© 2016 IJSRSET | Volume 2 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Stress Analysis of Process Piping Systems with Grooved Pipe Coupling Joint

Ashutosh Punyani*[1], Mitheshwar R. Thombre[2], V. D. Bharani[3]
[1,2]Piping Stress Engineer, Fluor Daniel India Private Limited, Gurgaon, Haryana, India
[3]Principal Stress Engineer, Fluor Daniel India Private Limited, Gurgaon, Haryana, India

ABSTRACT

The use of an alternative coupled pipe systems are becoming much more widely used in the petrochemical industries because of their comparatively cheap installation costs, their ability to install complete systems very quickly, reduction in overall weight of the system and the flexibility they offer in terms of alterations and disassembly/reassembly all without welding, as compared to traditional pipe joining processes. The use of an alternative coupled pipe system to that of the more traditional welded/socket welded or threaded system for any project is a critical decision that has to be considered and implemented as practicably as possible. This paper will discuss the utilities of the joining system, the types of clamps and grooves used in piping system, procedure for stress analysis of systems carrying grooved pipe coupling joint, and its advantages over conventional joining processes.

Keywords: Grooved mechanical couplings, Piping stress analysis, Bending moment check

I. INTRODUCTION

The basis of the grooved system is that each end of the pipe or component to be joined is grooved. A specially designed housing or clamp and seal ring is then bolted into position where the clamp sits in the grooves and presses the gasket across the joint to make the seal. The clamp therefore locks the joint together along with holding and supporting the gasket.

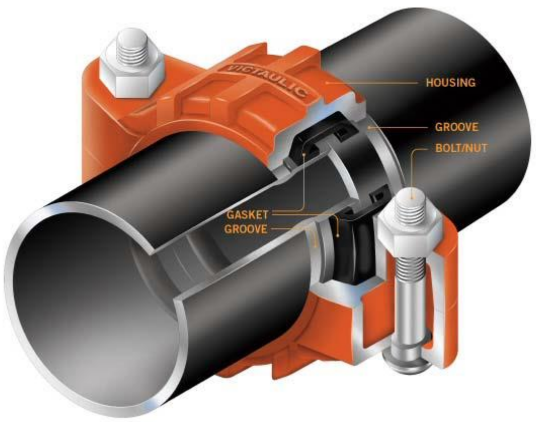


Figure 1 : A Victaulic Grooved Joint (Courtesy of Victaulic Products)

It is normally proposed to use the grooved mechanical joint system for water and gas utility systems. Whereas other service applications include potable water, utility water, demineralised water**,** instrument air, nitrogen etc.

Types of Clamps for Grooved piping Systems

There are two types of joints:

- A Rigid Type where the joint is kept rigid by a patented angled pad design which constricts the clamp as it keys into the groove around the full encirclement of joint to create a rigid joint. The clamp slides on angled pads to lock the joint. This sliding motion, rather than a square mating, forces the key sections into opposed contact on the inside and outside of the groove edges, which locks the coupling onto the pipe ends and creates a rigid connection.
- A flexible type where the joint has a small amount of flexibility which can be useful in certain situations. This type of joint allows for a small amount of angular linear and rotational movement at

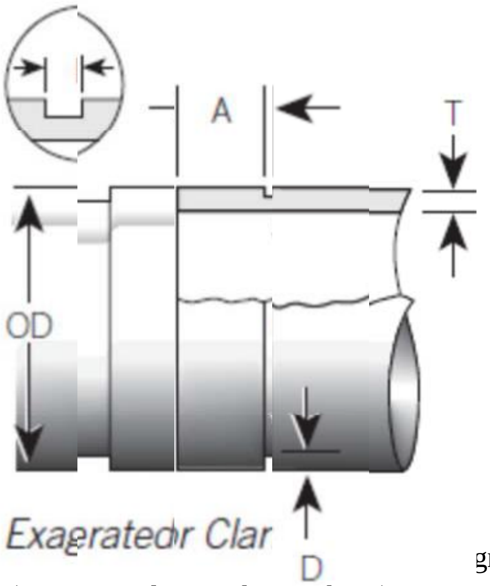
each joint to accommodate expansion and contraction, settling, vibration, noise and other piping system movements.

•

Types of Grooves for Grooved piping systems

There are two types of grooves:

- Cut Grooves: In reviewing the groove profiles, cut grooved systems shall not be used. This is due to the loss in material at the groove which reduces the wall thickness of the pipe and pressure containment capabilities as per ASME B31.3. This loss of material requires additional wall thickness to be added to account for cut groove.



Figur gn
(Courtesy of Victaulic Products)

- Rolled Grooves: The rolled groove profile presses/ rolls the profile into the pipe and no material is lost. There is a potential for a small amount of deformation and thinning through the profile of the groove. This potential for thinning has been reviewed against the recommended pipe wall thickness and there is enough additional material to permit an amount of thinning and still meet the full design pressures required for the utility systems.

