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A Study on the Efficient Flow Analysis due to Valve Shape

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밸브 형상에 따른 효율적인 유동해석에 관한 연구

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ABSTRACT

This study investigates the flow efficiency based on valve shape. Three models are designed for the throttle, ball, and butterfly valves. Results show that Flow Model B, representing the ball valve, demonstrates the fastest flow rate among the three models. Although pressure contours are present on the side surfaces of the valve wings for all models, Flow Model C, representing the butterfly valve, demonstrates to be under the least amount of applied pressure among the three models. The results of this study can be utilized to efficiently control the air flow through various types of valves.

Keywords : Valve Shape(밸브 형상), Flow Analysis(유동 해석), Pressure(압력), Flow Rate(유속)

1. Introduction

A recent research on the development of low-fueled vehicle with high-performance has been steadily carried out as the efficiency of car has increased. As the result, the several auto parts are being improved in an effort of each company in order to improve the fuel efficiency. The valves used mostly in the vehicle are throttle valves. The throttle valve refers to a valve that is opened or closed at controlling the air flow[1-3] through the vaporizer or throttle body, which regulates the opening degree of valve. A mixture of gasoline blended at the carburetor with air passing through the throttle body is sent from the intake manifold to each cylinder. As the role of the intake manifold is to bring the mixed gas into the cylinder as flexibly as possible, it is efficient to make the curves as small and smooth inside as possible so that the flow resistance[4-6] is small. The intake air flown into the throttle valve has a significant effect on the ignition system, such as engine load, atmospheric pressure, coolant temperature, air temperature, engine speed. Therefore, it is important to transfer the air into the correct quantity through the valve times in order to regulate the volume of intake air. This study is investigated on the efficient flow analysis[7-10] by changing the valve shape.

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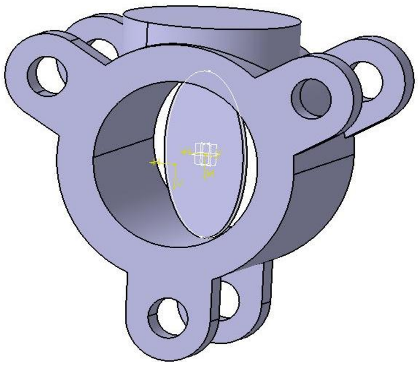
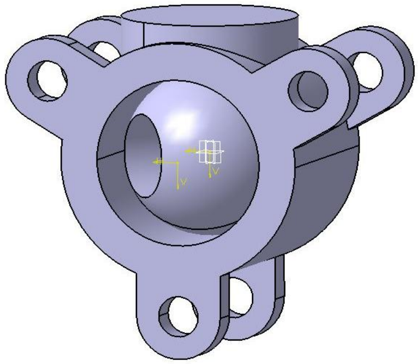
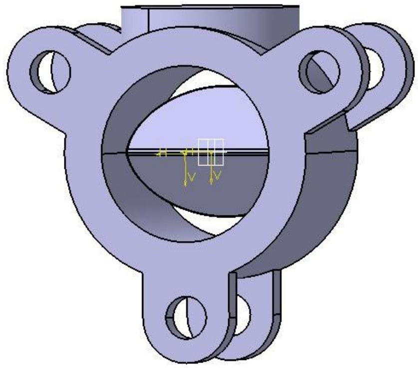


(a) Model A



(b) Model B



(c) Model C

Fig. 1 Shapes of valve models

2. Study Models and Analysis Conditions

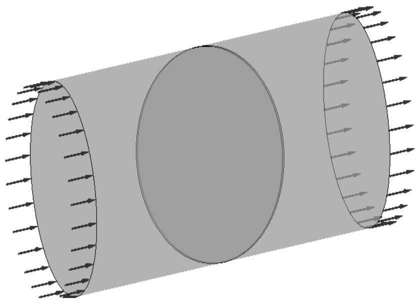
2.1 Study models

As shown by Fig. 1, the models A, B and C were named as the throttle valve, ball valve and butterfly valve, respectively.

