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Review Paper on the Faliure Analysis of Weld: Neck Flanges

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Abstract:
The modern mechanised world depends largely on several mechanical components to survive each day, one such component is the flange, and any pipe interconnection requires a flange, today the usage of pipes in different fields' ranges from city water distribution networks to sub sea oil transportation to cryogenic applications. Hence it was deemed that the study of such a critical component in today's industrialised world was very much important and thus this study was taken up to analyse the various failure criterions of welded neck flanges and to optimize their performance in service and also to come up with standards and procedures in their manufacturing and integration withlarger systems. The inferences obtained were a result of several metallographic, hydrostatic and material tests, along with multi-dimensional analysis using computer models of the flange in stress and thermal loads.

1. Introduction

A flange joint is a connection of pipes, where the connecting pieces have flanges by which the parts are either bolted, welded of fastened together.

There are many different flange standards to be found worldwide. To allow easy functionality and inter-changeability, these are designed to have standardised dimensions. Common world standards include ASA/ANSI/ASME (USA), PN/DIN (European), BS10 (British/Australian), and JIS/KS (Japanese/Korean). In most cases these are not interchangeable (e.g. an ANSI/ASME flange will not mate against a JIS flange). Further, many of the flanges in each standard are divided into "pressure classes", allowing flanges to be capable of taking different pressure ratings. Again these are not generally interchangeable (e.g. an ANSI/ASME 150 will not mate with an ANSI/ASME 300).

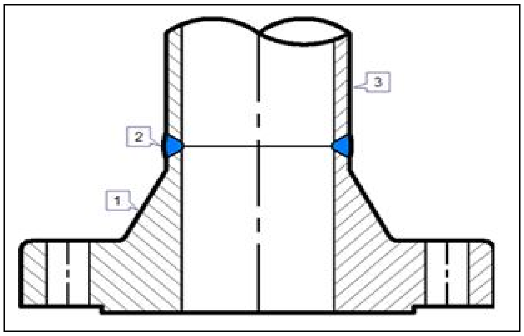
These pressure classes also have differing pressure and temperature ratings for different materials. The flange faces are also made to standardized dimensions and are typically "flat face", "raised face", "tongue and groove", or "ring joint" styles, although other obscure styles are possible. Flange designs are available as "weld neck", "slip-on", "lap joint", "socket weld", "threaded", and also "blind".

Figure shows a typical Welded Neck Flange

2. Types of Flanges

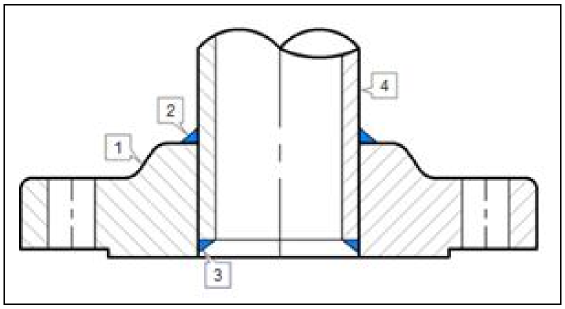
- Welding Neck Flange
- Slip On Flange
- Socket Weld Flange
- Lap Joint Flange
- Threaded Flange
- Blind Flange

2.1. Details of Welding Neck flange



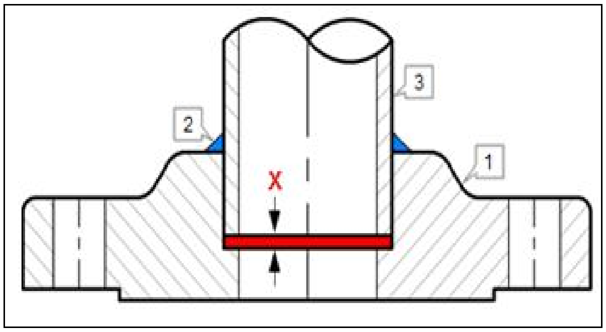
1. Weld Neck flange, 2. Butt Weld, 3. Pipe or Fitting

2.2. Details of Slip On flange



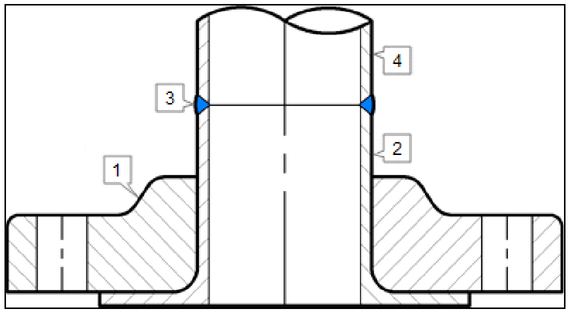
1. Slip on flange, 2. Filled weld outside, 3. Filled weld inside, 4. Pipe