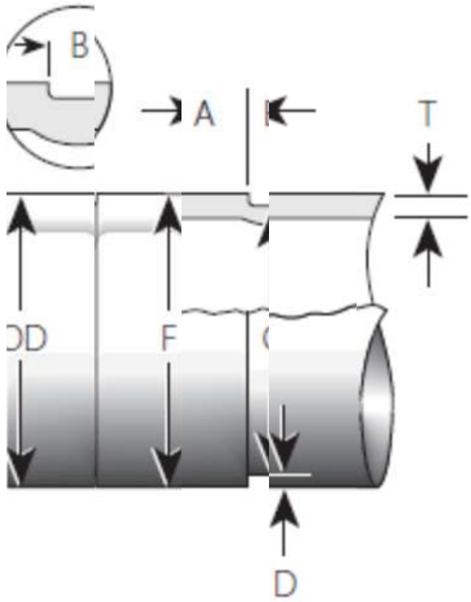


Figure ign

Stress **oved Mechanical Joints**

1. Modelling

All spools/components (for example tee, elbow, etc) have been taken into account for the extra length of clearance on either side for the groove required to attach the coupling. These rigid couplings were represented using a single flange at connecting node with joint SIF 2.3 and weight as per vendor data (For example: 8" coupling will have a weight 6.8 kg as per Victaulic vendor).

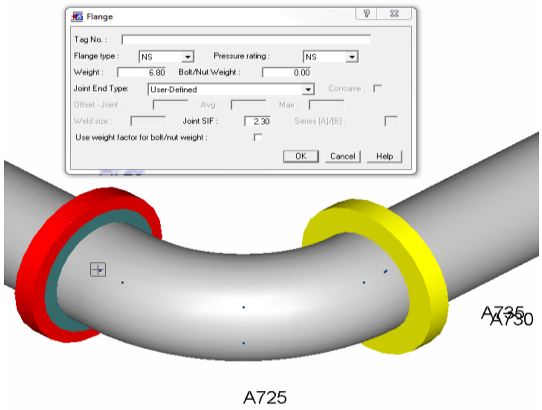


Figure 4 : Representation of Grooved coupling for 8" line

Two model variations were prepared for the piping system. Flexible Joint (say 5mm (assumed)) can be considered at every connecting node for both the variations. The variation had been in the value of torsional stiffness as explained below:

Model 1: Couplings without torsional stiffness case

Torsional Stiffness at each flexible joint is considered as 1e-005 Nm/deg as shown below:

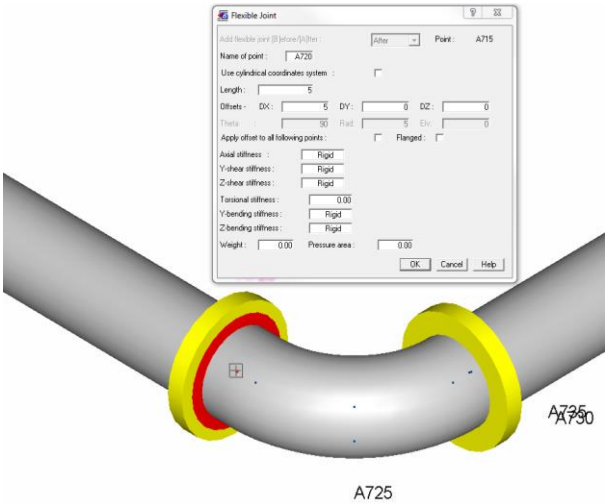


Figure 5 : Value of torsional stiffness for flexible joints is considered as 1e-005 Nm/deg

Model 2: Couplings with torsional stiffness case

Equivalent Torsional Stiffness is calculated as per the formula

$$K_T = A\left(\frac{GJ}{L}\right)$$

Where,

K_T = Equivalent Torsional stiffness (N-m/deg)

G = Modulus of Rigidity (N/m^2)

L = Equivalent pipe length (m)

A = Coupling joint coefficient factor (vendor specific i.e. 0.3 as in this case)

J = Polar moment of inertia of pipe (m^4)

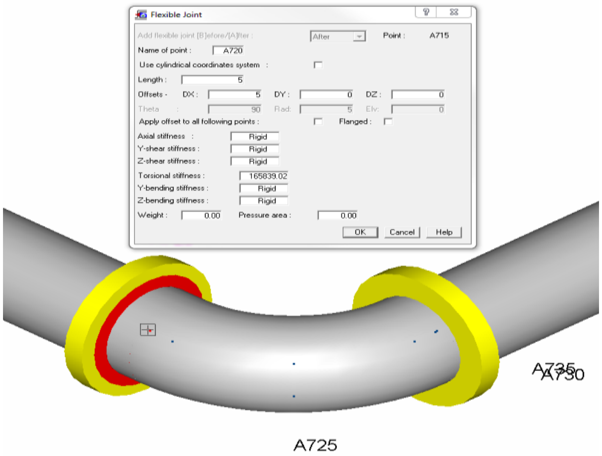


Figure 6: Value of torsional stiffness for flexible joints is considered as 165839.02Nm/deg

As per these methods, following process piping system (Connecting tank with AG/UG interface via control station; having 75^0C/1.45MPa as design temperature/pressure) is modelled.