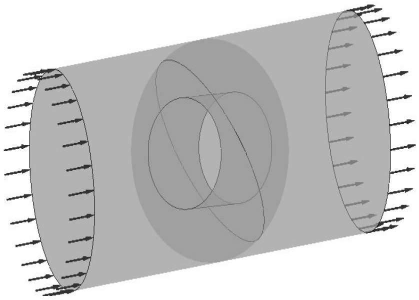
The bodies of models A, B and C were commonly designed to be 194mm in diameter. The holes of ball valve were drilled with the diameter of 97mm and the butterfly valve was chamfered off with the angle of 45°.

2.2 Analysis conditions

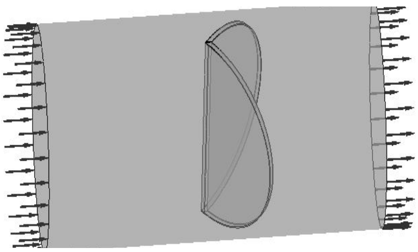
Assuming that the solid models were enclosed by the cylindrical models, the flow models were designed



(a) Model A



(b) Model B



(c) Model C

Fig. 2 Boundary conditions of models

Table 1 Meshes of flow models

Intents	Number of Nodes	Number of Elements
Model A	86056	481119
Model B	72854	392145
Model C	86391	482324

by extracting the solid models from the cylindrical models as shown by Fig. 2.

Fig. 2 shows the flow models as models 1, 2 and 3, respectively. Table 1 shows the informations of meshes at all flow models. The flow model was the air at the temperature of 25℃. The flow condition was isothermal. As the boundary conditions, the inlet and outlet ports were designated on the front and back of turbine, respectively. The inflow rate at the inlet was 10m/s and the air was discharged at the outlet on the state of atmosphere at the pressure of 0 Pa.

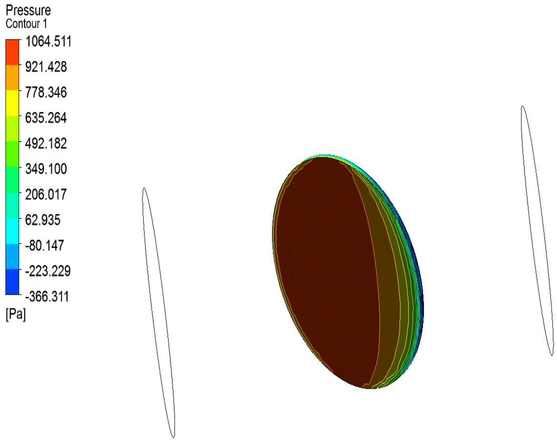
3. Analysis Results

Fig. 3 shows the pressure contours on the side surfaces at the wings of valve models A, B, and C. The highest pressures at three models become 1064.511 Pa, 3787.023 Pa and 1040.478 Pa for flow models A, B and C, respectively.

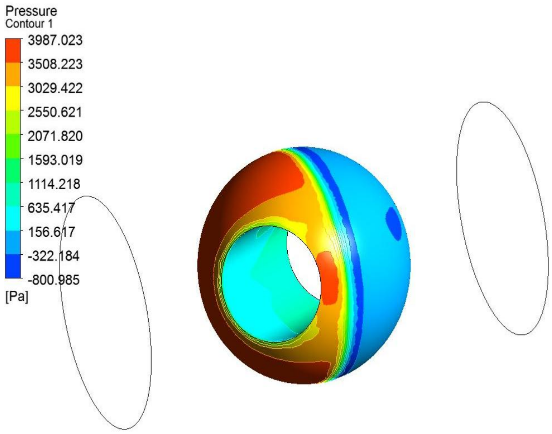
Among three valve models, model C has the highest pressure as 1040.478 Pa. The model C of butterfly valve is shown to be applied under the least pressure among three flow models. Fig. 4 shows the streamlines with flow rates at flow models 1, 2 and 3. The highest flow rates at the three flow models become 46.190 m/s, 80.860 m/s and 49.513 m/s for flow models A, B and C, respectively.

