FINITE ELEMENT ANALYSIS ON THE SEALING BEHAVIOR OF PROTRUSION O-RING FOR AUTOMOTIVE

Byungmo Yang
Department of Mechanical Engineering, Kongju National University,
Chungcheongnam-do, Republic of Korea

Haengmuk Cho*
Department of Mechanical and Automotive Engineering, Kongju National University,
Chungcheongnam-do, Republic of Korea
*Corresponding author: haengmukcho@hanmail.net

ABSTRACT
There have been lots of cases that sealing has been assembled with sealing not connected to groove in flange etc. Sealing assembled with groove separated causes gas or oil to be leaked. Failure of parts resulting from damaged sealing entails a lot of expenses. This Article designed a protrusion in existing sealing to prevent sealing from being separated and examined strain and stress according to the size of protrusion through simulation analysis. It was found that protrusion of sealing with 1mm larger than the width of groove showed low strain and high stress, which suggests that the foregoing method is the most suitable in preventing sealing from being separated.

Key words: Protrusion sealing, Sealing performance, Peak contact stress and Finite element method

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1. INTRODUCTION
O-ring plays a role of preventing oil or gas from being leaked from driving part or delivery part with high temperature and pressure. O-ring is widely used in a part of connection and assembly in pipes that requires sealing. O-ring is widely used in various devices. O-ring allows workers to seal fluid easily in a state of static or dynamic contact. The price of O-ring is relatively low but failure of sealing entails lots of expense.

O-ring is made from elastomer such as rubber. O-ring is pressured in groove with constant compressibility producing contact capability higher than pressure of fluid working on groove through elasticity resulting from compression securing sealing performance [1-3].
Design is made in a way that groove is formed along circumference so that O-ring can be inserted in inner diameter or outer diameter in a pipe or driving shaft and O-ring is put together and then covered completely. O-ring inserted in groove should be fixed so that it cannot be separated even if deformation behavior occurs due to sealing pressure difference and more importantly elasticity deformation behavior should be excellent and durability and sealing performance [4,5].

Failure of O-ring resulting from wearing, compression, corrosion and aging led air or oil to be leaked. It is necessary to secure good sealing performance in order for safety of workers and equipment to be maintained. There have been lots of cases that O-ring was assembled with it poorly connected to groove when products are manufactured or equipment is maintained to make O-ring malfunctioning [6,7].

This study designed a protrusion in sealing to prevent sealing from being separated when assembling sealing. We conducted finite elements analysis of sealing according to the size of protrusion to secure safety of pipes that transport oil. We made comparative analysis of sealing performance.

2. DESIGN AND CONDITION
In general, sealing performance of O-ring is assessed based on the ratio of peak contact stress to applied pressure. Leachy et. al reported that when pressure applied is greater than maximum contract stress, leakage occurs in O-ring. It is known that contact stress is caused by compression and pressure of O-ring and magnitude of maximum contact stress depends on compressibility, clearance gap, pressure etc. [8-10].

The diameter of center circle in sealing which the protrusion is designed is 17mm. Width and height of sealing is 1.7mm, and 6.5mm respectively. Depth and width of flange groove is 5mm and 3mm respectively. As shown in Figure 1, sealing has cross section of rectangle. We designed four protrudes inside sealing and another four protrudes outside sealing. We designed in a way that the size of the protrusion was larger than sealing groove in flange to prevent sealing from being separated. We modeled four sizes of protrusion in sealing. We modeled in a manner that protrusion in sealing was 0.5mm, 1.0mm, 1.5mm, 2.0mm larger than width of groove.

3. FINITE ELEMENT ANALYSIS
In this simulation analysis, maximum contact stress according to pressure applied was calculated through finite elements methods by using 3D model. For efficient simulation analysis, as shown in Figure 2, only one of four protrusions was cut before analysis was made. We set symmetry region in each cross section which sealing was cut to assume that there was the same model. The number of mesh element is about 14 thousand. Material of
sealing was assumed as hyper plastic material. Mooney-Rivlin 5 Parameter model was applied. Flange was set as general structural steel. 0.14 was applied as coefficient of friction in a part where sealing and flange contacted. We conducted analysis with a case that sealing entered groove in flange and a case that two flanges were connected. We examined stress and strain in a contact with a gap of 0.5mm between protrusion in sealing and groove in flange sealing.

![Mesh model of protrusion sealing](image)

**Figure 2** Mesh model of protrusion sealing

### 4. RESULTS AND DISCUSSIONS

Figure 3 represents strain and stress which a sealing is inserted to flange. As the size of protrusion increased, strain and stress rose. There was lots of load in protrusion. We found that a sealing which was 1mm larger than width of flange groove was the most suitable. In a sealing which was 1mm larger than flange groove, maximum strain was about 0.180m/m and maximum pressure was about 549Pa.

![Strain and stress in cases that sealing is inserted in a flange](image)

**Figure 3** Strain and stress in cases that sealing is inserted in a flange
Figure 4 represents a result of analysis of cross section of protrusion when flange and sealing are assembled. As with a result of above analysis, as protrusion increased, strain rose but stress showed almost the same result. As shown in a graph of Figure 5, as protrusion increased, maximum stress rose. As shown in red circle folded in Figure 4(b), stress became high.

Figure 4 Strain and stress in cases that flange and sealing are assembled

Figure 5 shows maximum stress and maximum strain in graph. As protrusion increased, strain and stress rose. When a flange was assumed, at 1mm, somewhat low strain and high stress occurred. When a protrusion was designed in a manner that the width of flange groove was 1mm larger, it led to low strain and high stress, which suggests that the foregoing method is the most suitable in preventing separation at the time of assembling.
Von mises stress

Figure 5 Variance and stress according to the size of protrusion

Figure 6 represents strain and stress in a case that flange and sealing were assembled. Protrusion was 1.0mm greater than the width of groove. It was found that high strain and stress occurred in a boundary of sealing body and protrusion but it did not have a significant influence on sealing function.

5. CONCLUSIONS

This Article designs a protrusion in a sealing to prevent separation when assembling sealing. We got the following results after conducting simulation analysis with a sealing connected to a flange.

(1) We designed a protrusion of cylinder shape in four places inside sealing body and four places outside sealing body to prevent sealing from being separated. We conducted analysis with a size 0.5mm, 1mm, 1.5mm, 2.0mm greater than width of flange groove.

(2) It was found that a protrusion with 1mm larger than width of flange groove had low strain and proper stress and was the most suitable in preventing separation.
It was found that when flange was assembled, maximum stress occurred in a boundary of sealing body and protrusion and it is necessary to develop proper design for the foregoing. This study helps build database.

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REFERENCES


