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OVERVIEW OF INDUSTRIAL PIPING STRUCTURAL DESIGN

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ABSTRACT
Piping network design system has significant role in industrial sector to minimizing losses through designing effective and simplest network. Piping system is time consuming, complex and expensive effort process for construction and chemical plants. The objective of paper is to explore overview of piping network system design, its requirements. ASME B31.3 design grade has elaborated with application. Concept of flexibility such as flexibility factor, stress intensification factor has discussed. Use of different piping analysis software overviewed for their effectiveness study.
KEYWORDS: Pipe Line Design, ASME Code, Stress Intensity Factor.

I. INTRODUCTION
Design of piping network plays important role in convey/ transport fluids (liquid/ gasses) effectively and efficiently in industry. This design network system utilised in several industrial processes and manufacturing processes requirement. Piping design and analysis has to study for perspective aspects of industrial process needs. Design of piping network system meets various application which has health and safety for work environment. Design of generation and processed steam flow has considered issues using pressure, temperature and flow rate along with dryness fraction. The selection of piping materials and its dimensional standard also has importance in their design analysis of required output. Generally ASME B31.3 grade code used in piping network designs which included various sector of petroleum refineries, chemical plants, paper plants, electrical works, instrumental assemble stations, resin industries, textile industries [1].

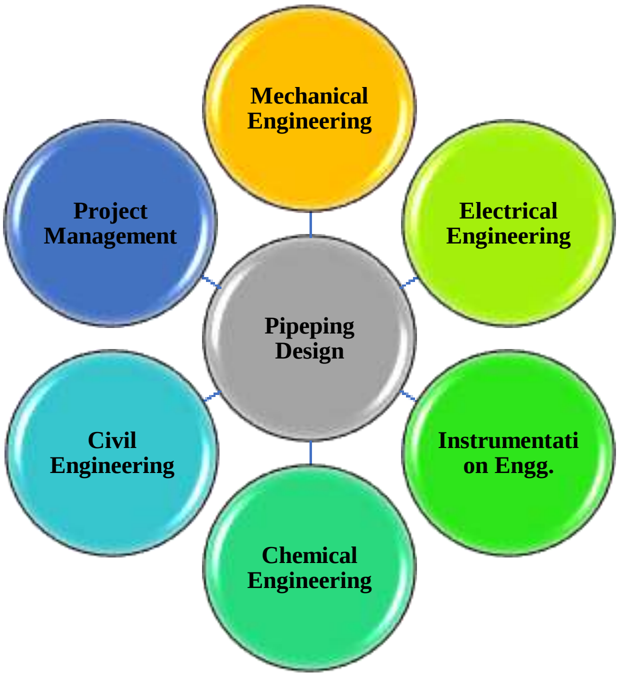

Figure 1. Application of Piping Design [1]

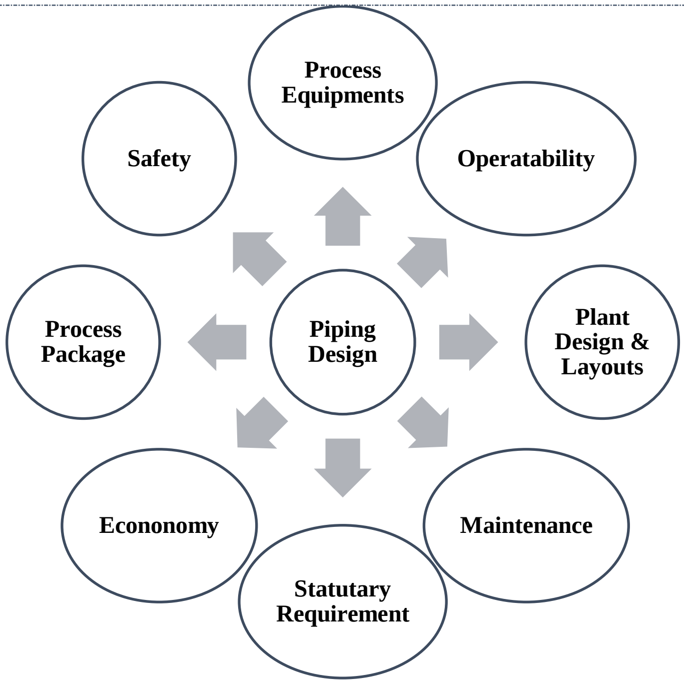

Figure 2. Importance of Piping Design [1]

Design and construction of piping network for any plant and service sector is time consuming, complex and expensive effort making work. The inline component in plants known as attachments or fittings which helped to control pressure, flow rate and temperature of transmitted fluid. The detailed specification of physical piping layout within the industrial concealed documents known as drafting. Plumbing is familiar with piping system which consist of fluid transportation that used to provide potable water and fluid to their appliances. It consist of number of different piping attachment such as valves, flanges [1].

- Flanges- Circular round disk provided with bolted, separable joint in piping network. The most of valves flanged their end with companion or alternate matching attachments. Gasket inserted in between them and bolts tightened to firm joints. It used to clear need for removal of valves or equipment for access their maintenance. Flange has some limitation of potential to leak source, therefore it kept minimum number for safety and reasonably convenient operation and maintenance.
- Bolts and Gaskets- Coupling of two or more attachments in system need bolted arrangement, and prevention of leakage and tightening attachment gasket play important role in industrial application. Choice of bolting material governed by service fluid and its temperature. The most commonly used bolt in piping refinery is ASTM A193 Grade. B series Stud bolts also categorised in high strength group. It can work efficient in range of 25- 450 degree centigrade. A gasket of thin circular disc made of soft compressible materials. The most of valve coupled flanged arrangement with inserting gaskets and tightening it by bolted joint.
- Valve- Valves used for regulating fluid flow. There are various types of valves such as gate valve, glob valve, check valve, ball valve, and plug valve. Gate valve manually operated and designed for open or shut operation. Flow can enter either end of valve body. Glob valve used for throttling.

Stress analysis in piping design

Process piping and power of piping typically checked on the basis of routing, nozzle loads, hangers and supports which are properly placed and selected which allow prevent piping stress exceeded sustained loads, operating load and pressure testing loads. The evaluation of these loads performed with assistance of specialized FEA pipe stress analysis computer program such as Auto PIPE, CAEPIPE and CAESAR [1].

Type of load categories

- Sustained load- These load presented throughout normal plant operation. Typical sustain load are internal or external pressure and dead weight load

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- Expansion load- These load developed due to displacement of piping. Thermal expansion, seismic anchor movement, thermal anchor movement and building.
- Occasional load- These load generated due to infrequent interval during plant operation. The earthquake, wind, fluid transient such as water hammer, relief valve discharge.

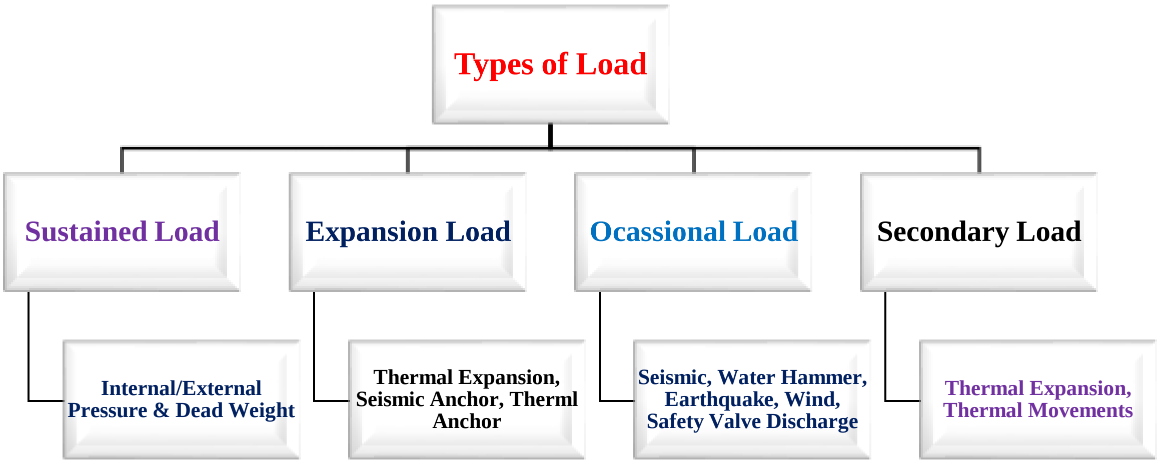

Figure 3. Type of loads [1]

There are certain standards codes that has to follow while designing and developing piping network system. The organization that assets piping standard that are shown below Table 1. The role of piping design procedure is highlighted in Table 2.

Table 1. Type of piping design standards use in piping network [1]

ASME B31.1	**Power Piping (Steam Piping)**
ASME B31.2	**Fuel Gas Piping**
ASME B31.3	**Process Piping**
ASME B31.4	**Liquid Piping**
ASME B31.5	**Refrigeration Piping And Heat Transfer Component**
ASME B31.8	**Gas Transportation And Distribution Piping System And**
ASME B31.9	**Building Service Piping**
ASME B31.11	**Slurry Transportation Piping Systemspiping**
ASME B31.12	**Hydrogen Piping And Pipeline**

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Table 2 Steps in Design of steam pipeline network methodology [8]

Proces Design	• **Process Flow Design** • **Processs & Instumental Diagrams**
Piping Structural Design(load)	• **ASME Grade Code**
Piping Design Criteria (Stresses)	• **Primary Stresses** • **Secondary Stresses**
Pipe Design Calculations	
Analysis	• **Static Load** • **Thermal**

II. RECENT DEVELOPMENT IN PIPING DESIGN PROCESS

Sharma et. al. [2] designed and analysed process plant piping system using comparative software. They explained concept of flexibility such as flexibility characteristics and flexibility factor and stress intensification factor in referred standard codes. They used CAD packages of ACAEPIPE to developed comprehensive analysis of complex system and the finite element analysis method carried out to find sorted code stresses, code compliance stress, element forces and moments in coordinates and development at all node in pipeline layout. Their comparative study of stress intensifier factor resulted against result obtained through CAEPIPE by using FEM equation. The conclusion of ratio of maximum stress induced in maximum allowable stress below one affected pipe system becomes safe in regarded design. CAD package provides a systematic and efficient methodology for designing and analysis with less effort. Their analysis of piping system found more accurate using CAEPIPE.

Sustainability of designed steam piping system for dryers in paper machine using finite element analysis had checked by Yadav and Kadagaonkar [3]. Their work study had considered 2-D and 3-D piping system designs with standards. Finite element analysis had performed with application of various loading cases using suitable data design service condition. Their results of study had shown primary and secondary stresses within code allowable limits. Pipes carried weight helped in avoid vibration, shock movements for flexibility design of pipeline. Support element directed to prevent pipe stresses which permitted through code, leakage at joints. The trust and movements on connected equipment, excessive stresses helped in supporting elements. They intensity technical and administrative measures and finding material strength relationship between treated substance and equipment’s.

Sivanagarju et al. [4] studied stress analysis of process pipe line system. They focused to explain flexibility characteristics, external forces and displacements and stress identification factor referring to code and ensuring allowable limits as per standard at different load contribution of hydrostatic, sustained operating and experimental. The experimental analysis of process plant piping system using CAESER found same results of SIF and CAESER for more accuracy in comparison. More et al. [5] studied development of steam piping system with stress analysis for optimum weight and thermal effectiveness. They reported design of piping and stress analysis using specified flow diagram. The wall thickness calculated for safe design consideration of pressure in pipe. They observed calculated wall thickness 3.54 mm standard minimum wall thickness was 8.18mm which greater than calculated more than 2.3 time. Different load conditions was considered and optimize design piping. Analysis of system was safe and result verified by manual calculation and ANSIS software.

Senithilkumar et al [6] worked on analysis of piping layout under static load in petrochemical industry. They studied critical lines in the layout which connecting main distillation unit and air fin cooler had taken for analysis. Design of piping system interrelated with piping layout, pipe support design and analysis of stresses in pipe. They had observed functional failure of pipe due to accidents, shutdown and lot of damages in refinery and human due to leakage of fluids. Critical loads considered such as earthquake, heavy fluctuation in wind force. They used FEA approach to sustain hydro, occasional loads and referred ASTM B 31.3 grade for design purpose. Pipe had analysed independently in X,Y,Z direction and corresponding displacement. They concluded static analysis for static loads well within material yield and endurance limit and found factor of safety 4.06 for static conditions.
They also conclude base shear in steel pipe rack less than the combined pipe rack because of less seismic weight which gives better response during earthquake. As concrete gives better fire protection, so combined pipe rack will be more suitable than steel pipe rack. Observation of petrochemical plants contained in various pipes and industrial structures. Therefore, the applicable design methods was required. The scaling method has advantage and it also applicable for structural design. Result of this evaluation show that scaling method satisfies the piping system performance for supporting structures. Therefore, this method used for pipe rack and Pipe Bridge design. According to this result, the pipes which ware design should be controlled for differential displacement. So the scaling method had reliable for piping system design while the pipe finally controlled.
Sweta Bisht and Farheen Jahan [7] studied stress analysis of critical components of piping network design through which important parameters like safety of related components & connected equipment. Objective of stress analysis was prevent premature failure of piping system & to done analysis. CAESER -|| software had used which an integrated error checker. This paper also given deep information about various principles for selection of material, application of code criteria & tools used in stress analysis software. They tried to maximize the distance between supports keeping the values of stresses and deflection within safe limits. The aim was to reduce the number of supports to reduce the total cost of erection. Sakharkar et.al.[8] explained overview of pipe system design and analysis. They highlighted process design and steam distribution system for chemical industry plant. Design steps ware helped to understand piping design procedure to overcome different limitations. Further references has studied for stress analysis and stress developed in the material during mechanical loading condition. That help to understand endurance and fatigue life of material for their application purpose. The selection of material and loading conditions in piping application has mention important role for further development in design of network system.

III. CONCLUSION

This paper highlighted the design information of piping network system for industrial work application. It detailed information about type of forces developed on pipeline network due to different loading condition and it chosen from design application criteria. Different piping ASME standards are highlighted for selection of application work environment. Recent advancement is explained on basis of literature reviews for different literature survey of piping design. Force analysis and its application limitation has identified in literature reviews.

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