Among three flow models, the fastest flow rate as 80.860 m/s is shown at model B and the lowest flow rate as 0.081 m/s is shown at model A.

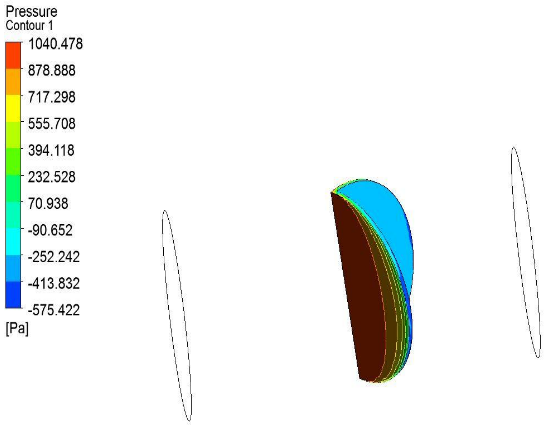
Fig. 5 shows the overall appearances of the flow rates with vectors at all flow models. The highest



(a) Model A

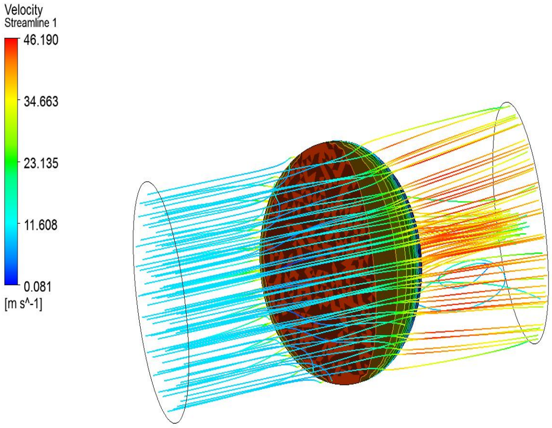


(b) Model B

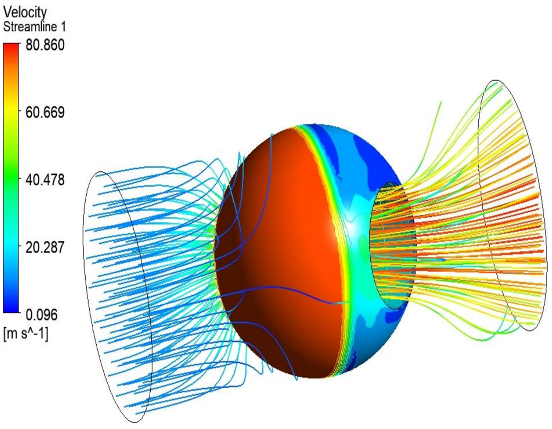


(c) Model C

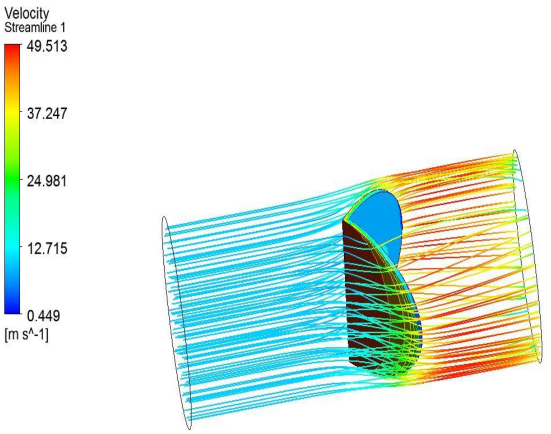
Fig. 3 Pressure contours of flow models



(a) Model A

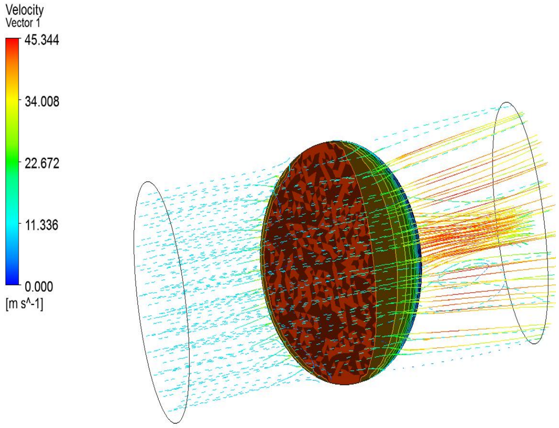


(b) Model B

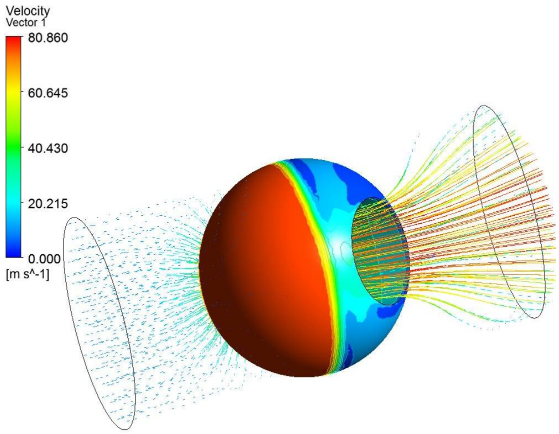


(c) Model C

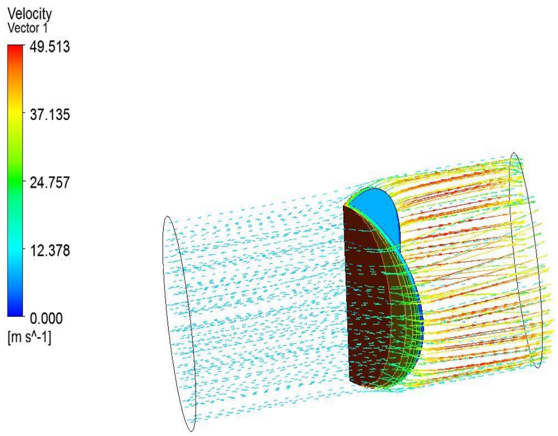
Fig. 4 Streamlines with flow rates at models



(a) Model A



(b) Model B



(c) Model C

Fig. 5 Vectors of flow rates at models

flow rates at three models become 45.344 m/s m/s, 80.860 m/s and 49.513 m/s for flow models A, B and C, respectively. Among three flow models, the fastest flow rate of 80.860 m/s is shown at model B. And all flow models A, B and C have a low speed at 0.000 m/s. At the flow model B of ball valve, the fastest flow rate is shown among three flow models.

4. Conclusion

This study is investigated on the efficient flow analysis due to the valve shape. All valve models with three shapes are the throttle valve, ball valve and butterfly valve as models 1, 2 and 3. The following study results are as follows;

1. At the pressure contours on the side surfaces at the wings of the valve models, model C has the highest pressure as 1040.478 Pa among three models.
2. At the highest flow rates at three flow models, the fastest flow rate as 80.860 m/s is shown at model B and the lowest flow rate as 0.081 m/s is shown at model A.
3. At the overall appearances of the flow rates on three flow models, the fastest flow rate as 80.860 m/s is shown at model B. And all flow models A, B and C have a low speed at 0.000 m/s.
4. At the flow model B of ball valve, the fastest flow rate is shown among three models. On the contrary, the flow model C of butterfly valve is shown to be applied under the least pressure among three models. The analysis result of this study can be utilized at controlling the air flow of various valves efficiently.

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