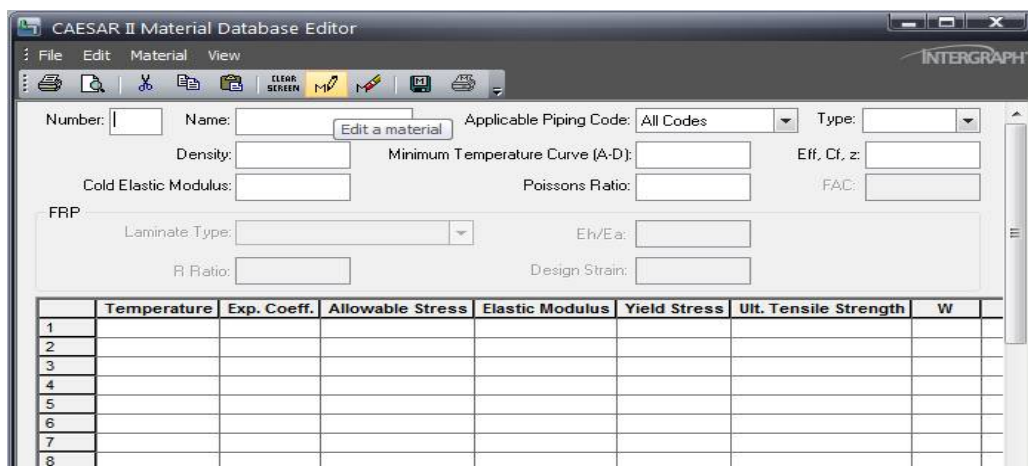


Fig 1.9 Properties to be inserted on CAESAR II package

The properties of the material with respect to temperature are collected from online sources. Then the Routing of the INCONEL material is drawn and analysed. The image showing the same routing with the inconel material is shown below.

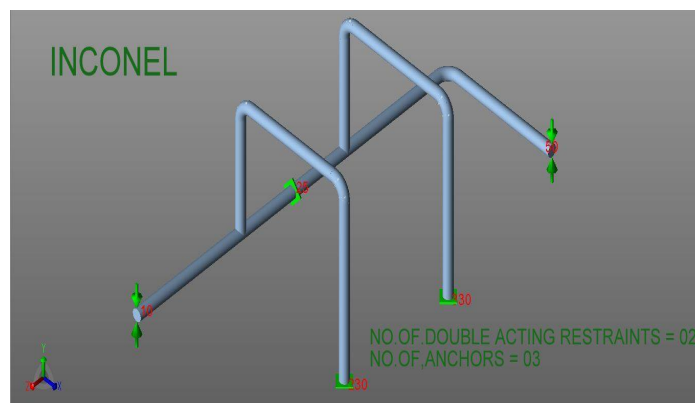


Fig 1.10 CAESAR routing with INCONEL material

Both the above routing is accepted since the code ratio is below the maximum value. The routing with the carbon steel piping needs many supports as shown 5 double acting restarant and 3 anchors. While the routing

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with the INCONEL has only 3 anchors and 2 double acting restrainers. This reduction of routing supports will reduce the the supporting cost and total operating cost of the piping.

