iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 7 **Issue:** IV **Month of publication:** April 2019

**DOI:** https://doi.org/10.22214/ijraset.2019.4520

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

# FE Analysis of a Leak Repair Clamp for Misaligned Pipelines

Hiren Patel[1], Chetan Vora[2]
[1]M.E. (Machine Design), [2]Associate Professor, Mechanical Engineering Department, Kalol Institute of Technology and Research Centre, Gujarat Technological University, Gujarat, India

***Abstract: The Pipelines are the most important mode of transportation for fluid and gas. The maintenance of pipelines is always critical because it has been carried out without interrupting the transportation process or other operation. The following dissertation is about misalignment in the pipeline which are working underwater and having critical operation. The most probable place for misalignment is welded joint.***

***Due to misalignment the welded portion gets stretched and crack starts thereafter. Under such condition it is very difficult to replace the pipe or providing the alternation.***

***The dissertation describes the possible solution of providing a clamp type structure. The model will be designed in CRE-O software and the finite analysis is carried out in ANSYS software. The validation of the solution will be made through the manual calculation as per the standards.***

***Keywords: Clamp, pipelines, misalignment, maintenance, finite analysis***

## I. INTRODUCTION

The resources are very important to be handled. Not all the places are getting all the resources naturally. Similarly other materials are also not available at all the places.

The material can be in any form solid or liquid or gas.

There are number of ways for transporting material from one place to another. One of the major and most general method of transferring the needful material of liquid and gas is the pipelines. The liquid and gas are difficult to transport compared to solid. The pipelines are the heart of the petroleum (or Oil and Gas) sector.

### *A. Failure in Pipelines*

There are major three aspects of the physical failure mechanisms in pipelines.

1) Pipe properties, material type, pipe-soil/water interaction, and quality of installation.
2) Internal loads due to operational pressure and external loads due to soil overburden, traffic loads, frost loads, corrosion and
3) Third party interference.

### *B. Pipeline Damage Scenarios*

The damage scenarios can be expressed by categorizing pipeline damages as follows (ABS Guide for Building and Classing Subsea Pipeline Systems, 2006):

1) *Internal Damage:* Pipeline service and flow conditions can be damaged by Corrosion of the pipes. Corrosion damage happens more likely at pipe low points, bends and fittings. Internal erosion damage occurs through abrasion by the pipeline flow, generally at bends, trees, valves, etc. Erosion may be a primary cause of corrosion too.
2) *External Damage:* Dropped objects due to activities on or surrounding nearby installations like platform, drilling units, etc. and abrasion between cable or chain and the pipe outer surface. Damage caused by direct hit, snagging or dragging due to anchoring or trawling is also included in external damages occurred on pipelines.
3) *Environmental Damage:* Severe storms and excessive hydrodynamic loads (e.g. Hurricanes), Earthquake, Seabed movement and instability, Iceberg liquefaction, Corrosion is the most frequent pipeline damage scenario, especially when it comes to deep waters, where anchoring and trawling less probable. The environmental damages are also common for some areas like in Gulf of Mexico.

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887*
*Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com*

*C. Misalignment*

The pipelines are either above ground or underground. The problems on the above ground can be diagnosed and resolved by many ways. But there are many problems in maintaining the underground pipelines. The pipelines which are underground have many loads internal as well as external. The more problem occurs when the pipelines are underwater as the work capacity and use of maintenance becomes limited. The result causes the pipelines misaligned from either the weak portion or the joint. ( most at welded joints ).

*D. Different Solutions*

1) The repairing of the pipe is started when the crack is detected. The most general procedure of repairing includes the providing the sleeve.
2) The sleeve is generally provided with the same thickness of pipe. The material must be same or higher grade than the pipe material for the sleeve. In most cases the standard pipes of API 5L sizes are preferred for the applications. The sleeve provides and increases the effective life of the operation.
3) Another method is to provide the clamp; the clamp is fitted on the pipes where the crack is detected. The Clamp is selected according to the pipe size and crack area. The Clamp is bolted around the pipe. The crack area is an important factor because the leak will only be effective if the crack area is properly covered.

