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The metal gasket sealing performance of bolted flanged with fem analysis

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Abstract. There is a wide variation of flange style and configuration, but only four types of facing are widely used, which are raised face, flat face, ring joint facing and lap joint flange. Corrugated metal gaskets 400MPa-mode has better performance than gaskets 0Mpa-mode for flat face flange type. In this study we investigated the performance of corrugated metal gasket 400MPa-mode for three types of flange facing which are raised face, flat face and combination raised-flat face. The finite element method employed to analysis the effect of different types of flange on contact width and contact stress in relation with axial force of corrugated metal gasket. The result shows corrugated metal gasket 400MPa-mode give good performance for all type of flange face.

1. Introduction

In the piping system there are several types of pipe connection methods. One of them is a mechanical joining system. In mechanical systems there are several methods used and this system continues to evolve as technology advances. A flange joining is one of the mechanical connection systems. Flange is a non-permanent tightening mechanism, it can be dismantled and installed using bolts as a fastener. Pipes that use this method are usually because they often have to be dismantled when repairs. The flange that is used to connect also will differ in type. In general there are two types of flange, namely flat face type and Rise face type.

However, due to flange surface imperfections, there is still a leak in the pipe connection. So we need components that can cover the imperfections of the flange surface to prevent leakage. Gaskets are components that are inserted between flanges, which when in contact with the surface of the flange are deformed plastic and fill the gap of the flange surface which is not perfect so as to prevent leakage. With advances in technology research on gasket design and material is growing rapidly too. Research on corrugated metal gaskets producing super seal gaskets has been carried out to obtain an optimal design [1]. The research then continued by considering the influence of the forming process [2]. The research about the corrugated metal gasket by utilizing simulation method [3, 4] which is validated also by experiment [5]. The surface roughness of the flange also affects the performance of the gasket

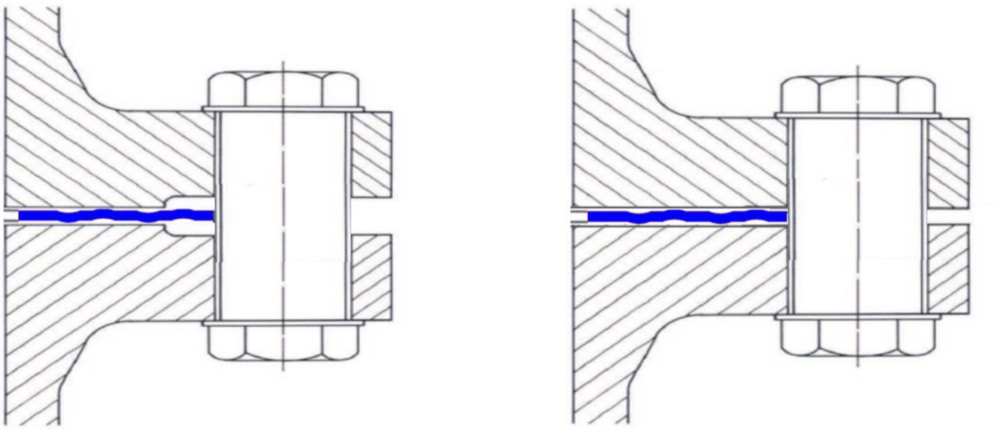
[6].

Previous research is a study to produce new design products from corrugated metal gaskets based on full face flange. The forming process use open dies type. Referring to the design concept from previous research that the contact width and contact stress are the important sealing performance parameter. In this research the aim to determine the contact stress and contact width by considering forming by closed die in contacted with full face and rise face flange. The analysis using computer simulations design and manufacturing processes so that the cost and time for trial-error processes will be reduced.