2.3. Details of Socket Weld Flange



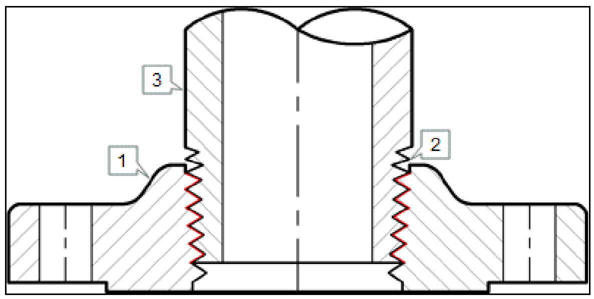
1. Socket Weld flange, 2. Filled weld, 3. Pipe, X = Expansion gap

2.4. Details of Lap Joint Flange



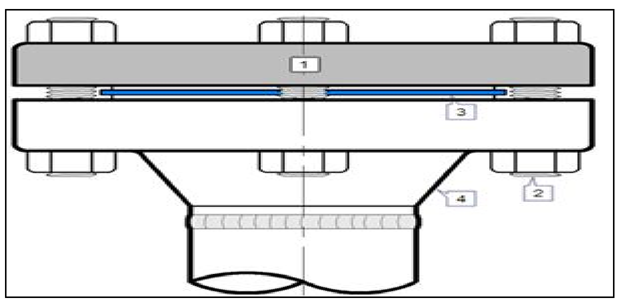
1. Lap Joint flange, 2. Stub End, 3. Butt weld, 4. Pipe or Fitting

2.5. Details of Threaded flange



1. Threaded flange, 2. Thread, 3. Pipe or Fitting

2.6. Details of Blind flange


1. Blind flange, 2. Stud Bolt, 3. Gasket, 4. Other flange

3. Types of Flange Welding Process

- Magnetically Impelled Arc Butt
- Pressure gas welding
- Resistance seam welding
- Electromagnetic pulse welding
- Multi-pass manual arc welding

Several journal papers published in journals all-round the globe were studied for the purpose of the literature survey of this project, and the major causes of failure of the flange; identified from the study are as follows:

I. Incorrect manufacturing process
II. Vibration induced fatigue[2]
III. Non-homogeneity in microstructure[1]
IV. Thermal stresses on the welded neck
V. Forces in pipes transmitted to the flanges
VI. Magnitude of internal pressure and temperature
VII. Sudden change in internal pressure and temperature
VIII. Cavitation inside the pipes near the flanges
IX. Heat Affected Zone (HAZ) created by welding
X. HAZ alter microstructure from coarse grained region to pearlite region thus weakening the material properties[5]

XI. Incorrect or lack of proper welding procedures[7]
XII. Residual stresses and deformation
XIII. Welding deformation
XIV. Contact stresses with seal gasket
XV. Use of dissimilar metals
XVI. Non uniform temperature distribution[6]
XVII. Flange size

The above mentioned parameters were determined as factors contributing to failure after subjecting the several failed and in service flanges along with two dimensional and three dimensional computer models through the following analysis methods:

- Micrography
- SEM fractography
- TEM fractography
- Load analysis using koves' method
- Finite Element Analysis
- Hydrostatic testing
- Three-dimensional non-linear heat transfer analysis
- Axi-symmetrical three-dimensional theory of elasticity numerical calculation[9]
- CTOD fracture toughness tests

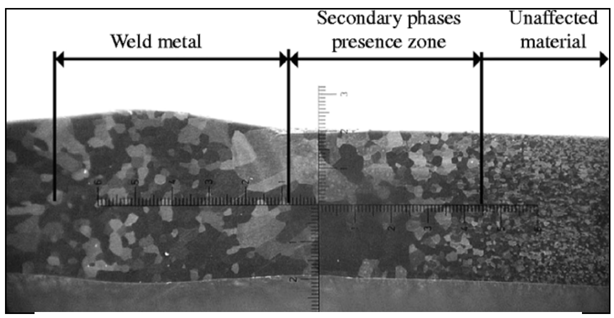
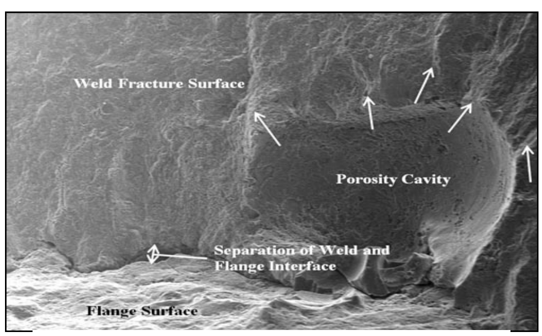


Image of the welded area at the Neck of the Flange

4. Composition of Flange Materials

In the journals studied it was found out that the material of the Flanges used were Low Carbon Steel (0.18% C, 1.3% Mn, 0.3% Si, 0.3% Cr and 0.4% Cu), 0.25% Carbon Steel [5], Austenite Stainless Steel [11] and Steel (with composition: 0.31% C, 0.28% Cr, 0.04% Ni, 0.25% Si, 0.8% Mn, 0.04% S, 0.035% P, 0.035% Cu and 0.12% Mo)