4.4 CAESAR II REPORT

Table 1.3 Displacement result for CARBON STEEL

Node	DX in.	DY in.	DZ in.	RX deg.	RY deg.	RZ deg.
10	-0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	-0.0003	-0.0000	0.0000	-0.0012	0.0009	0.0000
20	-0.0008	-0.0008	0.0000	0.0003	0.0011	0.0000
25	-0.0014	-0.0000	0.0000	0.0000	0.0010	-0.0002
30	-0.0019	-0.0008	0.0000	-0.0002	0.0008	-0.0004
35	-0.0023	-0.0000	0.0000	0.0010	0.0008	-0.0001
38	-0.0026	-0.0001	0.0000	-0.0008	0.0008	0.0001
39	-0.0027	-0.0002	-0.0000	-0.0009	0.0008	0.0002
40	-0.0027	-0.0002	-0.0001	-0.0009	0.0008	0.0003
45	-0.0027	-0.0000	-0.0004	-0.0009	0.0008	0.0002
50	-0.0027	-0.0000	-0.0009	-0.0009	0.0008	0.0001
208	-0.0008	-0.0008	0.0002	0.0002	0.0006	-0.0004
209	-0.0007	-0.0008	0.0002	0.0002	0.0005	-0.0007
210	-0.0007	-0.0009	0.0002	0.0002	0.0005	-0.0007
218	-0.0007	-0.0003	-0.0001	-0.0000	0.0002	0.0021
219	-0.0006	-0.0001	-0.0001	-0.0000	0.0002	0.0019
220	-0.0005	-0.0000	-0.0001	-0.0001	0.0002	0.0014
230	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000
308	-0.0014	-0.0008	-0.0001	-0.0001	0.0004	-0.0010
309	-0.0013	-0.0008	-0.0001	-0.0001	0.0003	-0.0011
310	-0.0013	-0.0009	-0.0001	-0.0001	0.0002	-0.0010
318	-0.0013	-0.0003	-0.0002	-0.0002	0.0000	0.0024
319	-0.0012	-0.0001	-0.0002	-0.0002	0.0000	0.0023
320	-0.0011	-0.0000	-0.0002	-0.0002	0.0000	0.0020
330	0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0000

Table 1.4 Stress analysis report for Carbon Steel

Node	Bending Stress lb./sq.in.	Torsion Stress lb./sq.in.	SIF/Index In Plane	SIF/Index Out Plane	Code Stress lb./sq.in.	Allowable Stress lb./sq.in.	Ratio %	Piping Code
10	71.9	0.0	1.000	1.000	378.2	10800.0	3.5	B31.1
15	190.3	-0.0	1.000	1.000	496.5	10800.0	4.6	B31.1
15	190.3	0.0	1.000	1.000	496.5	10800.0	4.6	B31.1
20	252.7	-0.0	1.000	1.000	559.0	10800.0	5.2	B31.1
20	6.0	5.2	1.000	1.000	318.4	10800.0	2.9	B31.1
208	30.5	-5.2	1.000	1.000	338.5	10800.0	3.1	B31.1
208	33.3	5.2	1.089	1.089	338.5	10800.0	3.1	B31.1

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Node	Bending Stress lb./sq.in.	Torsion Stress lb./sq.in.	SIF/Index In Plane	SIF/Index Out Plane	Code Stress lb./sq.in.	Allowable Stress lb./sq.in.	Ratio %	Piping Code
209	19.4	-5.0	1.089	1.089	326.7	10800.0	3.0	B31.1
209	19.4	5.0	1.089	1.089	326.7	10800.0	3.0	B31.1
210	20.3	-2.1	1.089	1.089	325.4	10800.0	3.0	B31.1
210	18.7	2.1	1.000	1.000	325.4	10800.0	3.0	B31.1
218	4.1	-2.1	1.000	1.000	312.1	10800.0	2.9	B31.1
218	4.4	2.1	1.089	1.089	312.1	10800.0	2.9	B31.1
219	43.2	-0.6	1.089	1.089	346.0	10800.0	3.2	B31.1
219	43.2	0.6	1.089	1.089	346.0	10800.0	3.2	B31.1
220	58.9	1.0	1.089	1.089	360.4	10800.0	3.3	B31.1
220	54.1	-1.0	1.000	1.000	360.4	10800.0	3.3	B31.1
230	6.3	1.0	1.000	1.000	312.9	10800.0	2.9	B31.1
20	250.0	-2.7	1.000	1.000	556.3	10800.0	5.2	B31.1
25	318.1	2.7	1.000	1.000	624.3	10800.0	5.8	B31.1
25	318.1	-2.7	1.000	1.000	624.3	10800.0	5.8	B31.1
30	251.7	2.7	1.000	1.000	558.0	10800.0	5.2	B31.1
30	14.9	5.1	1.000	1.000	324.2	10800.0	3.0	B31.1
308	21.0	-5.1	1.000	1.000	329.6	10800.0	3.1	B31.1
308	22.9	5.1	1.089	1.089	329.6	10800.0	3.1	B31.1
309	8.2	-4.1	1.089	1.089	317.4	10800.0	2.9	B31.1
309	8.2	4.1	1.089	1.089	317.4	10800.0	2.9	B31.1
310	33.9	-1.0	1.089	1.089	337.4	10800.0	3.1	B31.1
310	31.1	1.0	1.000	1.000	337.4	10800.0	3.1	B31.1
318	13.2	-1.0	1.000	1.000	319.6	10800.0	3.0	B31.1
318	14.4	1.0	1.089	1.089	319.6	10800.0	3.0	B31.1
319	26.7	-0.5	1.089	1.089	330.8	10800.0	3.1	B31.1
319	26.7	0.5	1.089	1.089	330.8	10800.0	3.1	B31.1
320	45.6	0.0	1.089	1.089	348.1	10800.0	3.2	B31.1
320	41.8	-0.0	1.000	1.000	348.1	10800.0	3.2	B31.1
330	31.9	0.0	1.000	1.000	338.1	10800.0	3.1	B31.1
30	245.5	4.1	1.000	1.000	551.8	10800.0	5.1	B31.1