2. Material and Method

The gasket used in this study is a corrugated metal gasket 400 MPa mode mounted between two flanges on the upper and lower sides, as illustrated in Figure 1. The flanges type used in this paper are flat face and rise face flange. When the gasket material is tightened between the two flanges, then the two bead on the gasket will come into contact with the flange and creating contact width lines that have a high contact stress to prevent leakage (Figure 2). Although the contact width that occurs in this corrugated type gasket is small, it will produce contact stress which is high so that the tightening load smaller is needed.

This research was carried out using computer simulation. The material used is SUS 304 steel material because it is resistant to high temperature and corrosion resistance. This material using JIS standards based on strength tests drag JISZ 2241, as shown in table 1.



a) Rise Face type b) Flat face type

Figure 1. Flange type

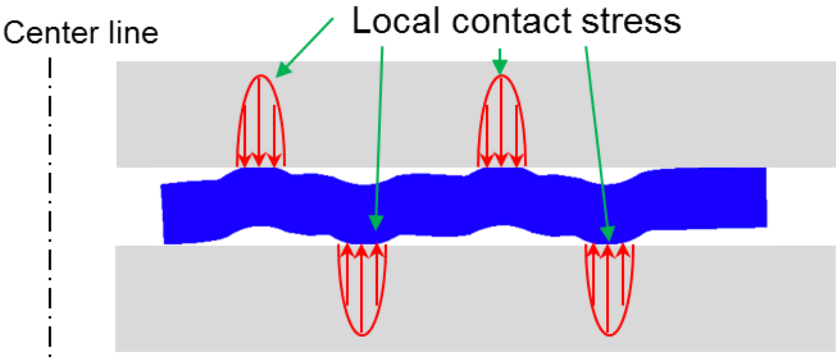


Figure 2. High local contact stress on small contact width

Table 1. Mechanical properties of SUS304

Properties	Value
Yield stress (Mpa)	398,83
Modulus tangen (Mpa)	1900,53
Modulus elasticity (E) GPa	210
Poisson ratio (v)	0.3

Material is modeled isotropic bilinear hardening because it is used to analyze plasticity experienced by workpieces as a result high strain. Stress-strain curve bilinear was obtained by including the yield strength and tangent values of the modulus. Segment slope first on a curve equivalent to young modulus while the slope of the second segment is equivalent to tangent modulus. Figure 3 shows material model relationship from Stainless Steel SUS304.

The corrugated gaskets model analyze uses the finite element method based simulation. Both flanges are assumed to be rigid body, while gaskets are assumed to be deformable. Modeling is made with 2 dimensions assuming an axe-symmetrical model. Displacement in the axial direction is used as a model tightening the upper flange and lower flange against the gasket (Figure 4 and Figure 5).