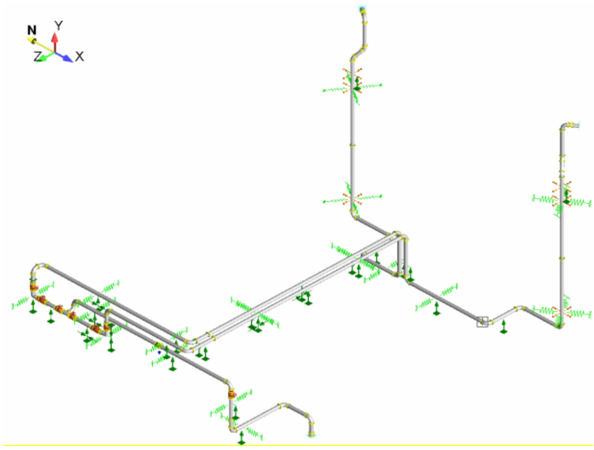


Figure 7 : Model of process piping system

III. ANALYSIS AND RESULT

Both the models were analysed for nozzle qualifications, flexibility check, sagging, support loads as per ASME B31.3.

Further Grooved mechanical couplings were checked separately to ensure that the resultant bending moment (Summation of Model 1 and Model 2 maximum bending moment) on each coupling lies well within the maximum allowable bending moment on each coupling (as per vendor data), as specified for the cases given below:

Model 1 for "Sustained Cases" – weight, pressure, wind.

Model 2 for "Thermal Cases"

Node Number	Line Size	BM (N.m) (Sustained Case)	BM (N.m) (Thermal Case)	Total BM (N.m)	Allowabe BM (N.m)	FAIL/PASS
A10	8"	640	1997	2637	10941	PASS
A20	8"	432	3088	3520	10941	PASS
A30	8"	1192	1948	3140	10941	PASS
A40	8"	339	8855	9194	10941	PASS
A50	8"	556	9385	9941	10941	PASS
A60	8"	1369	8470	9839	10941	PASS
A70	8"	1093	8559	9652	10941	PASS
A80	8"	928	7974	8902	10941	PASS

Table 1 : Sample BM Check table for the couplings

As per results obtained from Table 1, all the couplings were qualified for resultant BENDING MOMENT check.

Advantages of Grooved Mechanical Couplings

- **Schedule:** The installation time is greatly reduced against conventional joint selections with very little rework due to leaks at the point of hydro testing.
- **Installation comparisons with other joining processes:** Skilled labors are not required for the installation of these couplings. Material may be slightly more in bill of material of these systems as compared to welded bill of materials, but this is offset by saving in labor cost.
- **Hookups:** The adjoining pipe work between two modules can be easily adjusted by either moving pipe work within the limit of the adjoining clamp or joint, or quickly cutting the pipe to suit, re grooving and joining the two pipes together with the coupling.
- **Maintenance**: Maintenance of these piping systems is always simple and less time consuming as compared to conventional piping systems.
- **Assembly Weight**: The total weight of such fittings is less as compared to that of fittings with flanged joints, and thus it reduces the overall weight of the assembly.

Limitations of Grooved Mechanical Couplings

- The maximum design parameters considered for such systems will be 110^0C/16 bar at present.
- These couplings cannot be used for Category M fluids as per ASME B31.3.

IV. DISCUSSION AND FUTURE SCOPE

This discussion shows that how grooved mechanical couplings have an edge over other conventional fittings in utility lines for both galvanized carbon steel and stainless steel in cost saving and schedule. It is easier to install, dismantle or modify the utility piping systems in a cost effective manner as compared to conventional fittings like socket welded and threaded joints.
Following are the significant points that should be kept into consideration while using these kinds of joints:

- Galvanized lines are generally provided with these kinds of fittings where welding is not permitted, thus clamped supports for insulated lines or integrally fitted supports are normally used.
- In such kind of systems, spans are dictated by maximum loads i.e. indirectly by maximum allowable bending moment on the joints rather than deflection. Thus it is necessary to stick to the project specific span chart provided for lines having such kind of fittings. For example for a 3" Schedule 80 line, a span of 7 m is provided for normal fittings, whereas a span of 6.096 m is required for lines with these couplings.

V. ACKNOWLEDGEMENT

The authors would like to acknowledge Fluor Corporation for its consistent encouragement and motivation to its employees for professional paper presentation and publication of papers in industry and academic forums.

VI. REFERENCES

[1] ASME B31.3 Process Piping Code.
[2] Sam Kannapan, "Introduction to Pipe Stress Analysis" 1986, USA.

Websites and Links

[1] www.victaulic.com