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35	196.1	-4.1	1.000	1.000	502.5	10800.0	4.7	B31.1
35	196.1	4.1	1.000	1.000	502.5	10800.0	4.7	B31.1
38	15.6	-4.1	1.000	1.000	323.9	10800.0	3.0	B31.1
38	17.0	4.1	1.089	1.089	323.9	10800.0	3.0	B31.1
39	7.7	-5.6	1.089	1.089	319.5	10800.0	3.0	B31.1
39	7.7	5.6	1.089	1.089	319.5	10800.0	3.0	B31.1
40	20.3	-0.0	1.089	1.089	324.9	10800.0	3.0	B31.1
40	18.6	0.0	1.000	1.000	324.9	10800.0	3.0	B31.1
45	59.5	0.0	1.000	1.000	365.7	10800.0	3.4	B31.1
45	59.5	0.0	1.000	1.000	365.7	10800.0	3.4	B31.1
50	0.0	0.0	1.000	1.000	306.3	10800.0	2.8	B31.1

Table 1.5 Displacement result of INCONEL

Node	DX in.	DY in.	DZ in.	RX deg.	RY deg.	RZ deg.
10	0.0000	-0.0000	-0.0000	-0.0071	0.0000	0.0011
20	-0.0000	-0.0025	-0.0000	0.0046	0.0000	0.0011
25	0.0000	-0.0000	0.0000	-0.0000	-0.0000	0.0000
30	0.0009	-0.0096	0.0000	-0.0299	-0.0033	0.0106
38	0.0040	-0.0460	0.0000	-0.0432	-0.0033	0.0357
39	0.0042	-0.0480	0.0001	-0.0428	-0.0033	0.0382
40	0.0043	-0.0464	0.0004	-0.0423	-0.0033	0.0417
50	0.0043	-0.0000	0.0034	-0.0423	-0.0033	0.0551
208	-0.0010	-0.0025	0.0029	0.0035	0.0010	0.0013
209	-0.0011	-0.0025	0.0031	0.0033	0.0012	0.0011
210	-0.0011	-0.0024	0.0031	0.0032	0.0014	0.0011
218	-0.0011	-0.0004	0.0018	0.0024	0.0015	0.0034
219	-0.0010	-0.0001	0.0017	0.0023	0.0013	0.0030
220	-0.0008	-0.0000	0.0015	0.0022	0.0012	0.0023
230	0.0000	-0.0000	0.0000	0.0000	0.0000	-0.0000
308	-0.0057	-0.0096	-0.0186	-0.0227	-0.0083	0.0082
309	-0.0063	-0.0094	-0.0200	-0.0216	-0.0091	0.0080
310	-0.0065	-0.0088	-0.0199	-0.0209	-0.0100	0.0080
318	-0.0065	-0.0011	-0.0112	-0.0153	-0.0099	0.0103
319	-0.0062	-0.0003	-0.0101	-0.0146	-0.0090	0.0098
320	-0.0055	-0.0000	-0.0088	-0.0135	-0.0082	0.0089
330	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000