Both of the solutions are used as per the conditions and solution requirement. Generally the clamp is more preferable because it has longer life and can be replaced. The studs and nuts/bolts are disassembled in sequence to replace or remove the clamp; the sleeve is used where the crack is minor or not so much effective to the strength and operation.

## II. DESIGN METHODOLOGY

Internal design pressure = 10.2 MPa
External design pressure = N.A.
Design temperature for internal pressure = 20°
Design temperature for external pressure = N.A.
Inside diameter = 610 mm
Material = API 5L GR. 70
Allowable stress at design temperature = 482 MPa
Joint efficiency for longitudinal joint = 1.0
Joint efficiency for circumferential joint = 0.85
Corrosion allowance = 3 mm

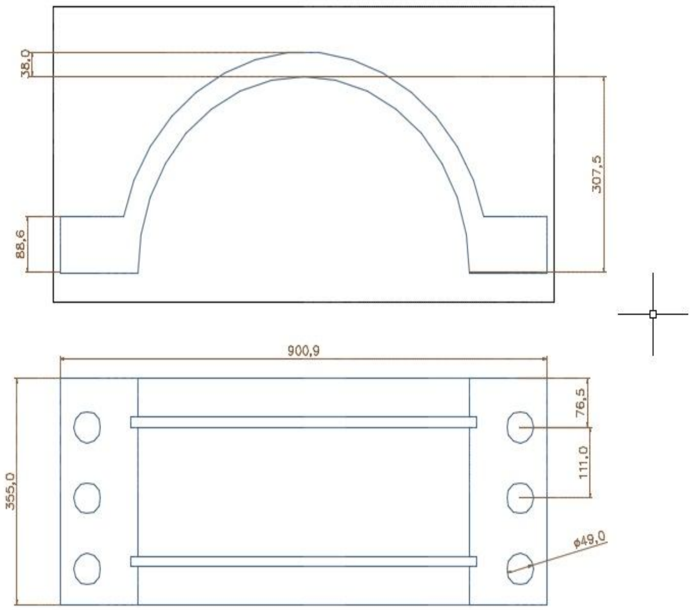



Fig. 1 Clamp geometry

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

*A. Equivalent Stress (Von-Mises Stress)*

From three dimensional stresses, equivalent stress can be found by the equation,

$$\sigma_e = \sqrt{\frac{1}{2}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2\right]}$$

where, $\sigma_1$,$\sigma_2$,$\sigma_3$ are three-dimensional stresses , $\sigma_e$ is an Equivalent stress

Failure occurs when: $\sigma_e \geq S_y$ , Factor of safety: $\eta = \frac{S_y}{\sigma_e}$

Typically, Factor of safety occurs to limit $1.25 \leq \eta \leq 4$

*B. Maximum Tangential stress at Inner Surface*

According to Lame's Equation,

Tangential stress, $\sigma_t = \frac{P(r_i)^2}{(r_o)^2 - (r_i)^2}\left[1 + \frac{(r_o)^2}{x^2}\right]$

And radial stress at any radius x, $\sigma_r = \frac{P(r_i)^2}{(r_o)^2 - (r_i)^2}\left[1 + \frac{(r_o)^2}{x^2}\right]$

P = Internal fluid pressure in the pipe

$r_i$ = Inner radius of pipe

$r_o$ = Outer radius of pipe

Now, tangential stress is maximum at inner surface ($x = r_i$) and
minimum at outer surface ($x = r_o$).

$\sigma_{t(max.)} = 87.9362$

## III. DESIGN ANALYSIS

The Design of the model has been done in the CreO software and the static structural analysis has been carried out in Ansys software.

The figure shows the model for the 24 inch pipe. The assembly of model contains the following parts:

1) Clamp
2) Seal and
3) Bolt

For the ease of analysis operation, clamp with 3 bolts at each side is taken into consideration for analysis purpose.

The unit system is taken as metric. A single path is generated as construction geometry in the Ansys software.

