Finite Element Prediction and Failure Analysis of Integral Elastomeric Spigot and Socket Joints for Steel Pipes

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Introduction

Pipes are widely used components in mechanical and civil engineering works. They are used mainly in manufacturing plants, refineries, water and gas distribution works. Very often, these pipes are sujected to internal pressure. In terms of construction, several pipes need to be joined. Current practice is to use flanges and in some cases in-situ welding is carried out. To quicken and ease the job of pipe joining, push fit joining method is used. One of the components used for this method is the spigot and socket. Currently, spigot and socket joint are used in hydraulic and pneumatic tubes. The materials are soft such as plastics, pvc and copper. The sizes are small (below 50 mm in diameter). However, for steel pipes especially large diameter pipes used for water distribution, gas utilisation and chemical transport, this push fit method (particularly integral joint) has not been widely used. The objectives of this project are to determine the design parameters that affect the contact forces between the elastomer and spigot and socket joint in steel pipes. Finite element method was used.

Materials and Methods

The research work involves construction of finite element model of the pipe joints and the elastomeric rubber ring. For this purpose, LSDYNA and LUSAS finite element packages are used. The manufacturer supplies the material properties used for the steel pipe and rubber ring. The finite element analysis determines the contact pressure distribution between the elastomeric ring and the pipe. From this distribution, maximum values are obtained which will determine the pressure joint capacity. An experimental test rig is designed to determine the actual pressure capacity of joint. Both static pressure test and leakage test are carried out. The results between the finite element analysis and the experimental work are then compared.

Results and Discussion

The result from this study is the contact pressure distribution for different squeeze using plane-stress and axisymmetry analysis. It is found that 13 mm squeeze gave the maximum pressure at top and bottom surface for both analyses. The result for axisymmetric analysis gave the value of 28.5 MN/m^2 for top surface and 23.8 MN/m^2 for bottom surface. The plane-stress analysis results gave the value of 23.5 MN/m^2 for top surface and 31.7 MN/m^2 for bottom surface. The results also indicated that increasing t and h values reduces the maximum pressure. The suitable combination of t and h of the elastomer size obtained when t = 3 mm and h = 0.5 ℓ at 48% squeeze. It has also been found that the higher the hardness values results in higher pressure. For the pushing analysis of each case, stress in y direction is used. Higher stress was found at the front edge of the elastomer. From the shear stress results, the pushing force to fit the joint is determined. From the present work, a value of 10 kN is obtained. The design parameters that affect the pressure distribution of the elastomeric spigot and socket joint are rubber properties (which includes C_1, C_2), IRHD values from the load – displacement curve, geometrical sizes (which is t and h values) and squeeze percentage. An experimental test was carried out for elasromeric lip ring of IRHD number of 58 and dimension overall thickness 28.3mm and width of 54.0 mm fitted to a 654 mm diameter spigot and 669 mm diameter socket joint. The joint provides a squeeze of 13.02 mm (46 %). For this case, when the water pressure above 6.25 bar is applied, leaking occurs. Hence, the joint capacity of pipe is 6.25 bar. The finite element results obtained give and overestimate by 4 times.

Conclusions

The joint capacity, that is the maximum permissible working pressure for the elastomeric spigot and socket steel pipe joint investigated is 23.8 MN/m^2. This value satisfies the criteria of no leaking condition. The size, squeeze and material hardness are identified as important design parameters for elastomeric spigot and socket joint. The joint capacity of pipe as obtained experimentally is 6.25 bar, which is 4 times lower than that predicted by finite element method

Benefits from the study

The material and dimensional specification for the elastomeric ring to be used for integral spigot and socket joint are obtained for use in the design of pipeline installation. The fabricated test rig can be used for testing of pipe joints.

Literature cited in the text

None.

Project Publications in Refereed Journals

None.

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Graduate Research

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