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AIR FLOW CHARACTERISTICS FOR THE GEOMETRY MODIFICATION OF BELLOWS PIPE ON INTAKE SYSTEM OF AUTOMOBILE

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ABSTRACT

Bellows is a component used to reduce the joint or vibration in various pipes. It is used in intake or exhaust pipes for cars and usually used to solve the vibration problem caused by components such as an engine. Until now, the structural analysis was normally more emphasized, so research had made progress mainly on structural analysis. However, for intake pipes, geometric form of bellows could influence the performance of the engine, thus requiring research. Therefore, in this paper, we investigated the flow characteristics such as pressure loss and velocity change of each shape after various modeling by varying the geometric shape of the bellows with the width or pitch of the bellows. Based on these results, we investigated the factors influencing the flow change and the changes by the factors. As a result of observing the effect after adding change to the width and number of the bellows among the design factor of bellows, pressure loss had shown the most significant change with 162Pa when the number of the bellows was changed.

Key words: Bellows, Intake system, Pressure, Parameter.

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1. INTRODUCTION

Bellows is a component used to reduce the joint or vibration in various pipes. It is used in intake or exhaust pipes for automobiles, and it improves the durability of the pipe and is used for the purpose of improving the NVH performance [1]. In the intake system of automobiles, it is mostly used in the middle section of the pipe or curved pipes, and when used, it is mostly for NVH performance improvement rather than efficiency improvement due to flow. Bellows is composed of a form with bellows on the cross section, and due to this form, has a structure that absorbs vibrations well while on the flow perspective, there will be loss compared to regular pipes. In the preexisting study, research which included structural analysis was conducted more than research on factors that influence the flow by focusing on the NVH performance improvement through bellows, but research and analysis on the fields related to flow were rarely conducted[2]. Moreover, in the intake system, little change can influence the performance of the engine, so research in the field related to flow needs to be conducted [3],[4],[5].

Figure 1 shows the approximate form of the automobile intake system. It shows the form in which air that came in through the snorkel goes through the duct and the air cleaner and is delivered to the engine. The part in which bellows could be installed is the duct, and it can be installed in the part shown on the dotted line.

Therefore, in this paper, we have used the modeling technique for different bellows which have a different geometrical form in order to research the influence of each factor to the intake system by setting the factor of the bellows as the variable. Also, a flow analysis is conducted of the pressure loss, flow change, etc. due to each factor through flow analysis of each bellows.

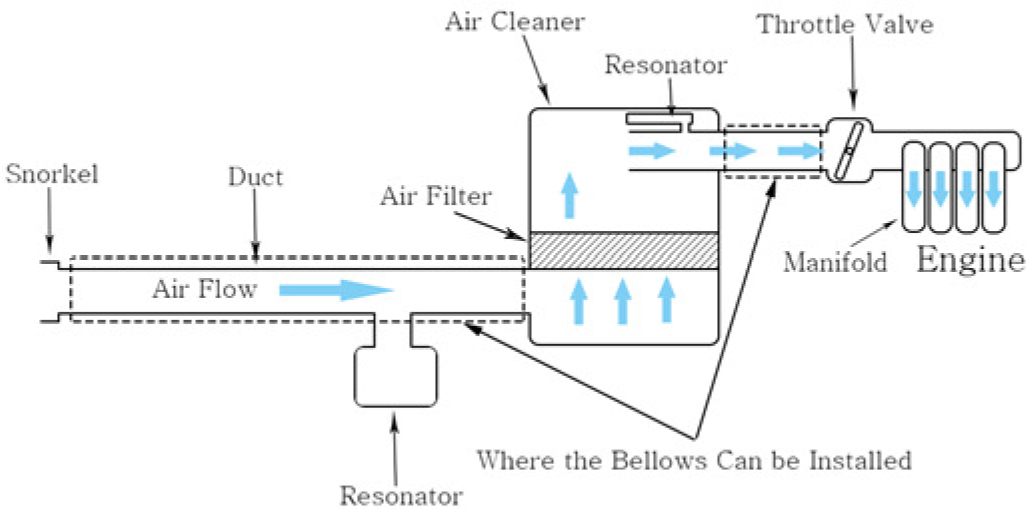


Figure 1 Simple diagram of the intake system

2. BELLOWS

In order to make the bellows fit for analysis, each model was made with the form of the bellows inserted in the middle of the pipe of fixed length. Bellows can be categorized into U model, S model, and the Ω model according to its form and in this research, I conducted the analysis using the U Bellows model.