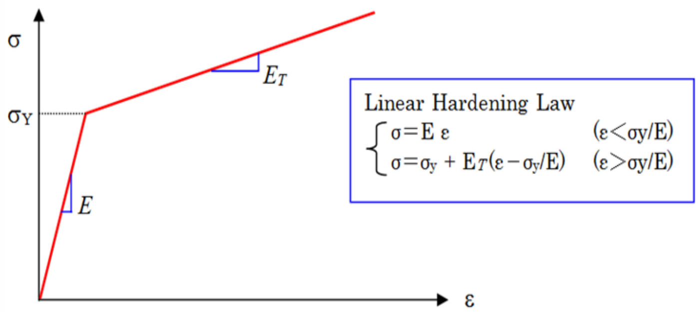


Figure 3. Linear strain hardening model for SUS304

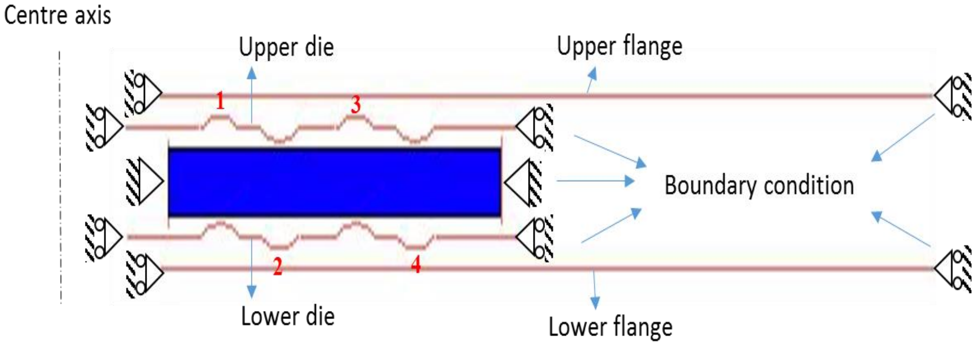


Figure 4. Simulation for flat face flange axisymmetric gasket model

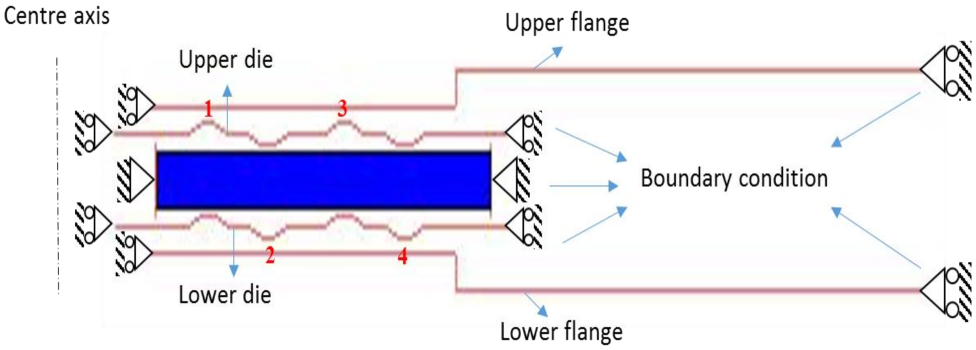


Figure 5. Simulation for rise face flange axisymmetric gasket model

In previous studies, it was known that contact width affects the resistance level gasket to prevent leakage with consider contact stress that occurs [2]. The contact width is measured by the number of gasket elements that have contact with the flange. Determination of contact width is done by considering contact stress by removing contact stress values below the yield stress of 398.83 MPa. Sealing lines will form on contact widths that have plastic contact stress conditions (Figure 6).

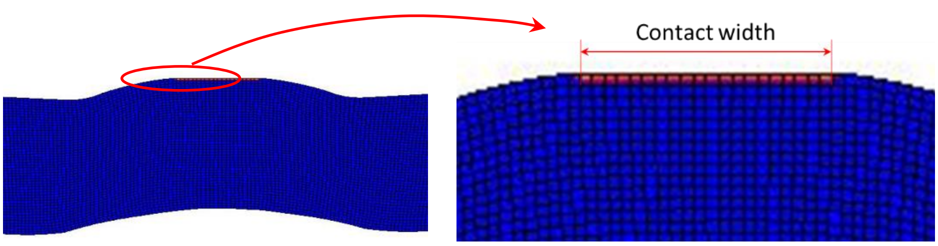


Figure 6. Contact width on the convex gasket

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3. Result and Discussion

The result of computer simulation, there is a distribution of contact stress and contact width that occurs. The magnitude of the flange tightening load on the gasket is accompanied by the stress distribution patterns and gasket deformation that occur. Based on previous research that contact width that have high plastic contact stress condition occur most on convex 2 and convex 3. Therefore our focus analysis on convex 2 and convex 3 because influence gasket sealing performance to reduce leakage.

Firstly we plot graphics with horizontal axis gives the axial force for tightening flange while contact width or average contact stress is given along the vertical axis. Figure 7 shows the axial force relation to contact width for convex portion 2. It shows for axial force under 80 KN the contact width between three types of flange almost the same value. For the same closed dies type the contact width value seems the same for flat face and rise face flange for each axial force. For the same flat face type the contact width value for open dies is higher than closed dies for each axial force. Overall the flat face flange type with open dies has highest contact width value.

