FAILURE ANALYSIS OF EXPANSION JOINTS (BELLOWS)

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Abstract - *An expansion or movement joint containing one or more bellows is designed to absorb the heat induced during thermal contraction and expansion of construction materials, hold parts together, vibration, to allow movement, produce flexibility within pipe. Expansion Joints absorb variations of ducts caused by thermal expansion and contraction. These joints also absorb vibrations due to flow of gases. Failure of the duct is been observed in expansion joints. Sleeve of the expansion joint is failing and because of these failures, bellows directly exposed to hot gases also fails.*

This report describes the Analysis carried out to investigate the causes of failure using FEA package and Analytical method. Design modifications are provided to ensure proper working of the Expansion Joint. Fatigue Calculations are done for modified design. Reanalysis of the modified design and a cost effective solution so as to ensure the reliable performance of the Expansion Joint.

***Key Words*: Expansion joints, thermal expansion, fatigue calculation, Modified design, Re-Analysis**

1. INTRODUCTION

The Objective of the accompanying undertaking is to outline advancement and investigation of roar for a steel plant with greatest firmness and least weight.

As a rule, outline and comprehensive of these unpredictable models is impossible with encounter and experimental learning alone. Goal and imperative capacity of complex models are generally extremely non-direct, broken, non-raised or even locally vague Thus profoundly specific techniques from various controls, similar to PC helped geometrical outline, computational mechanics and non-straight scientific programming must be joined to take care of muddled issues. This outcomes in a pivotal interest for adaptability and measured quality of computational condition. The universes of calculation recreation has encountered awesome advancement as of late and need to confront significantly more critical shifted difficulties to fulfill the developing requests for sensible and point by point forecast in virtual plan.

1.1 Expansion Joints

An expansion or movement joint containing one or more bellows is designed to absorb the heat induced during thermal contraction and expansion of construction materials, hold parts together, vibration, to allow movement, produce flexibility within pipe. They are commonly used between sections bridges, cement industries, ships, piping systems, railway structure and other structures to produce flexibility within the piping so as to catch up on variations long.

A howls is an adaptable seal is intended to adaptable when warm developments happen in the funneling framework. The quantity of convolutions relies on the power that must be utilized to this avoidance. The longitudinal load (weight push) consumed by gadgets incorporate pipe grapples, tie bars, pivots, or gimbal structures.

The advantages of expansion joint benefits is capable for absorbing any movement, compact arrangement, maintenance free and long life.

1.2 Types of Movements

The various dimension changes that an expansion joints is needed to absorb are axial rotation, lateral deflection, angular rotation and torsion movement. Mainly bellows are created to absorb axial movements solely however many combos of bellows will be used as expansion joints, that are capable of absorbing many movements.

i. Axial movement : it's the movement happens parallel to the line of the bellows and may be either expansion or contraction.

ii. Lateral deflections: It's the movement that happens at right angles or perpendicular, to the line of the bellows. Lateral deformation will occur on one or a lot of axis at the same time

iii. Angular rotation: it's the bending of an expansion joint on its line.

iv. Torsional movement: additional to axial, lateral and angular movements, an expansion joints could also be subjected to torsional motion of bellows is restricted. Truly bellows don’t seem to be most popular for torsional movements.

2. OBJECTIVE AND SCOPE OF THE WORK

2.1 Problem Definition

All bellows with 1.6 millimeter thick SS316 sleeves was put in and initial run of EGC was done and following things are found out.

• First failure according on bellow and it absolutely was found that Bellow was Leak as shown in fig 1

• Same bellow was removed & both bottom & prime bellows (1.6mm thick) found in broken condition as shown in figure 2 & 3.