2.1. Setting the Factor of the Bellows

To conduct the analysis of the bellows, the factor of the model must be set. There are 6 factors in total, but in this analysis, the analysis will be conducted by setting 3 factors as variables. Figure 2 is the picture showing the cross-section and the factor of bellows and Table 1 is showing each factor. Especially among the factors, the length of the bellows was set as the dependent variable, not with a fixed value because it is influenced by the pitch, the number of bellows, and the width of the bellows.

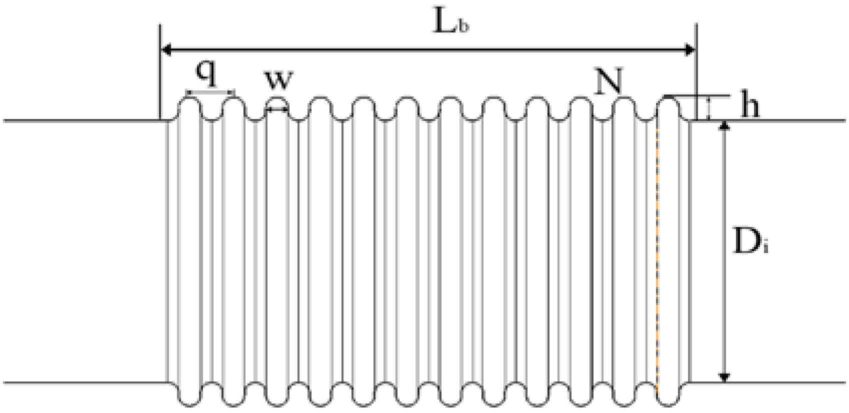


Figure 2 The factor of bellows

Table 1 Design factor of bellows

Design factor	Description	Value
D	Inner pipe diameter	66mm
w	Width	2,5 mm
N	Number of bellows	12, 24, 36
q	Pitch	5mm
h	Height	4mm
L_b	Length	Dependent variable

2.2. Setting and generating the mesh of the bellows

In order to proceed the finite element analysis, a mesh on each bellows was created. They were created by selecting the tetra model as the basis and created a boundary layer for friction flow of the surface. The tri for the analysis model of the boundary was used, used 3 layers, and for each analysis bellows model, 900,000~1,100,000 meshes were created. Figure3 shows the creation of the mesh of bellows.

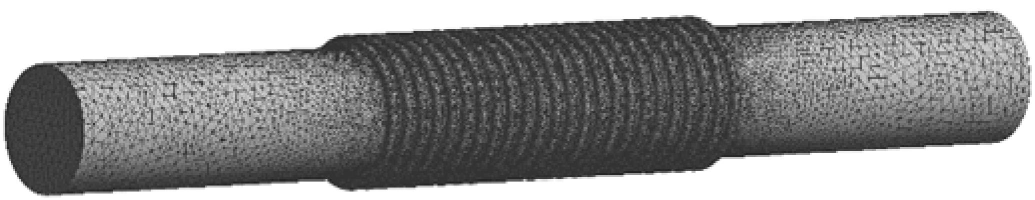


Figure 3 Mesh creation of bellows

2.3. Setting the Case according to the variable of bellows

In order to observe how each factor influences the flow of the bellows, each case was created by setting the width and the number of the bellows as variables. Changes to the pitch were added, and the number of the bellows after setting the width of the bellows to 2, 5mm and the diameter and the height are same as the value in Table 1. Table 2 shows the design factor for each case. Also, in cases 1~3, the width of the bellows was fixed to 2mm, and in cases 4~6, the width of the bellows was fixed to 9mm each and set the number of the bellows as a variable.

Table 2 Setting the case of the bellows and each factor

Case	Width of the bellows(w)	Number of bellows(N)	Pitch (q)
Case 1	2 mm	12	9 mm
Case 2	2 mm	24	9 mm
Case 3	2 mm	36	9 mm
Case 4	5 mm	12	9 mm
Case 5	5 mm	24	9 mm
Case 6	5 mm	36	9 mm

2.4. Setting Condition of Flow Analysis of Bellows

With the condition of proceeding with the flow analysis of bellows, the analysis was proceeded assuming that the automobile is running. The assumption was made that the flow inside the bellows and the pipe is incompressible turbulent flow and using the k-ε Realizable model which is the model most stable for reenacting turbulent flow. The material properties of air as 20□ and proceeded with the assumption in extreme conditions with the number of rotation of the engine at 5000rpm. Specific values used in the analysis is as follows in Table 3.

Table 3 Conditions and setup of flow analysis

Condition	Value
Mass flow rate	275/h
Inlet pressure	Atmosphere pressure
Outlet Pressure	-3226
Air Density	1.225 kg/m^3
Air Viscosity	1.7894x10^{-5} kg/m·s
Solution Algorithm	Coupled
Turbulence Model	k-ε model

3. RESULT OF THE FLOW ANALYSIS

In order to look for the change in the flow caused by the number of bellows, it was analyzed with the assumption of 6 cases in total. In each case, the width and the number of the bellows among factors are same, and the same conditions of analysis were given to table 3, and the result of analysis for each category is as follows.