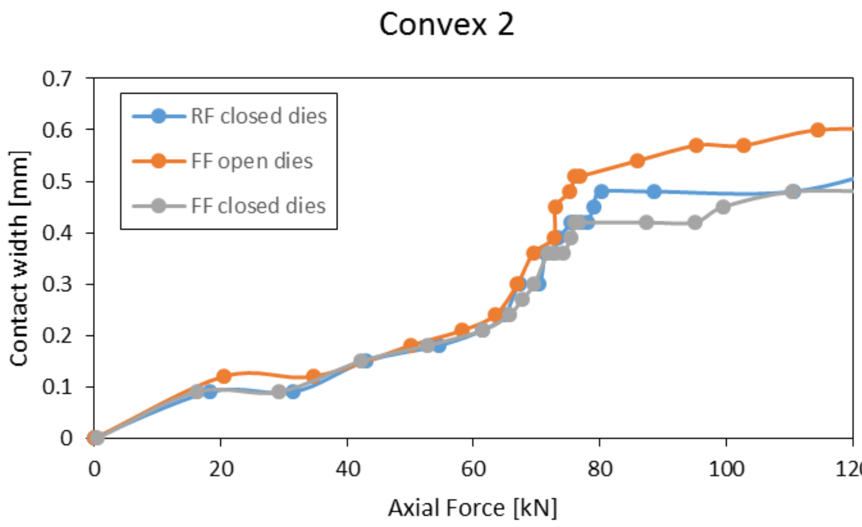

Figure 7. Contact width versus axial force for convex 2

Figure 8 shows the axial force relation to contact width for convex portion 3. It shows for axial force under 80 KN the contact width between three types of flange almost the same value. For the same closed dies type the contact width value seems the same for flat face and rise face flange for each axial force. For the same flat face type the contact width value for open dies is higher than closed dies for each axial force. Overall the flat face flange type with open dies has highest contact width value.

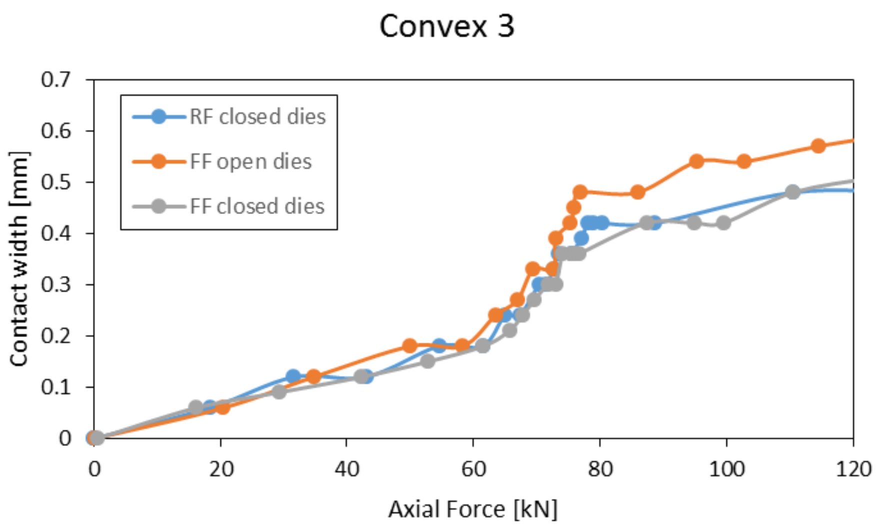

Figure 8. Contact width versus axial force for convex 3

Figure 9 shows the relation between axial force and average contact stress for convex portion 2. For the same closed dies type the average contact stress value seems the same distribution for flat face and rise face flange for each axial force. For the same flat face type the average contact stress value for closed dies is higher than open dies for each axial force. Overall the closed die type has highest average contact stress value.

