Design And Thermal Analysis Of Thermal Expansion Joint In Industrial Application

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Abstract

Present study covers different types of expansion joints used in industry. The expansion joints are used to dissipate the energy during contraction or expansion in pipes. Different types of expansion joints are widely used in piping industries. This covers detailed calculation from EJMA (Expansion Joint Manufacturers association), Design, Modelling, Thermal and Structural analysis of axial type expansion joint. All design process will be performed with aid of FE analysis using ANSYS software.
Keywords: Thermal Expansion Joint, Expansion Bellows, Bleed system

I. INTRODUCTION

An Externally Pressurized Expansion Joint takes pressure from the outside of the bellows element rather than on the inside as in a conventional expansion joint. In conventional type of expansion joints with internally pressurized bellows it is not possible to accommodate large axial movements due to the squirm associated with the higher bellows length.

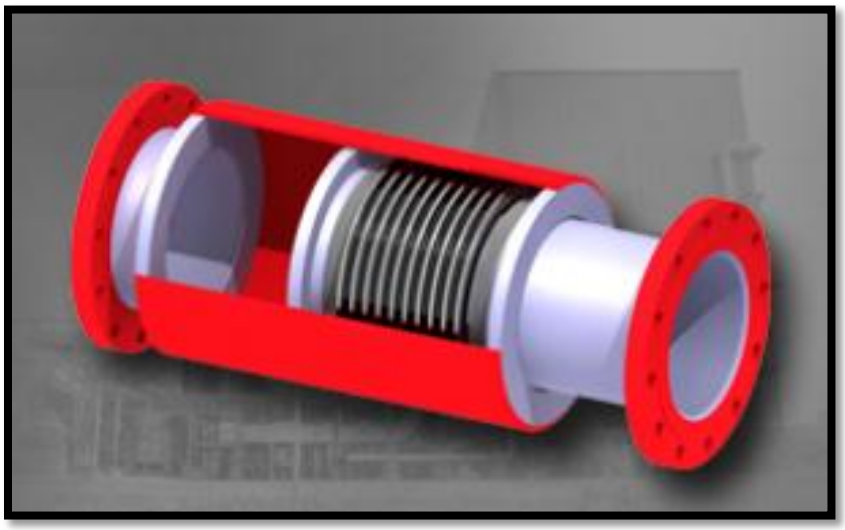

Fig 1.1 Thermal expansion bellows

The stabilizing effect of the external pressure increases the bellows capacity to absorb high axial movements without squirm making the externally pressurized expansion joints the best solution for applications involving very high axial movements. The construction of an externally pressurized expansion joint consists of a heavy outer pipe which contains the pressure and serves as a shroud to protect the bellows and also functions as pipe-guide. The outer pipe in externally pressurized expansion joints contain the full pressure of the system and if bellows failure occurs the medium does not escape radially outwards, thus protecting the personnel working in the vicinity. The externally pressurized expansion joint is extremely easy to insulate and steam tracing can be used to maintain the temperature of the medium flowing through it. Another important advantage of this type of expansion joint is that in the event of anchor failure the bellows get compressed and act as a shock absorber to maintain the overall system stability.The externally pressurized expansion joints provide very low turbulence to the flowing medium due to the fact that the internal surface of the pipeline itself works as the liner for this expansion joint. As the thermal expansion in externally pressurized expansion joints occurs the bellows element gets extended bringing the internal guide rings closer reducing the gap between them and the medium can flow through this joint as if it were not there.The drain vent and purge connection can be provided in the outer pipe to allow the draining of any sediment or residue that may collect or venting of the expansion joint to assure fluid filled pipeline. The drain connection is also an ideal location for a steam trap for joints used in steam applications. Bellows Expansion Joints are great for accommodating axial, lateral and angular movements for a wide array of piping applications. Some applications may contain high flow velocities, which can induce severe vibration and lead to premature

failure to the bellows element. The way to address this is to utilize a bellows expansion joint containing an internal sleeve, also known as a flow liner. A flow liner within a bellows expansion joint protects the integrity of the bellows element by redirecting the media (air, gas, steam, water, etc.) away from flowing directly over the bellows convolutions as it passes through.

