CONTENT

- Abstract
- Acknowledgement
- Abbreviations
- List of Figures
- List of Tables

Introduction
1.1 Overview of the Study
1.2 Introduction
1.3 Expansion Methods in Piping
1.4 Expansion Joints
1.5 Types of Movements
1.6 Accessories of an Expansion Joints
1.7 Types of Expansion Joints
1.8 Selection of Expansion Joints
1.9 Design Variables
1.10 Thermal Growth Estimation
1.11 Determination of Pressure Thrust Force
1.12 Movements absorbed by Bellows
1.13 Force Analysis of Expansion Joints
1.14 Expansion Joints Manufacturers Association (EJMA)
1.15 Chapter Plan

2 Literature Review
2.1 Important Theory – Books and Handbooks Review
2.2 Research Papers Review
2.3 Overall conclusions of Review study
2.4 Areas for further Research work

3 Metallic Bellows
3.1 Construction of Bellows
3.2 Components of a bellow
3.3  Geometry of a Bellow
3.4  Convolution shapes of bellows
3.5  Bellows materials
3.6  Manufacturing of Bellows
3.7  Single or Multiply material
3.8  Reinforcement of Bellows
3.9  Internal Sleeve
3.10 Criteria affecting Bellow Design
    • Internal Pressure Capacity
    • Fatigue Life Expectancy
    • Stability of Bellows
    • Spring Rate of Bellows
    • Cold Springing of Bellows
3.11 Design Approach
3.12 Design Procedure
3.13 Testing of Bellows
3.14 Failure of Bellows
3.15 General Applications of Bellows
3.16 Characteristics of Bellows used in Instrumentation
3.17 Conventional Design of Bellows
3.18 Estimation of stresses as per EJMA
3.19 Design of Components of Expansion joints

4  Objectives of Research Work
4.1 Objectives of Study
4.2 Research Methodology
    • Analysis of Design Parameters
    • Parametric Optimization
    • Finite Element Analysis
    • Performance Testing of Bellows

5  Finite Element Analysis of Bellows
5.1 Introduction
5.2 Overview of FEA procedure
5.3 The basic element of geometry
5.4 Typical range of elements
5.5 The rules for compatibility
5.6 Structure Material property
5.7 Meshing
5.8 Restraints
5.9 Constraints
5.10 Structural loads
5.11 Boundary conditions
5.12 CAE Softwares
5.13 Linear and Non-linear Analysis
5.14 Stress Analysis of a Bellow using FEA
5.15 Axi-symmetry approach of FEA
5.16 Practical considerations in FEA
5.17 Comparison of convolution shapes
5.18 Structural and Thermal analysis
5.19 Stability Analysis
5.20 Dynamic Analysis

6 Performance Testing of Bellows
6.1 Purpose of testing
6.2 Non-Destructive testing
6.3 Hydrostatic Pressure testing
6.4 Pneumatic Pressure testing
6.5 Spring Rate test
6.6 Destructive Testing
   - Squirm testing,
   - Meridional yield rupture testing
   - Fatigue Life testing.
6.7 Experimental Work
6.8 Design of Experiment (DOE) for Axial Spring rate
6.9 Applying DOE on Spring Rate of bellows
6.10 Spring Rate Test
6.11 Squirm test
6.12 In-plane stability tests
6.13 Squirm failure mechanism
6.14 Dynamic Analysis

7 Results and Discussions
7.1 Design of Bellow
7.2 Design of Accessories
7.3 Discussion of Results from FEA
7.4 Discussion of Results from Performance tests

8 Conclusions
8.1 Final Conclusions
8.2 Limitations of study
8.3 Future scope of work

9 References
Appendices
A – Thermal expansion in pipe length of different materials
due to temperature variation
B - Modulus of Elasticity at elevated temperature
C - Materials of bellows: chemical compositions, properties &
other applications
D - Thermal expansion coefficients for some common
materials.
E – Technical Specifications of FFT Analyzer
F - Material selection guide for pressure vessel applications
considering range of operating temperature

Research Publications
Remarks / Notes

"Research develops patience and hope"