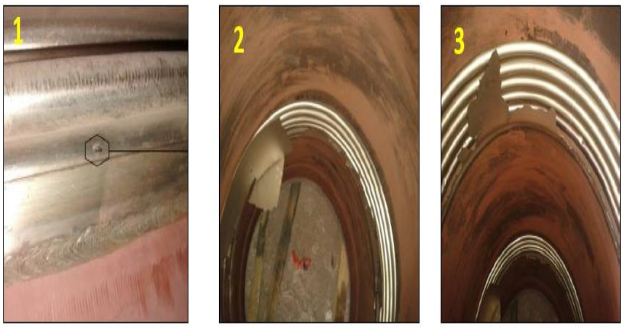


Figure 2.1 Wear out of the sleeves covering bellows

• After some amount as bellows were found in broken condition it absolutely was set to exchange the entire EGC discharge bellow with a bellow having thickness of three millimetre.

• With 3mm bellow, EGC was place operating once per week. Throughout hot adjustment, bellow was leaked [4,5] at MS pipe to convolution welding.

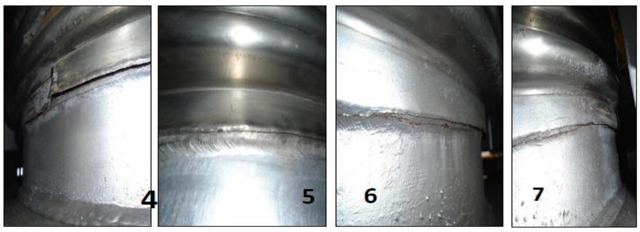


Figure 2.2 welding crack of bellows

• After 2 week same bellow was removed for review and it absolutely was found that three millimetre thick SS316 Bellow that was replaced by earlier was additionally found in broken condition.

• It was set to switch EGC discharge bellows broken sleeves by 6mm thick A-516 grade 60/70 material equipped by M/s Precise Engg. – Baroda

•Finally, six millimetres thick A-516 grade 60/70 material bellows put in for each discharge EGC. This was followed by a gas pressure check at 2bar (g) pressure and a escape was witnessed from convolutions of each the bellows.

•As each bellows were having escape, it absolutely was set to switch complete bellow having 6mm thick A516 grade 60/70 material

2.2 Objectives:

1. Careful study to research the causes for the expansion joint failures.

2 .Give appropriate design modifications or operative parameter modifications to confirm reliable performance at the given operative conditions.

3. Re-analysis the changed style to confirm the reliable performance.

2.3 Scope of Project

1. Careful study to research the causes for the failure of Bellow includes

2. Study of expansion Joint and its sort in conjunction with totally different applications.

3. Finite element Meshing, loading, boundary conditions etc.

4. Finite element Analysis

3. ANALYTICAL CALCULATIONS

Bellow tangent Circumferential Membrane stress due to pressure (S1):-

$$S1 = \frac{P(Db + n*t)^2 * Lt * Eb * k}{2[n*t*Eb*Lt(Db+n*t) + tc*k*Ec*Lc*Dc]}$$

$$= \frac{0.359(500+3)^2 * 17 * 2 * 10^5 * 0.65}{2[3*2*10^5*17*(500+3) + 3*0.65*2*10^5*17*503]}$$

$$= \frac{1.957 * 10^{11}}{2[5.13*10^9 + 3.33*10^9]}$$

$$= \frac{1.957 * 10^{11}}{1.692 * 10^{10}}$$

S1= 11.6 MPa

4. FINITE ELEMENT ANALYSIS

4.1 Material Properties

The simulations and mechanisms the user builds require material processing suitable properties. Material is one of the most important properties which define the behaviour of geometry.

Young's modulus = E= 2×105 M-Pa,
Poisson ratio = μ =0.3,
Density of steel = ρ = 7.8×10-9 kg/mm3