3.1. Result from the change in number of bellows

The width of bellows was set to 2mm for cases 1~3 and 5mm for cases 4~6 and changes were given to the number of bellows for each case. The change in pressure loss, the velocity, and the flow individually was confirmed. Firstly, the influence caused by the width of the bellows was observed significantly. Clearer results for cases 1~3 with the width of 2mm were shown compared to cases 4~6 with the width of 5mm, and it is thought that this result was because the narrow width of the bellows created weak air flow.

Figure 4 is showing the pressure loss of each case in a graph, and it is displaying a tendency where in principle, with the increase in the number of bellows, the pressure loss also increases. Especially when the number of bellows increased in the case with the width of the bellows as 2mm, it showed the result of the increase in pressure loss by about 1.5 times, and it rose to 162 Pa in maximum. In other words, when having the same number of bellows, smaller width of bellows showed more significant pressure loss.

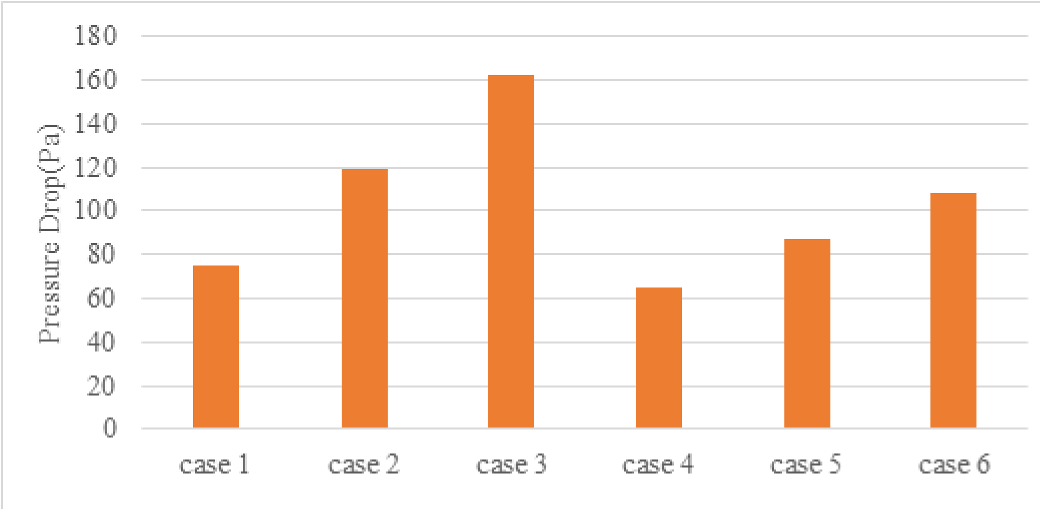
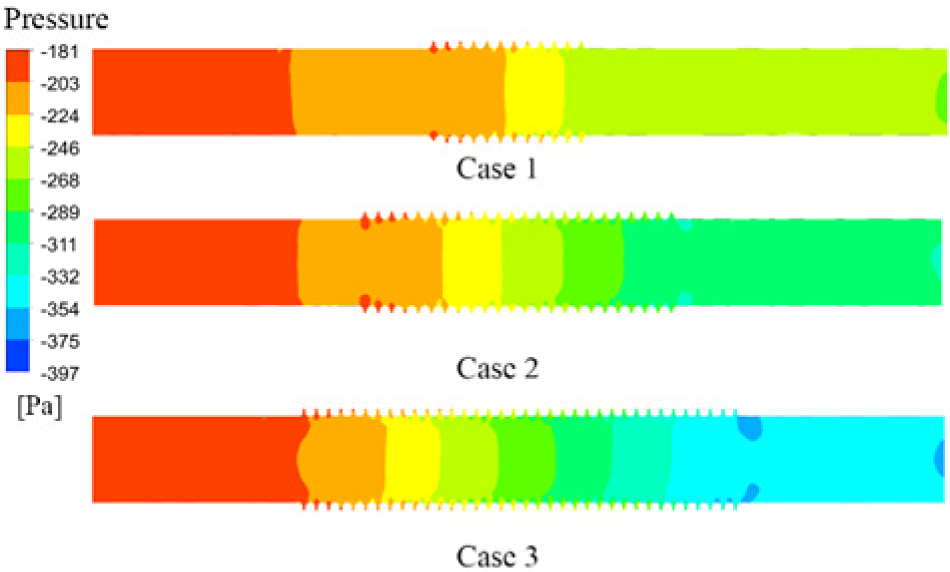


Figure 4 Pressure loss graph in accordance with the change of number of bellows

Figure 5 is a picture showing the change in pressure. Figure 4 is showing the result of the graph, and it is showing the decrease of pressure as the number of bellows increased, and it could be confirmed that decrease of pressure is shown with almost the same rate of change. It could be confirmed that in the case of 5mm width of the bellows, the rate of change for the decrease of pressure is smaller.