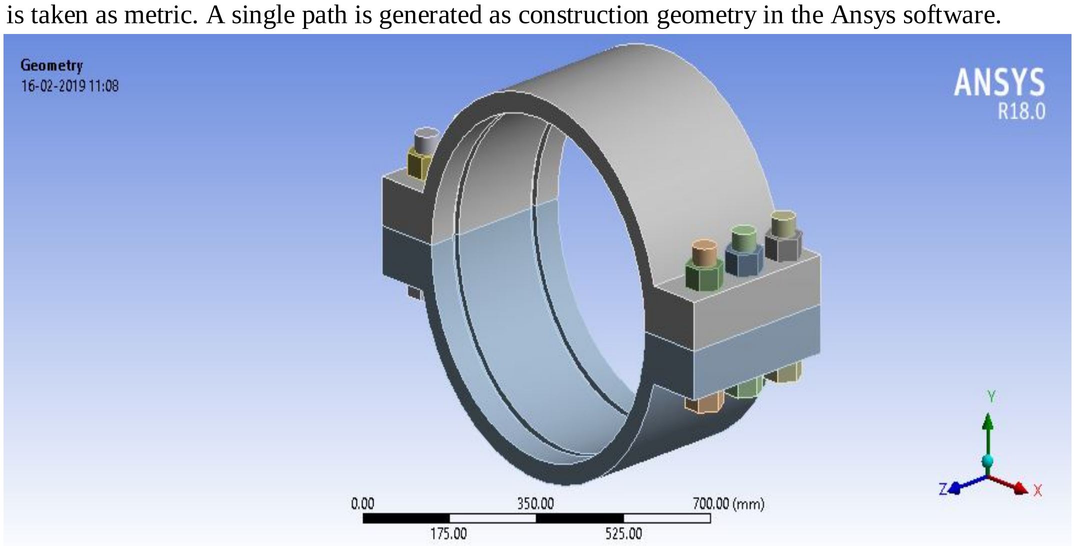



Fig. 2 3D CAD Model

The path is used for linearized equivalent stress calculation result. The Coordinate system was taken as front portion of the clamp.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

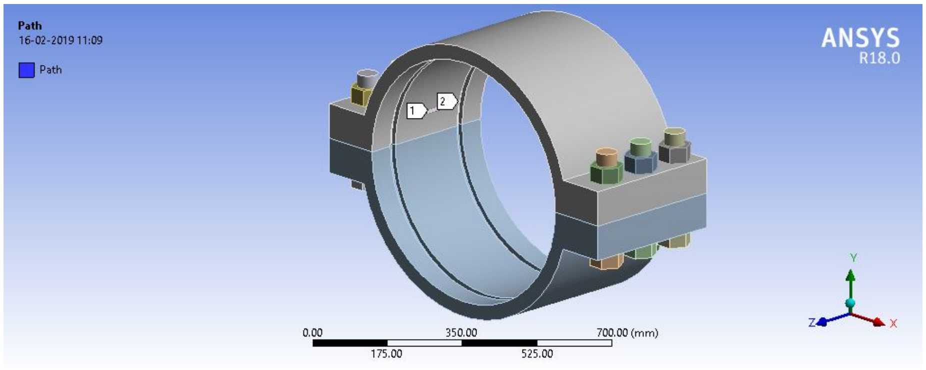



Fig. 3 Path generation in Ansys software

The first boundary Condition as Pressure applied is taken as 10.2 MPa or it can be said 102 bar.
The pressure is applied on the internal surface of the Clamp. The Area which will bear most pressure will be the area between the seal in the clamp.
Another Boundary condition taken is the fixed support.