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Table 1.6 Stress analysis report of INCONEL

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10	0.0	0.0	1.000	1.000	153.1	85000.0	0.2	B31.1
20	278.0	0.0	1.000	1.000	431.1	85000.0	0.5	B31.1
20	57.9	-11.2	1.000	1.000	215.2	85000.0	0.3	B31.1
208	30.2	11.2	1.000	1.000	190.7	85000.0	0.2	B31.1
208	32.9	-11.2	1.090	1.090	190.7	85000.0	0.2	B31.1
209	31.9	1.6	1.090	1.090	182.6	85000.0	0.2	B31.1
209	31.9	-1.6	1.090	1.090	182.6	85000.0	0.2	B31.1
210	29.5	-7.7	1.090	1.090	184.3	85000.0	0.2	B31.1
210	27.1	7.7	1.000	1.000	184.3	85000.0	0.2	B31.1
218	34.2	-7.7	1.000	1.000	190.6	85000.0	0.2	B31.1
218	37.2	7.7	1.090	1.090	190.6	85000.0	0.2	B31.1
219	83.4	-0.2	1.090	1.090	229.6	85000.0	0.3	B31.1
219	83.4	0.2	1.090	1.090	229.6	85000.0	0.3	B31.1
220	98.0	8.6	1.090	1.090	244.7	85000.0	0.3	B31.1
220	90.0	-8.6	1.000	1.000	244.7	85000.0	0.3	B31.1
230	62.9	8.6	1.000	1.000	218.3	85000.0	0.3	B31.1
20	325.8	-16.9	1.000	1.000	480.6	85000.0	0.6	B31.1
25	760.3	16.9	1.000	1.000	914.2	85000.0	1.1	B31.1
25	2068.4	165.0	1.000	1.000	2247.6	85000.0	2.6	B31.1
30	479.7	-165.0	1.000	1.000	735.3	85000.0	0.9	B31.1
30	311.5	56.1	1.000	1.000	484.2	85000.0	0.6	B31.1
308	137.1	-56.1	1.000	1.000	330.3	85000.0	0.4	B31.1
308	149.4	56.1	1.090	1.090	330.3	85000.0	0.4	B31.1
309	170.9	3.7	1.090	1.090	310.2	85000.0	0.4	B31.1
309	170.9	-3.7	1.090	1.090	310.2	85000.0	0.4	B31.1
310	100.4	54.5	1.090	1.090	295.9	85000.0	0.3	B31.1
310	92.2	-54.5	1.000	1.000	295.9	85000.0	0.3	B31.1
318	101.7	54.5	1.000	1.000	302.3	85000.0	0.4	B31.1
318	110.9	-54.5	1.090	1.090	302.3	85000.0	0.4	B31.1

