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A critical Review of Expansion Bellow

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Abstract - *Bellow is the pliable element of the expansion joint with numbers of convolutions to permit the physical changes in dimensional resulting from various mechanical forces, vibrations, shocks or any thermal expansion or compression of the pipelines. Out of various types of expansion bellows the tubular metal expansion bellow is widely used in the industries because of its higher efficiency in absorbing capacity. Metal bellows have wide application in the piping systems across various industries like Chemical plants, Power plants, Automobiles, Marine Industries, Petrochemical industries, HVAC Systems etc.*

In this Review the author would like to discuss about Safety recommendations for expansion bellows design, various Design concerns like movements, Stability, Forces, Vibrations, Internal pressure capacity, Deflection stress, Fatigue life expectancy, Bellow spring rate and various literature reviews.

Key Words: *Bellow, HVAC, Convolution*

1.INTRODUCTION

Expansion bellows are designed to absorb various dimensional changes both in lateral, longitudinal and angular directions resulting from various mechanical forces, vibrations, shocks or any thermal expansion or compression of the pipelines. After being a flexible element of expansion joint the bellow should be pliable enough to accommodate the dimensional changes and strong enough to withstand induces various stress components on the bellow components. Similarly the bellow should have enough endurance to serve the purpose of certain system requirements. The design of bellow with various concerns including flexibility, strength and endurance make the design, manufacturing and testing processes of Expansion bellow quite unique..

1.1 SAFETY RECOMMENDATIONS EXPANSION BELLOWS DESIGN

For the safe working throughout the life of expansion Joints, bellow design should consider certain safety recommendations like

Confirmation of the designs as per Design codes:

Expansion joint design should confirm the design requirements of the standards like ASME, ANSI and ASME codes. Apart from that structural stability and test data should be analyzed.

Design Quality control plan: Expansion joints designers and manufacturers should prepare the quality control plan and the proper follow up of the plan should be taken care of.

2. DESIGN CONCERNS OF EXPANSION BELLOW

Movement equations

Expansion joints are subjected to axial movement, angular rotation, lateral deflection, or any combination of these. Total movement is absorbed by a uniform displacement of all convolutions.

For axial movements

e=X/N (For single bellow Expansion Joint)
e=X/2N (For single bellow Expansion Joint)

And for angular movements

en=ØD/2n (For single bellow Expansion Joint)
en=ØD/4n (For single bellow Expansion Joint) In design of expansion bellows we need to consider a no. of design parameters as discussed bellow

Force and movement calculation

In order to calculate the loads upon piping, supports or equipment's it is required to determine the forces and moments required to move the expansion joints. For convenience it is desirable to divide this forces by the rated movement for bellow resistance factor or section or working spring rates.

Maximum axial compression based on instability

A long bellow or series of unguided interconnected bellows may sometimes buckles when compressed Buckling occurs when the lateral stiffness is insufficient to resist the lateral forces generated by axial compression of the bellows. The maximum axial compression movement per convolution based on instability is

$$eA = 1.25(Dm)(Dm)/(N)(N)q$$

Where N = total no of convolutions.

Vibration

When the vibration is present and the frequency is known the bellow shall be designed to the natural frequency and the higher mode coincide with the system frequency. To avoid the resonance the response in the bellow the natural frequency shall be less than 2/3 of the system frequency or greater than 2 times of the system frequency

$$fn = Cn\sqrt{(K/W)}$$

Where W = weight of the bellow including the reinforcements
C = constant for single bellow axial and lateral vibration frequency
N=1,2,3,…….

Internal pressure capacity

High value of hoop stress in the straight portion causes circumferential yielding. To reduce this effects reinforcements or reinforcements with welding or collar is added with bellows.

Excessive meridional pressure stress in the convoluted section of a u shaped bellows will produce bulging of the side wall. Any gross changes in the convolution shape will decrease the space between convolutions and the ability of bellows to absorb movements. Such changes in shape cause fatigue life. Excessive meridional pressure stress in bellow produce meridional yielding and possible rupture.

Deflection stress

The stress in the convoluted section of the bellows due to deflection. The typical calculated stress range values are 50,000psi to 500,000 psi. These values are not true stresses since they exceed the elastic limit on the material. They are meaningful when correlated with actual test results in evolution of fatigue life.

Fatigue life expectancy

Fatigue life prediction of an Expansion bellow is affected by various factors such as operating temperature, the bellow material, the movements per convolution, bellow thickness, convolution pitch, depth and shape of the convolution. Any change in these factors will result in a change in the life of the expansion joint.

Fatigue life expectancy can be defined as the total number of complete cycles which can be expected from the expansion joint based on data tabulated from tests performed at room temperature under simulated operated condition.

2. DESIGN CONCERNS OF EXPANSION BELLOW

Literature review is very essential activity for any Design and research wok. During the Design and parametric study of bellow component process of Expansion Bellow various data were collected from various sources like Various Design and manufacturing hand books, Technical Articles, Reviews journals, Bellow design codes etc.

In the field of bellow design as there are very less numbers of literature available the author has followed various hand books from piping industries, previous research papers on bellows, Expansion Bellow Design codes like EJMA, ASME etc. Few of this literature review are studied, analysis and summary are as following

1. Sungchul Kim and Bongchoon Jang “Development of Bellows Design Software using MATLAB” ,Indian Journal of Science and Technology, Vol 8(S8), 201–206, April 2015

Review:

In this research authors have software based on EJMA code to design various types of U shaped expansion bellows. The investigation on the behavior of bellow while changing the thickness of the bellows were also carried out to determine the spring rate effects.