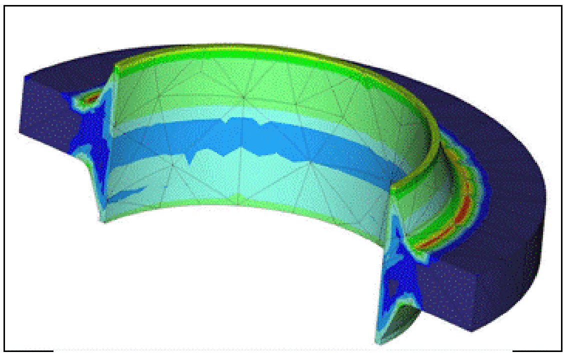


Weld defects on the Inside Surface of Flange

The coarse grain-size coupled with the pressure of pearlite rich patches in the microstructure had locally reduced the weldability of steel; i.e. increased its tendency towards HAZ cracking during welding, in this particular study Multi-pass manual arc welding with low carbon electrode was done. It is also observed that the Flanges are exposed to internal pressure and external loads primarily apart from thermal loads and other metallographic stresses. Stress variation on the flange side is more prominent due to its dimensional variation, whereas on the pipe side a slight variation in all the classes is observed. The root cause for the failure of the Flanges were observed to be due to vibration induced fatigue enhanced by non-homogeneity of the microstructure [1] [2]. It was also noted that the Pipe wall thickness has negative effect on the magnitude of the residual stresses because pipe of smaller wall thickness has low stiffness and more prone to the radial shrinkage resulting in bending stresses.The cracks had taken place because the stress was high because of reduced wall thickness caused by erosion corrosion and local deficiencies introduced during fabrication. The erosion corrosion may be because of operational excursions in absence of design deficiencies. [12]

A ruptured welded neck flange

Through the study it was found out that: Dissimilar material flange connections are often adopted to connect the austenite stainless steel pipes to the low alloy steel pressure vessels operated at an elevated temperature [11].
While the case might be to repair damaged or vulnerable flange units, the flange repair process is feasible for the gasification furnace. Spring deformation happens during the heat treatments for flange, piping. The temperature of post heat treatment of furnace flange repair is feasible. The thermal stress in flange, piping and the contacted bolts is limited in the elastic limit. There is no plastic deformation in the flange except the location beside the heat band and below. [13]
The two different software used for the analysis of the computer model of the flange were ANSYS and ABAQUS. However it was found that both softwares by itself could not support the modelling and produces suitable results. Therefore FE code ABAQUS was used to deliver the constraints suitably. Also ANSYS was benchmarked with a well-known FE simulation from 1978[8].



A flange model under simulation in ANSYS

5. Applications of Flanges

In Oil and Gas Subsea or riser applications. Cold work and Cryogenic applications Gas injection applications High Temperature applications Nuclear Applications. City Gas and Water distribution networks. Industrial fluid distribution and transmission systems.

6. Conclusion

This review paper aims to lay the foundation for the project being conducted for a comprehensive study on the failure of weld neck flanges.
Since flange is a mechanical component very much in use in today's industrialised world, the scope of this projects holds very much relevant. The insights and findings of this project will hopefully contribute to better design, manufacturing and integration of such critical components, which will optimize the efficiency of the systems in which they are employed.

7. References

1. Failure Analysis of a Weld Neck Flange of the Discharge Piping of an Ethylene Compressor in a Petrochemical Complex, Okpala, Alexander N
2. Failure Analysis of the Reducer Nipple of a Propylene Gas Tank in a Petrochemicals Complex, Okpala, Alexander Nwachukwu
3. Susceptibility to brittle fractureof flanges in ASTM A105, Dhooge and E. Deleu
4. Influence of the Type of Geometrical Imperfection on the Response of Steel Pipes Subject to Pure Bending, KavehArjomandi, FaridTaheri
5. Failure Analysis of a High Pressure Butt-Weld Flange, F. Ahmed1, F. Hasan1 and L. Ali
6. 3D thermal finite element analysis of single pass girth welded low Carbon steel pipe-flange joints, Muhammad ABID1, Muhammad Jawad QARNI2
7. Investigation Of Residual Stresses And Distortion In Welded Pipe-Flange Joint Of Different Classes, Sattar Ulloa and Muhammad Abid

8. Calculation of Welding Deformations in a Pipe Flange, Magnus Rhodin
9. A Stress Analysis of Pipe Flange Connections, T. Sawa, N. Higurashi, H. Akagawa
10. Evaluation of Flanged Connections Due To Piping Load, D.L.McKeehan, L.C.Peng,
11. Inelastic Analysis Of Dissimilar Material Flanges With Metal Ring Gaskets At Elevated Temperature, Takuya Sato, KenichiroKado
12. FailureAnalysis OF A Weld Neck Flange In A Refinery, NageshGoel
13. Study on Thermal Stress Distribution of Repair Welding Process for Gasification Furnace Flange, Xiaodong Hu, JiantaoLv, Quanshuai Gong, Sen Zhang