II. LITERATURE REVIEW

A. Brijesh M. Patel, B.D.Patel, V.M.Prajapati[1] "A Critical Review on Metal Expansion Bellows"

The flexible element of an expansion joints consisting of one or more convolutions with no more than five plies and the end tangent with length to diameter ratio not more than three. Any device containing one or more bellows used to absorb dimensional changes such as caused by thermal expansion or contraction of pipe line, duct or vessel or heat exchangers. Tubular bellows are one of the most efficient energy-absorbing elements for engineering system. Metal bellows have wide application in aerospace, micro electromechanical system, chemical plants, power system, heat exchangers, automotive vehicle parts, piping system, petrochemical plant, refineries, power stations, district heating installations, HVAC systems etc and wherever piping systems or ducts are subjected to movement through the effects of temperature, pressure or external forces etc. In this present Review the author have been found out the development of bellows, Forming Technology, analysis of movement test, buckling, Mechanical behavior, Design concept, Effective parameters and Analysis of the bellow by using commercial available software. As a part of my research work, I carried out literature work on Metal Expansion Joints by studying numerous of research papers of well known journals. The most related research paper on metal expansion bellows are thoroughly studied & explained with most required details in this present work. The development of the metal expansion bellows with proper geometry is suggested by Hyun Wook Kang. The analysis of buckling of metal expansion joints under internal pressure are suggested by D.E.Newland. The analysis of two types of metal expansion joints movement test are suggested by Jorivaldo Medeiros. The main key parameter responsible in the design and analysis of the metal expansion joint is the effective parameters of the metal expansion bellow are suggested by Gh Faraji. He suggested most effective parameters of the bellows are initial length of tube, internal pressure, axial feeding and velocity, mechanical properties and the type of materials by finite element (FE) analysis (LS-Dyna) and experimental tests. G I Broman suggested I – DEAS software for the simulation of the metal expansion bellows before realization of the bellows. At the end of the review work now the author concluding that the remaining part of the metal expansion bellow is the key objective for the next research work.

B. BLEED SYSTEM FOR A TYPICAL LIGHT TRANSPORT AIRCRAFT" H. T. Akshatha, A. Rinku, M. L. Shankar and Prashanth Banakara[2] "DESIGN,DEVELOPMENT,SIMULATION AND REALIZATION OF EXPANSION JOINTS IN ECS ENGINE

In a commercial aircraft, ventilation to the cabin is normally through environmental control system normal bleed air system, ECS emergency back-up pressurization system and ram air. Bleed air is primarily used to provide pressurization by supplying air to the environmental control system. Additionally, bleed air is used for de-icing of aircraft leading edges. The bleed air needs to be tapped from engine and conveyed to the ECS pack through pipe routings .The bleed air pipes that tap the air from engine would experience a varying pressure load (as high as 140psi) and varying temperature (as high as 340°C) at different segments. This would obviously produce the expansion/ contraction of pipes which will result in axial moment and swaying of pipelines from their nominal configuration. These movements should be compensated by means of providing suitable expansion joints/thermal compensators to avoid undesirable loads at the support points which may affect the overall functioning of the system. The real challenge lies in designing such a complex system where suitable expansion joints need to be provided within stipulated airframe configuration satisfying the installation requirements, yet cost and weight effective. In the present work, a methodology has been developed for design of ECS pipe routings, using flexible hose- metallic bellows as a thermal compensator, with the aid of finite element analysis. This paper also talks about the qualification of the bellows through acceptance tests and implementation on a typical light transport aircraft.

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light transport aircraft. The metallic braided bellows were designed, developed based on FE simulation. An optimal configuration for the entire ECS of LTA fulfilling the installation requirement was arrived with the aid of FE analysis. With the successful demonstration of functionality and reliability of metallic bellows by acceptance qualification tests and clearance from certification authority, the indigenously developed bellows were installed and are satisfactorily working on the aircraft, thus demonstrating the product design, development and realization cycle. Through this exercise, a proven methodology for simulation of bellows for finalization of appropriate pipe routing, based on FE was developed which would help future projects.

C. D. E. Newlan[3]"BUCKLING OF DOUBLE BELLOWS EXPANSION JOINTS UNDER INTERNAL PRESSURE"

Suggested that the Corrugated bellows expansion joints may buckle under internal pressure in the same way as an elastic strut may buckle under an axial load. This paper is concerned with the analysis of this phenomenon for the 'universal expansion joint' which incorporates two bellows joined by a length of rigid pipe. The principal conclusion is that, by providing a correctly designed supporting structure, the critical buckling pressure can be increased to up to four times its value for the same system with no supports Bellows expansion joints may buckle in the same way as an axially loaded strut buckles. By modelling each bellows as an equivalent axially loaded elastic strut, the buckling pressure of the universal expansion joint shown in Fig. 1 has been derived. This depends on the length ratio 1/L and on the lateral stiffness of the supporting structure **k.**shows a graph of the (non-dimensional) lowest buckling load P,P/EI plotted as a function of the (nondimensional) spring stiffness **kZ3/EI** for different values of Exact values are shown in Fig. **6.** The conclusion is thus that a correctly designed supporting structure can increase the buckling pressure by up to four times its value for the same system with no supports.

D. GAURAV R. MOHITE1, A. P. EDLABADKAR2 [5] "ANALYSIS OF EXPANSION JOINT IN HEAT EXCHANGER USING FINITE ELEMENT ANALYSIS METHOD"

The paper mainly focuses on Finite Element Analysis of Expansion Joint in heat Exchangers using ANSYS. The main Purpose of Expansion joint is to withstand axial deformation (thermal Expansion) & loads inside a High Pressure heat Exchanger. Hence the design of Expansion joint becomes critical. Heat Exchanger with Expansion bellows are widely used In Oil & gas industries today 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. 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.

III. CONCLUSION

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