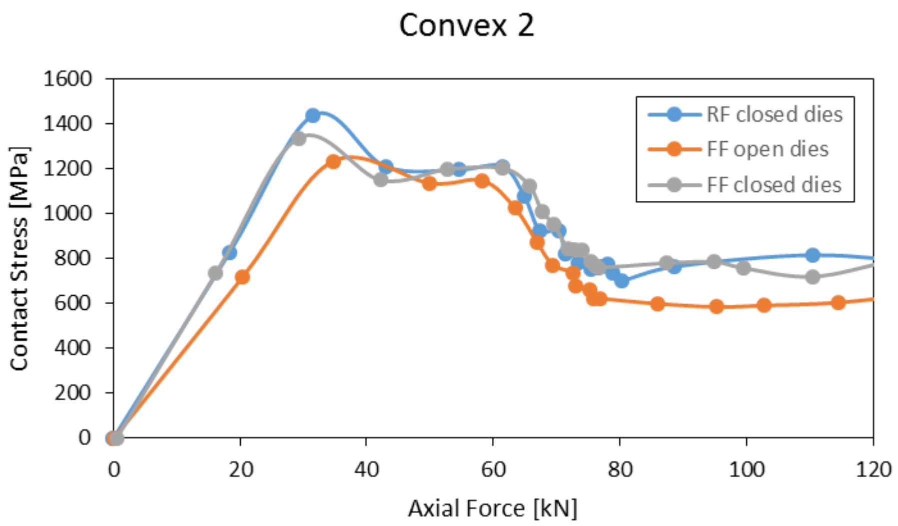

Figure 9. Average contact stress versus axial force for convex 2

Figure 10 shows the relation between axial force and average contact stress for convex portion 3. For the same closed dies type the average contact stress value seems the same distribution for flat face and rise face flange for each axial force. For the same flat face type the average contact stress value for closed dies is higher than open dies for each axial force. Overall the closed die type has highest average contact stress value.

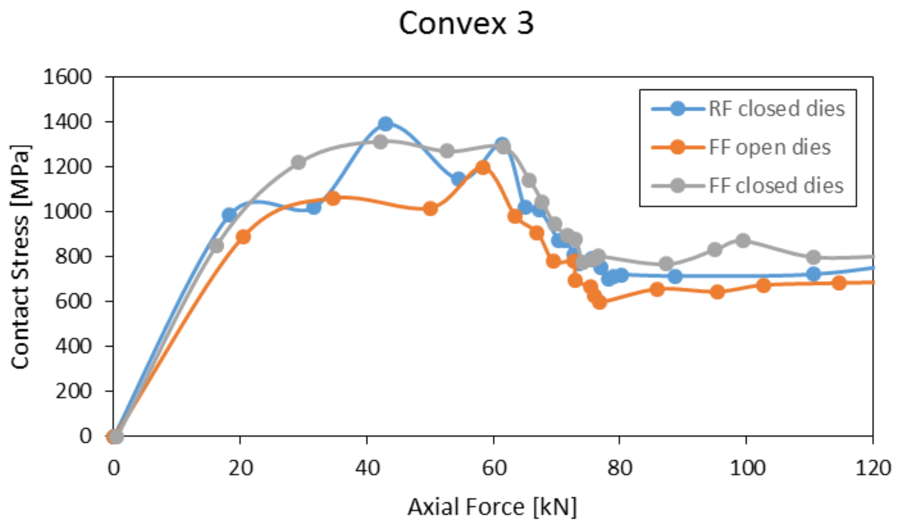

Figure 10. Axial force versus Average contact stress for convex 3

Metal gasket made by closed die has higher average contact stress than open dies because when forming process gasket made by open dies has lack of die fill, especially on the convex portion.

4. Conclusion

Based on simulation result, corrugated metal gasket 400 MPa has the good sealing performance for flat face and rise flat face type of flange. Gasket made by closed dies will give better sealing performance because has higher average contact stress than gasket made by open dies.

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