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Node	Bending Stress lb./sq.in.	Torsion Stress lb./sq.in.	SIF/Index In Plane	SIF/Index Out Plane	Code Stress lb./sq.in.	Allowable Stress lb./sq.in.	Ratio %	Piping Code
319	198.4	1.9	1.090	1.090	335.2	85000.0	0.4	B31.1
319	198.4	-1.9	1.090	1.090	335.2	85000.0	0.4	B31.1
320	191.1	-58.7	1.090	1.090	364.2	85000.0	0.4	B31.1
320	175.4	58.7	1.000	1.000	364.2	85000.0	0.4	B31.1
330	442.5	-58.7	1.000	1.000	611.0	85000.0	0.7	B31.1
30	759.3	218.0	1.000	1.000	1028.7	85000.0	1.2	B31.1
38	19.2	-218.0	1.000	1.000	589.6	85000.0	0.7	B31.1
38	20.9	218.0	1.090	1.090	589.6	85000.0	0.7	B31.1
39	337.5	-157.6	1.090	1.090	595.0	85000.0	0.7	B31.1
39	337.5	157.6	1.090	1.090	595.0	85000.0	0.7	B31.1
40	489.9	-0.0	1.090	1.090	602.8	85000.0	0.7	B31.1
40	449.7	0.0	1.000	1.000	602.8	85000.0	0.7	B31.1
50	0.0	0.0	1.000	1.000	153.1	85000.0	0.2	B31.1

The allowable stress in CARBON STEEL is 74.46 M Pa. The allowable stress in INCONEL is 586 M Pa and the tested Strength for the INCONEL material is 676 M Pa. The results were generated as per piping B 31.1.

V. RESULTS AND DISCUSSION

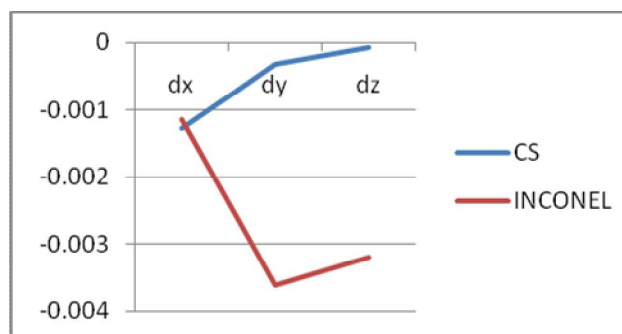


Fig 1.11 Comparison of average linear displacement

In average linear displacement result comparison the inconel and carbon steel has less displacement. But the supports used in inconel is less than carbon steel.

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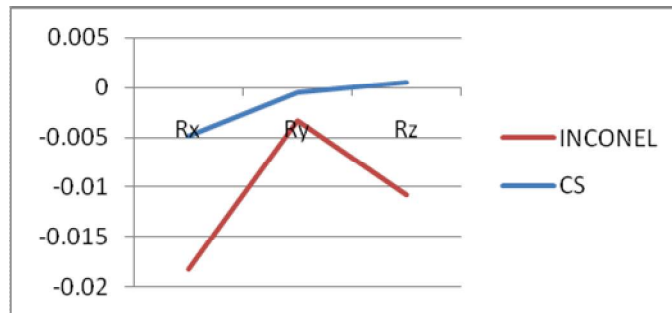


Fig 1.12 Comparison of average rotational displacement

In average Rotary displacement result comparison the inconel and carbon steel has less displacement. But the supports used in inconel is less than carbon steel

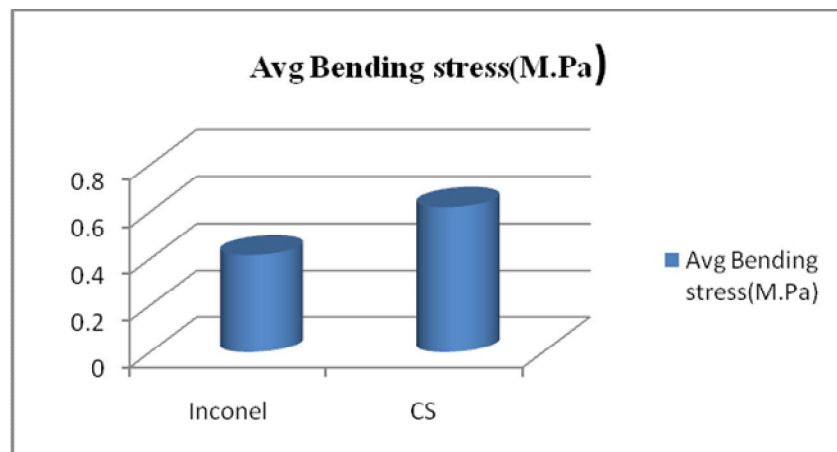


Fig 1.13 Comparison of average bending stress

In bending stress, the carbon steel material has more stress while compared to inconel because of the elongation property.