### *A. Analysis Results*

#### *1) Equivalent Stress*

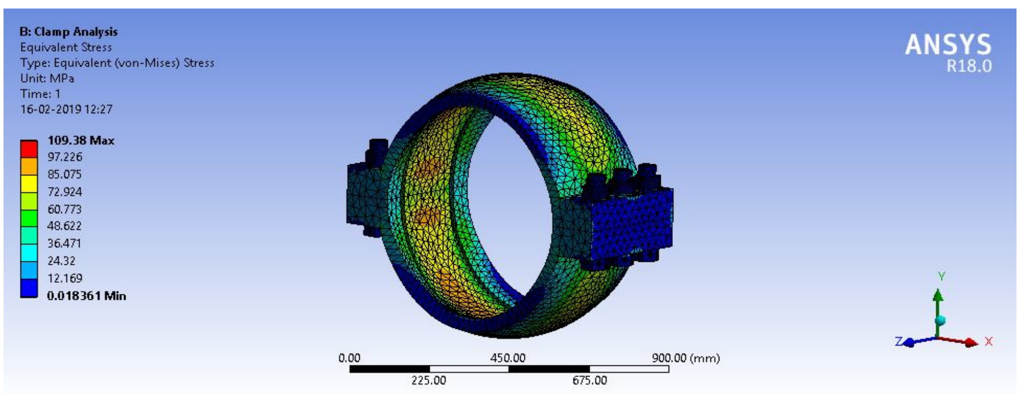



Fig. 4 Equivalent stress generated in Geometry

#### *2) Total Deformation*

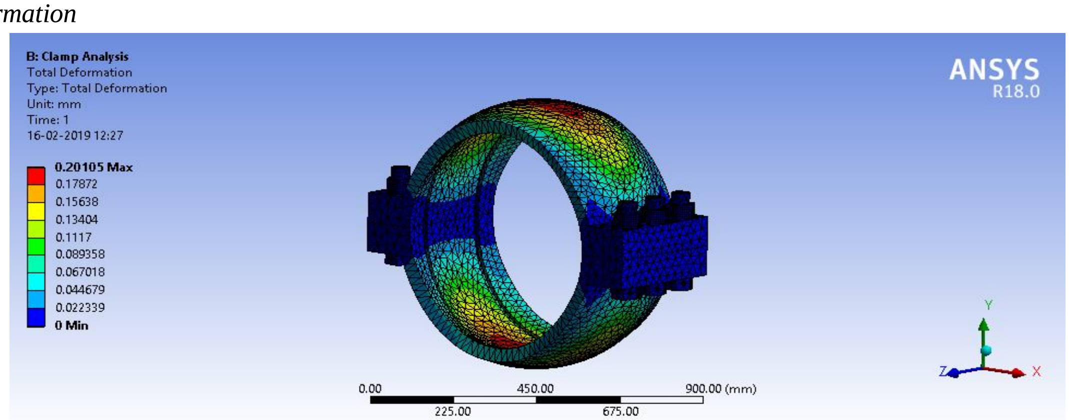



Fig. 5 Total deformation resulted in geometry

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887*
*Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com*

*3) Linearized Equivalent Stress Along The Path*

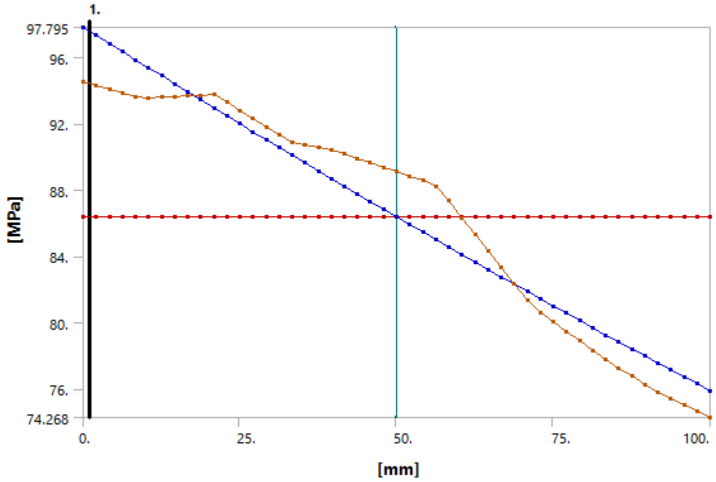



Fig. 6 Graph for linearized equivalent stress along the path

*4) Resultant Stresses*

TABLE I
Resultant stresses

| | |
|---|---|
| Membrane | 86.37 MPa |
| Bending (Inside) | 14.203 MPa |
| Bending (Outside) | 14.203 MPa |
| Membrane + Bending (Inside) | 97.795 MPa |
| Membrane + Bending (Center) | 86.37 MPa |
| Membrane + Bending (Outside) | 75.889 MPa |
| Peak (Inside) | 5.5671 MPa |
| Peak (Center) | 3.4458 MPa |
| Peak (Outside) | 11.609 MPa |
| Total (Inside) | 94.502 MPa |
| Total (Center) | 89.106 MPa |
| Total (Outside) | 74.268 MPa |

*B. Validation*

Design Pressure Conditions will be compared with ASME Codes (Protection against Plastic Collapse). Stress comparisons are made as per ASME Sect VIII, Div. 2 (Ed.2015).