Conclusion:

This technical paper discussed about the procedure developments of the bellows automatic design software, Bellows Designer, based on the design formula of EJMA 9th Edition. This software uses the MATLAB GUI to make access to the program code easy, to enhance security, and to reduce the possibility of program errors.

2. Gaurav R. Mohite, A. P. Edlabadkar, “Analysis of expansion joint in heat exchanger using finite element analysis method”, IJPRET, 2014; Volume 2 (9): 436-449, Published Date: 01/05/2014

Review:

The paper mainly focuses on Finite Element Analysis of Expansion Joint in heat Exchangers using ANSYS. Purpose of bellow is to withstand axial thermal deformation & Pressure of heat Exchanger. So the design of bellow become very essential and critical.

Conclusion:

The Expansion bellow is being analyzed both for thermal and mechanical loading. If induced stresses are lower than the allowable limits for all conditions, the design passes the criteria.

3. Brijesh M. Patel, B.D.Patel, V.M.Prajapati, "A Critical Review on Metal Expansion Bellows", International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 2, March 2013

Review:

The paper focus on the topic what the expansion bellow is, the application of expansion bellow as per its utility and field of applications in various industries wherever piping systems or ducts are subjected to movement through the effects of temperature, pressure or external forces etc. In the Review the author have identified various aspects of the development, Forming Technology, movement test, Effective design parameters and Analysis of the bellow various software

Conclusion:

This paper gives some basic ideas about what expansion bellow is, development of expansion joints, mechanical behavior of bellow, buckling of metal expansion joints, analysis of movement test, forming technology, effective parameters of expansion joint, software technology in expansion joints. Those points are helpful in initial level to understand about the bellow as a product.

4. Jayesh .B Khunt, Rakesh .P Prajapati, "Design And Thermal Analysis Of Thermal Expansion Joint In Industrial Application" IJIRST | Volume 1 | Issue 6 | November 2014

Review:

This paper focus on various types of expansion bellows are used in industry. The bellows are used to dissipate the energy during contraction or expansion movements in pipes. The design,3D modeling and analysis of bellow design is done as per EJMA design code and ANSYS softwere.

Conclusion:

The paper demonstrated on metallic braided bellows were designed, developed based on FE simulation and EF analysis. With the successful demonstration of functionality and reliability of bellows by QA & QC authority.

5. Brijeshkumar. M. Patel, V.A. Patel,"Design, Manufacturing and Analysis of Metal Expansion Bellows" IJESIT Volume 2, Issue 3, May 2013

Review:

This paper talks more about the industrial utility of expansion bellows in piping systems. The critical cases of failures of industrial bellows while operated under various physical environments like vibrations, chemical corrosions, pressure, temperature conditions etc.

What are the preventive and corrective measure to be taken to eliminate the failure modes of thebellows as described in EJMA.The paper also describes the design and manufacturing steps to be taken for better operation of the industrial bellows.

Conclusion:

This paper has taken care the compative study for few type of bellows for their respective benifits for a particular purposes and validate them with respect to the FEA process. Evolved with the suitable forming processes suitable for industrial bellows. New forming technology was invented for bellows which uses the method of applying pressure of fluids and compressive load in axial direction is developed.

3. CRITICAL REVIEW OF OVERALL STUDY

In the various literature various authors have discussed various aspects and dimensions related to the Expansion bellows. Those groups can be formulated as study on stress analysis, stability criteria, fatigue life, and vibration analysis.

On stresses analysis

1. The Strain concentration on bellow components can be used for stress analysis purpose for better results.
2. The stress Analysis on bellows can be used for endurance and fatigue life of expansion bellows
3. The main assumption for stress analysis of bellows are based upon beam model, shell model based of the bellows for strength of material.

On fatigue life analysis

1. Design of Bellows should consider low cycle fatigue during its working. The maximum numbers of cycle can be calculated as per design codes like EJJMA, ASME standards.

2. Premature fatigue should be control by effective design process considering the local and primary membrane stress.

3. The fatigue life depends on various bellow design parameters like The nos. of ply used for bellow materials, Pressure applied, Geometry of bellow.

4. Various environmental factors must be considered in the process of designing the bellows for its fatigue life.

CONCLUSION

After being a very critical part in the piping industry the Bellow related research papers, journals ,design catalogs and standards are studied in details. At the last of the review

author concluding that the bellow design is a very critical process and should be performed after studding each and every parameters of bellow for correct calculations various stress components like meridional bending stress and circumferential membrane stress etc. Each stress components has their own significance for the effective working of the Expansion Bellows and its Working life.

REFERENCES

[1] Sungchul Kim and Bongchoon Jang "Development of Bellows Design Software using MATLAB" ,Indian Journal of Science and Technology, Vol 8(S8), 201–206, April 2015

[2] Gaurav R. Mohite, A. P. Edlabadkar, "Analysis of expansion joint in heat exchanger using finite element analysis method", IJPRET, 2014; Volume 2 (9): 436-449, Published Date: 01/05/2014

[3] Brijesh M. Patel, B.D.Patel, V.M.Prajapati, "A Critical Review on Metal Expansion Bellows", International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 2, March 2013

[4] Jayesh .B Khunt, Rakesh .P Prajapati, "Design And Thermal Analysis Of Thermal Expansion Joint In Industrial Application" IJIRST | Volume 1 | Issue 6 | November 2014

[5] Brijeshkumar. M. Patel, V.A. Patel,"Design, Manufacturing and Analysis of Metal Expansion Bellows" IJESIT Volume 2, Issue 3, May 2013

[6] EJMA (Expansion Joint Manufacturing Association) Ninth Edition.

[7] ASME Section VIII Division-1 Appendix 26, 2010. (2004) 1–6.