Influence of dies type for gasket forming shape

I M G Karohika¹, I N G Antara¹ and I M D Budiana¹
¹Mechanical Engineering Department University of Udayana

Email: gatot.karohika@unud.ac.id

Abstract. Performance of metal gasket influenced by the final design of the forming result. Good shape of the gasket will give optimal leakage performance. It is difficult to produce good shape because of the spring back effect. In this study, we investigated the forming process of metal gasket 400MPa-mode for two types of dies which are open dies and closed dies. The finite element method employed to analyze the effect of different types of dies on the final design of the corrugated metal gasket. The simulation shows corrugated metal gasket 400MPa-mode with closed dies result in better final shape than open dies.

1. Introduction
Leaks in piping connections due to flange surface imperfections must be avoided. For this reason, a gasket is needed as a component inserted between two flange surfaces, in which there is a pressurized fluid, to prevent leakage. When tightening the fastening bolt between two flanges, the gasket will react by changing shape according to the level of elasticity. This change in shape will fill the space produced by the two flanges due to uneven workmanship. This change in shape causes the connection between the two flanges to become tight and allows to prevent leakage. Research on gaskets evolves over time. The development is in terms of material and system performance of the gasket. In material terms, metal, non-metallic and semi-metal materials are known. One of the gaskets made from metal is a corrugated metal gasket [1 – 8]. This gasket has a corrugated surface that produces high contact stress that can prevent leakage. While the flat part serves as a spring so that it can reduce the occurrence of loose bolts.

In the previous study the process of making corrugated metal gaskets using press mold forming method. The dies type used is open dies. There are still found some defects in the press results, especially at the peak of the convex portion that still does not fill the entire surface of dies [5]. This can affect the performance of the gasket when in contact with the flange surface, where the gasket does not work optimally to prevent leakage.

At present, the development of software technology is advancing so that it is possible to predict the results of forming processes using simulation methods. With the right modeling, the number and time of the experiment can be limited so that the costs incurred because the experiment process can be
reduced.

2. Material and Methods
In this paper, the simulation method is used to analyze the effect of the type of dies that is open dies and closed dies on the results of the forming process. The material used as a gasket material is SUS304 with mechanical properties indicated in table 1. The type of dies selected dies 400 MPa with a size as in table 2. The geometry of dies is shown in figure 1.

| 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         |

| Table 2. Dies design gasket model of 400-MPa |
|---------------------------------------------|
| Factor            | dimension (mm) |
| Overhang (OH)     | 3              |
| Pitch 1(p₁)       | 3.5            |
| Pitch 2 (p₂)      | 4.5            |
| Pitch 3 (p₃)      | 3.5            |
| Thickness (Tg)    | 1.5            |
| Radius (R)        | 2.5            |
| Radius (R₁)       | 2.3            |
| Height (h)        | 0.3            |
| Height (h₁)       | 0.33           |

![Figure 1. Dies geometry](image)
The simulation divided into 2 stages, the first stage of the plate is made using CAD software. The
second stage of the model that has been made is processed in FEM software which consists of process meshing and forming processes. In the meshing process for plate gasket with element size 0.03 mm quadrilateral element type. Next is the forming process assuming two dimensions of the axis-symmetric model in the axial direction between the upper and lower dies as shown in figure 2. Upper and lower dies are assumed to be rigid bodies while deformable bodies gaskets. The dies used are types of open dies and closed dies. The flowchart of the gasket simulation steps is shown in figure 3. In this simulation, the gasket material is Linear hardening law.

![Linear Strain Hardening Model for SUS304](image1)

**Figure 2.** Linear strain hardening model for SUS304

![Forming Process Simulation for Open Dies Axisymmetric Gasket Model](image2)

**Figure 3.** Forming process simulation for open dies axisymmetric gasket model

![Forming Process Simulation for Closed Dies Axisymmetric Gasket Model](image3)

**Figure 4.** Forming process simulation for closed dies axisymmetric gasket model
3. Result and Discussion

To analyze the forming results that occur, the focus is on 4 parts of the peak of convex of the gasket because the performance of the gasket is affected by that part [5]. The forming result is said to be good if the gasket formed fill the entire parts of the dies. If it does not fill the contents of the dies it is said the product defects and the defect amount is calculated based on the number of elements that are not in contact with the dies field.

\[
\text{Die fill defect} = \text{element size} \times \text{number of element (mm)} \\
= 0.03 \times \text{number of element (mm)}
\]