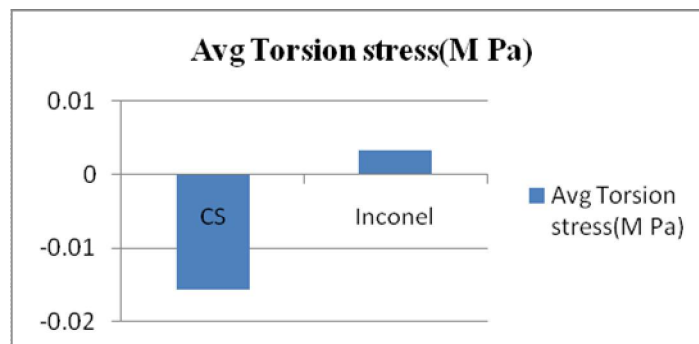


Fig 1.14 Comparison of average torsional stress

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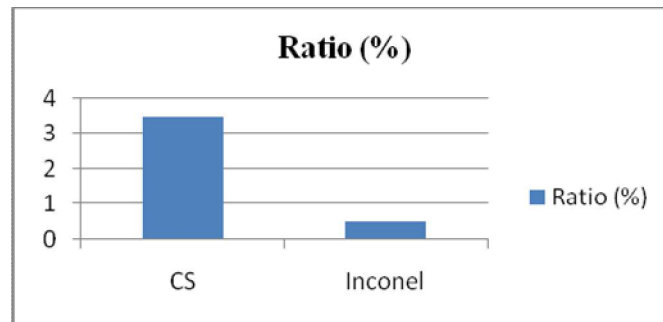


Fig 1.15 Comparison of code ratio

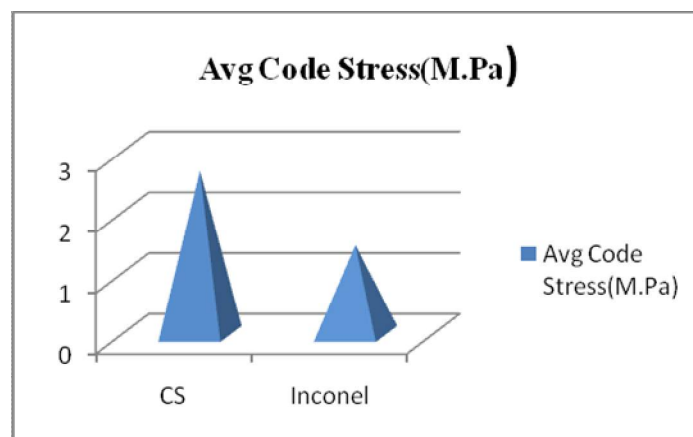


Fig 1.16 Comparison of average code stress

For a successful piping, the code stress should be less than 60. Although both Inconel and Carbon Steel got less than 60, the Inconel has a range from 1 to 1.5 which is more efficient.

Since the Inconel material is being used, the number of supports giving over the piping will be reduced because the Inconel material has more elongation property when compared to Carbon steel.

VI. CONCLUSION

In Boiler piping's, the carbon steel is being used. The carbon steel can't withstand more than 600°C. It also requires more number of supports in order to arrest the displacement over the piping. Hence we are replacing the carbon steel by INCONEL material (75 Ni 15 Cr 10Fe) which is of a nickel based alloy. The Inconel material has more strength and high elongation property when compared to the carbon steel material. Since the Inconel has more elongation property the number of supports will be reduced in order to arrest the displacement, rotational, stresses, etc... Another major advantage while compared to carbon steel piping will be of service life of the piping. By replacing the carbon steel material by Inconel the life time of the piping is increased.

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