PL + Pb + Q is compared with Sps

PL is compared with $S_{PL}$

Pm is compared with S

where, PL = membrane stress

Pb = bending stress

Q = external value of stress

S = allowable stress for material

= 0.72 x Yield Strength

$S_{PL}$ = 1.5 x S or Sy (1.5 x S shall be used when the ratio of the minimum specified yield strength to ultimate tensile strength exceeds 0.70)

Sps = allowable stress for primary and secondary stresses (ASME Section VIII, Div. 2, Part 5.5.6.1.d)

TABLE II
Conclusion for Primary stress

| Load Case | Location | PL (MPa) | Allowable | Result |
|---|---|---|---|---|
| Static Structure | At maximum Stress location (Shell Flange) | 86.37 | 347.472 | Pass |

TABLE III
Conclusion for Primary and secondary stress

| Load Case | Location | PL+Pb+Q (MPa) | Allowable | Result |
|---|---|---|---|---|
| Static Structure | At maximum Stress location (Shell Flange) | 97.795 | 1042.416 | Pass |

## IV. CONCLUSIONS

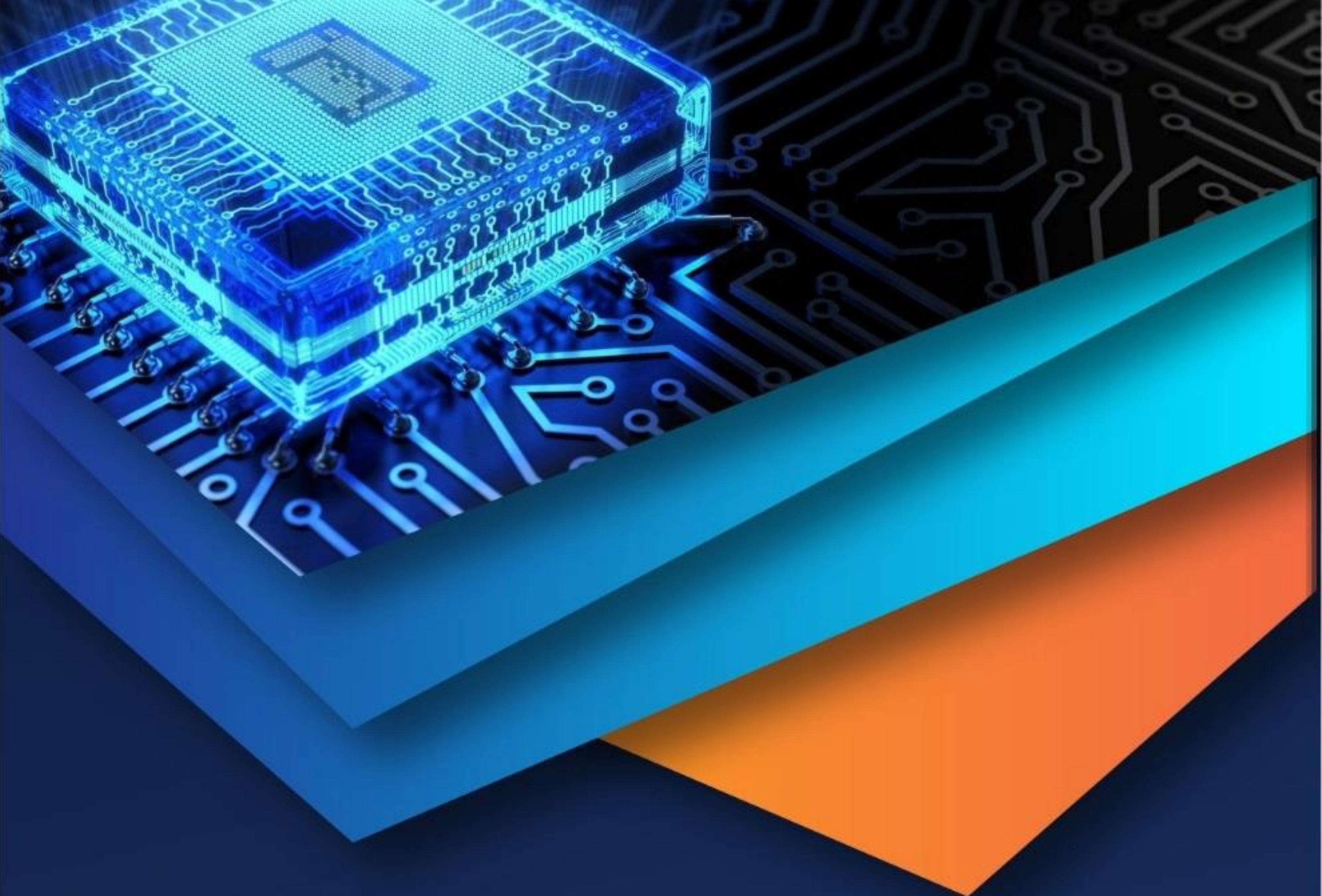
The Finite Element Analysis of the Clamp component is done by using ANSYS software for determination of stresses and deformations. As per ASME (American Society for Mechanical Engineers) Boiler and Pressure vessel standard validation, the stresses asserted on clamp body by applying high pressure of 10.2 MPa are under allowable stresses. By using clamp components on the misaligned or deformed pipe joints or sleeve, pipeline integrity can be ensured by minimizing deformations. By using Clamps as the permanent solution, Maintenance costs and damages to the pipelines can also be minimized.