![Figure 5. Contact status between the gasket and die](image)

![Figure 6. Forming result for open die type](image)

![Figure 7. Forming result for closed die type](image)
### Table 3. Die fill defect open dies

| Convex | \( C_1 \) | \( C_2 \) | \( C_3 \) | \( C_4 \) |
|--------|-----------|-----------|-----------|-----------|
| Die fill defect | 0.75      | 0.57      | 0.63      | 0.81      |

### Table 4. Die fill defect closed dies

| Convex | \( C_1 \) | \( C_2 \) | \( C_3 \) | \( C_4 \) |
|--------|-----------|-----------|-----------|-----------|
| Die fill defect | 0.33      | 0.39      | 0.36      | 0.3       |
Figure 8. Graphic Comparison die fill defect

Based on table 3 and 4, is showed when forming process, gasket material has plastic deformation. For open dies type the deformation occurs in the vertical and horizontal directions. In the vertical direction the plate changes shape to be corrugated, in the horizontal direction the gasket plate also becomes longer, therefore, the gasket plate does not fill the mold, especially at the peak of the corrugated shape.

For closed dies type, gasket plates only deform in a vertical direction because the horizontal direction is limited by dies. The shape of the gasket becomes more perfect. However, there is still a small element in the peak of corrugated gaskets that do not fill the dies. Figure 8 shows the comparative lack of die fill defect for closed die and open die type. The optimization design for designing closed type dies needs to be done in the future.

4. Conclusion
Based on dies type in the press mold process, by using the simulation method the resulting design was found. The result shows that gasket by closed dies type gives a better result than open dies type. Next, optimization design research is necessary for better gasket shape result.

Acknowledgment
The research/ article’s publication is supported by LPPM University of Udayana through Udayana Invention Research and partially funded by the United States Agency for International Development (USAID) through the Sustainable Higher Education Research Alliance (SHERA) Program for Universitas Indonesia’s Scientific Modelling, Application, Research and Training for City-centered Innovation and Technology (SMARTCITY) Project, Grant#AID-497-A-1600004, Sub
References

[1] Saeed, H.A., Izumi, S., Sakai, S., Haruyama, S., Nagawa, M., Noda, H., 2008, Development of New Metallic Gasket and its Optimum Design for Leakage Performance, Journal of Solid Mechanics and Material Engineering, Vol. 2, No. 1, pp. 105-114.

[2] Haruyama, S., Choiron, M.A., Kaminishi K., 2009, A Study of Design Standard and Performance Evaluation on New Metallic Gasket, Proceeding of the 2nd International Symposium on Digital Manufacturing, Wuhan China, pp. 107-113.

[3] Choiron, M.A., Haruyama, S., Kaminishi, K., 2011, Simulation and Experimentation on the Contact Width of New Metal Gasket for Asbestos Substitution, International Journal of Aerospace and Mechanical Engineering, Vol. 5, No. 4pp. 283-287.

[4] Nurhadiyanto, D., Choiron, M.A., Haruyama, S., Kaminishi, K., 2012, Optimization of New 25A-size Metal Gasket Design Based on Contact Width Considering Forming and Contact Stress Effect, International Journal of Mechanical and Aerospace Engineering, Vol. 6, pp. 343-347.

[5] Haruyama, S., Nurhadiyanto, D., Choiron, M.A., Kaminishi, K., 2013, Influence of surface roughness on leakage of new Metal Gasket, International Journal of Pressure Vessels and Piping, 111-112, pp. 146-154.

[6] Haruyama, S., Nurhadiyanto, D., Kaminishi, K., 2014, Contact Width Analysis of Corrugated Metal Gasket based on Surface Roughness, Advanced Materials Research, Vol. 856, pp. 92-97.

[7] Nurhadiyanto, D., Haruyama, S., Kaminishi, K., Karohika I M. G., Mujiono, 2015, Contact Stress and Contact Width Analysis of Corrugated Metal Gasket, Applied Mechanics and Materials, Vols. 799-800, pp. 765-769.

[8] Haruyama, S., Karohika, I M. G., Sato, A., Nurhadiyanto, D., Kaminishi, K., 2016, Development of 25A-Size Three-Layer Metal Gasket by Using FEM Simulation, International Journal of Mechanical, Aerospace, Industrial, Mechatronic, and Manufacturing Engineering Vol:10, No:3, pp.555-561.

[9] MSC Marc 2010, User Manual.