4.2 FEA RESULT

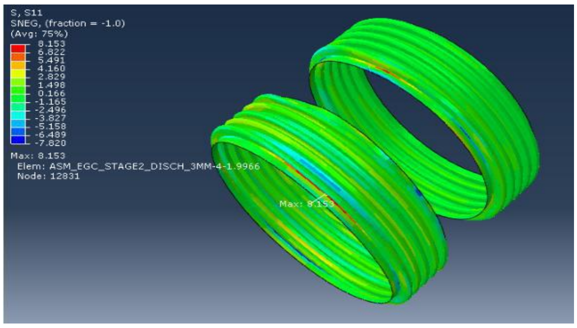


FIG 4.1 Bellow stress contour for EGC-2 with 6mm thickness

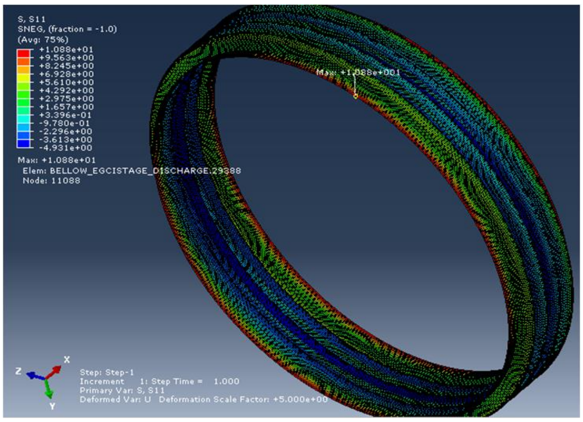


FIG 4.2 Stress contour plot for EGC-2 with 3mm thickness

5. RESULTS-:

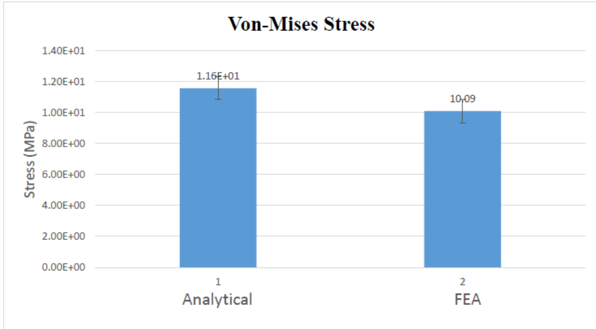
1. For EGC-2 Lonester model, thickness of 3mm is safe for given range of frequency.

2. For EGC-2 Lonester model, except 1.6mm thickness all others are safe for operating frequency. however as a result of geometric constraints we tend to thought of the 3mm sleeve.

Table: Comparison between FEA and Analytical Result

	FEA Result	Analytical Result
Stress (MPa)	10.09	11.6

Table 5.1



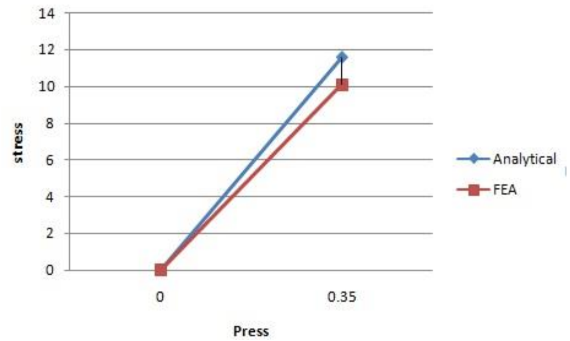


Fig.5.1 Graph: Comparison of Stresses on Bellow with Analytical and FEA results

6. CONCLUSIONS

1. As internal pressure will increase, stresses developed within the bellows also increases.

2. But in case of bellows, due to its convolutions features, the longitudinal stresses are always higher than circumferential stresses. This is also due to bending stress produced because of pressure force at pipe diameter.

3. The stresses are developed due to pressure and deflection. Since, bellows are made from thin sheet metal, material deforms elastically, but many times deformation extends to plastic region due to successive expansion/contraction loading. Stresses developed due to deflection are always higher than stresses due to pressure.

4. Maximum stresses produced at the root area of the bellow. This is because of stress concentration effect. Actually, U shape geometry creates minimum stress concentration effect compare to any other shape of convolutions. To minimize the maximum stresses at root area, reinforcement of rings may be provided.

5. The stress intensity is also high at the tangent length. Below is protected by circular collar at the tangent length, which controls the stresses at tangent length.

6. The stress intensities are higher at root and crest area of the convolutions.

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