## V. ACKNOWLEDGMENT

We are thankful to department of Mechanical Engineering of KIT&RC-GUJARAT, India for providing the necessary facilities for the successful completion of the work. Also I am thankful to Mr. CHETAN VORA, Associate Professor, Mechanical Engineering Department, KIT&RC-GUJARAT for his cooperation and guidance.

## REFERENCES

[1] Ahmed r. Alian a, mostafa shazly b, mohammad m. Megahed, “3d finite element modeling of in-service sleeve repair welding of gas pipelines” , international journal of pressure vessels and piping 146 (2016) 216 – 229.
[2] Ahmed r. Alian a, mostafa shazly b, mohammad m. Megahed, “finite element simulation of in-service sleeve repair welding of gas pipelines”, applied mechanics and materials vols. 313-314 (2013) pp. 957-961.
[3] A.f.m. Arif, y.n. Al-nassar, h. Al-qahtani, s.m.a. Khan, m. Anis, a.m. Eleiche, m. Inam, n.i. Al-nasri, h.m. Al-muslim, “optimization of pipe repair sleeve design”, proceedings of the asme 2011 pressure vessels & piping division conference pvp2011, july 17-21, 2011, baltimore, maryland, usa
[4] Igor orynyak, volodymyr stryzhalo, sergii ageiev, a. V. Bogdan, “strength analysis of a split sleeve in a pipe containing a defect”, strength of materials, vol. 41, no. 2, 2009
[5] J.l. Oteguia, a. Cisilinoa, a.e. Rivasa, m. Chapettia, g. Soulab, “influence of multiple sleeve repairs on the structural integrity of gas pipelines”, international journal of pressure vessels and piping 79 (2002) 759–765
[6] K. Dhalla, g. L. Jones, “asme code classification of pipe stresses: a simplified elastic procedure”, int. J. Pres. Ves. & piping 26 (1986) 145-166
[7] C. Bandera & a. Strozzi, “displacements in a clamped annular plate transversely loaded at an arbitrary point by a concentrated force”, int. J. Pres. Ves. & piping 49 (1991) 17-34
[8] H.m. Wen, “deformation and tearing of clamped circular work-hardening plates under impulsive loading”, int. J. Pres. Ves. & piping 75 (1998) 67-73
[9] Cornelis j. Dekkera, walther j. Stikvoortb, “improved design rules for pipe clamp connectors”, int. J. Pres. Ves. & piping 81 (2004) 141-157
[10] Shigley’s mechanical engineering design; 9th edition by richard g. Budynas and j. Keith nisbett; page: 113-115, 422-473
[11] Pm international suppliers, accessed on 20 august, 2018, https://www.api5lx.com/api5lx-grades/
[12] The american society of mechanical engineers, accessed on 5 january, 2019, https://www.asme.org/




10.22214/IJRASET

45.98

IMPACT FACTOR:
7.129

IMPACT FACTOR:
7.429


# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY