International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 01 | Jan 2021 www.irjet.net p-ISSN: 2395-0072

A Review on Optimization in Design and Construction of Pipe Supports, Pipe Frames and T Posts

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Abstract - *A pipe support is a steel structure which is used to support pipes inside a plant. It is used to transfer liquid between production equipment to storage facility. Optimization of steel pipe supporting structures in an oil & gas industry is complex and one of the important parts of structural systems for safe production processes. In this review work steel pipe support design as per international standards which result into optimize and safe design of steel pipe support with a minimum time. In this work different type of research regarding optimized design of pipe racks and pipe supports are studied and related.*

Key Words: Pipe rack, pipe frame, pipe supports, design, construction optimization

1. INTRODUCTION

Pipes carrying fluids like chemicals, steam, oil, water and many more, are usually laid between numerous components in any petrochemical, power or chemical and processing plants. It is not always feasible to support them on ground but at an elevated structure in order to avoid any obstruction and enable easy accessibility for maintenance. A pipe rack is the main channel of a process unit. Pipe racks carry process and utility pipes and also support cable trays. Pipe support design is an imperative module of process engineering. Model piping support design should take into consideration the thought of cost of installation, consideration of pressure loss on production, concern of stress level, effects of support and anchor, stability, maintenance ease, capacity of expansion etc. It should be least expensive over a long term. A pipe support is an element that transfers the load from a pipe to the supporting structure. The load includes the self-weight of the pipe, the content of the pipe fluid, all the pipe connections attached to pipe, and the pipe covering like insulation around the pipe. The key role of a pipe support is to anchor, guide, absorb shock, and sustain the load. The overall design configuration of a pipe support is dependent on the loading as well as operating conditions. If the piping system is not appropriately supported, many problems may rise. Mainly, the problems that generally occur are due to bending in the flange joints, bending of pipes, vibration, undue movement, higher deflection, line overstress and equipment nozzle overload and faulty piping support design. To avoid all these glitches, it is very important that your pipe support design is proper. Piping supports analysis and designs and the choosing of support material help improve the value of piping. There are ASME standards to ensure proper piping support.

2. LITERATURE REVIEW

2.1 Prem K.P. (2020)

In this paper different types of pipe supports and their optimization is discussed. In the pipe rack structure pipes are laid at different elevation, to support these pipes at a different level of elevation structural steel pipe support come into picture because it is not possible to carry all pipe at the same level on a pipe rack structure. Following are the different type of support that are generally used as pipe supporting structure in pipe rack assembly,

1. Tee (T) type pipe support.
2. 'L' type of pipe support with or without knee bracing.
3. Portal type of pipe support with or without bracing.

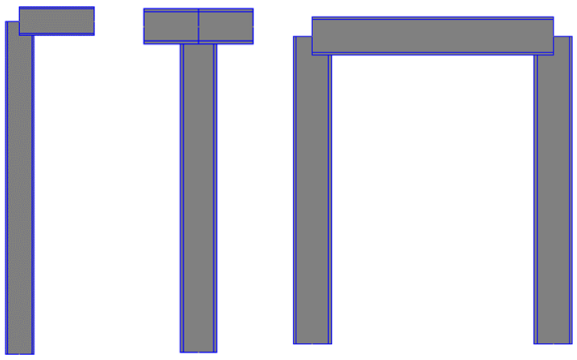

Fig -1: Type of Pipe supports

Author has suggested suitability of different types of pipe supports for different heights and different loads.

2.2 Richard M. Drake and Robert J. Walter (2010)

In this work author has described all the design criteria and design considerations regarding loading and analysis as per international standards. Author concludes that Pipe racks non-building structures that have resemblances to structural steel buildings and also have additional loads and design considerations. The requirements found in the building codes apply and dictate some of the design requirements. Some code requirements are not clear on how they are to be applied in case of pipe racks, because most of them are written for building structures. Several industry references exist to help the designer apply the intent of the code and follow standard engineering practices. Engineering practices vary and are, at times, influenced by client requirements and regional practices. Supplementary and updated design guides are required so that steady design approaches are used throughout the industry.

2.3 Akbar Shahiditabar and Sayed Rasoul Mirghaderi(2013)

In this paper author mentions that in current method of pipe and pipe rack design, first pipe is designed, and then pipe supports reactions are imposed on pipe rack. Then the pipe rack is designed as per the applied loading. There are some uncertainties and glitches in this pipe and pipe rack design method because of not modeling pipe in pipe rack design. The damages experienced in previous earthquakes confirm the stated claim. His study targets to recommend a new method for considering pipe rack and pipe interaction as an alternative of current method in order to solve current problems. In the suggested method, pipe is attached to pipe rack in all points and then pipe and supporting structure are design concurrently. Author concludes that by this method, current problems are resolved and the quantity of materials used is reduced by to 29%.

2.4 Mohammad Karimi (2011)

Author mentioned that seismic valuation of pipe rack and pipe supporting structures in a petrochemical and process complex is one of the most significant parts of structural systems. This is for safe and stable manufacturing processes. Author concludes that the most critical part of pipe supporting structures is in their lateral load resistance system. Braces commonly have large slenderness ratio and are susceptible during earthquakes. Connections of the lateral resistance system are very critical and should be given through thinking. Middle gussets to braces should be added, and in some cases, adjacent elements of braces don't have adequate capacity because of non-existence of lateral resistance system. For improving the weakness of lateral load resisting systems, we should add new systems or reinforce existing systems. Another option that can be considered in strengthening of lateral load resisting system is adding shear walls.

2.5 J.K. Sumanth (2018)

Author has worked on the pipe rack steel structure which has been modeled and analyzed using LRFD method in American code AISC 360-10 CODE in STAAD PRO V8i software. The orientation of the columns if H shape or I shape depends on the Moment of inertia. The shape is opted for which we get more moment of inertia. All the bracings are provided as per stability and project requirements. Plan bracings are provided to resist the lateral deflection and to transfer wind force, longitudinal forces to braced bay. The shape of the plan bracings generally opted are Rhombus shaped, L shaped. This bracing shapes helps to reduce the size of the structure and hence to reduce the cost. As the wind load and moment act in the lateral direction generally fixed but support is opted. This support is fixed in one direction and pinned in one direction. Shear connections are provided and vertical bracings carry the shear force to the base plates. Moment connections are provided on the plan bracing and transverse bays where the pipe with larger diameters are rested on beams.

2.6 M.G. Kawade (2019)

Author has worked on the optimized design of pipe racks by providing different location of braced bays. Author has concluded that as utilization ratio for all members is less than one, and deflection of all members is within permissible limit the design is safe for all the cases for different location of braced bays. Vertical deflection of structural members is less in pipe rack with bracing at center than pipe rack with bracings at 6th bay from either side or pipe rack same as case one but split at center.

2.7 Bambang Trigunarsyah (2007)

Author has worked on the innovation in the constructability of the pipe racks in this report. He has particularly studied the option of precast concrete pipe racks and he concludes that the cost saving in the precast concrete pipe rack compared to steel pipe rack is 30%. The qualitative benefits of this innovative construction are reduction in construction schedule, better site accessibility, and safety enhancement.

2.8 Nitesh J. Singh (2016)

In this work author has worked on the detailed design of a pipe rack considering lateral forces like Earthquake loads and wind loads in addition to pipe loads. The pipe rack length in this work is 113 m. Author has applied different loads to the structure based on American standards ASCE7-05 and has performed stability checks like story drift and vertical deflection check. Also strength checks like utility ratio check of different elements of the pipe rack have been summarized.

2.9 Rupam Saikia (2014)

In this work author has compared the pipe rack with bare frame with Moment Resisting Connections (MRC) and pipe rack with bracing introduced in it. He has concluded that the moments at the joints and shear forces in the beams are reduced with the introduction of bracings in the pipe rack. The detailed design of a pipe rack considering different types of bracings like X bracing, Inverted V bracing, K bracing, Eccentric D bracing, Y combined with inverted V was done. Author has compared the top node displacement in first 3 Modes for different bracings and has concluded that performance of X bracing is the most efficient.

3. CONCLUSION

Based on the above literature study it can be concluded that the pipe racks are the most complex and long structures and its design is mostly governed by piping requirements and client requirements. However the attempts should be made to standardize the design practice and optimization of the pipe rack to achieve most economical and stable structure.

4. FUTURE SCOPE OF WORK

Presently there is a need to have primary Design aspect with respect to pipe stress analysis for introduction of loops in the pipe line and location of braced bay for pipe racks for the optimization of the design.

Present study can be extended in following directions –

- Prepare a software model of a pipe rack with 65 m length.
- Apply the loadings as per standard practice.
- Assign the appropriate section properties to the members.
- Perform the analysis and design of the paperback.
- Redesign pipe rack with varying the location of the braced bay.
- Compare the results with respect to strength and serviceability.

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