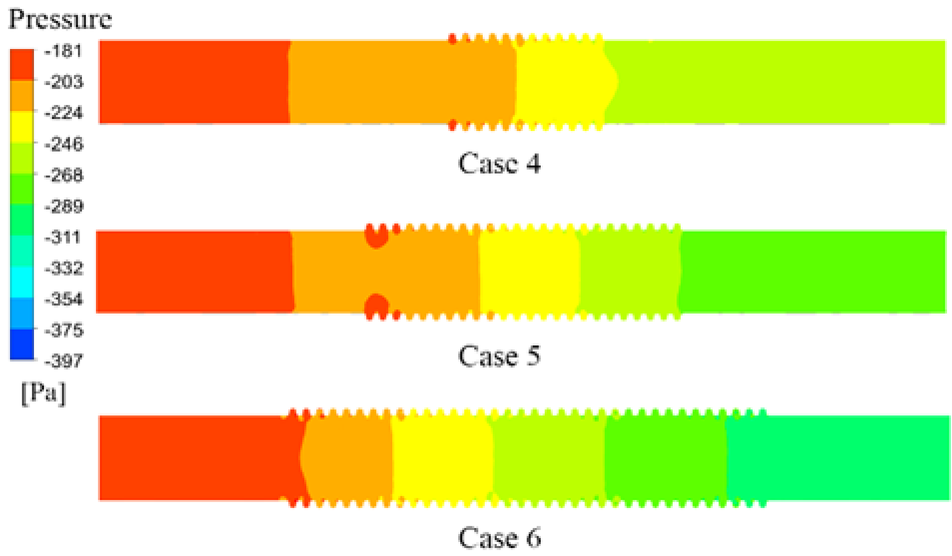
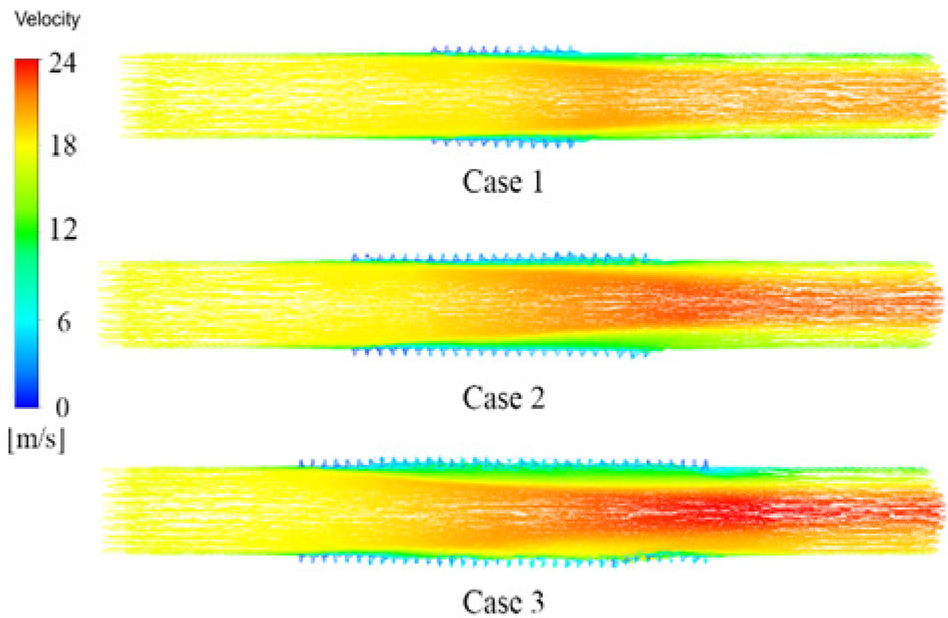


Figure 5 Pressure change following the change of number of bellows

Figure 6 is showing the velocity vector inside the bellows, and it could be seen that when the number of the bellows is the same just like the case for pressure loss, smaller the width, less influenced it is. When the number of bellows was 12, it is not influenced by the width of the bellows, but the influence by the width increased with the increase of the number of bellows. The main cause is thought that bellows create turbulence in inner flow and influences the flow of the middle section which was originally not influenced as a result. It is thought that with more number of bellows, it is more influenced by turbulence, so it shows faster velocity change in the discharge section.

When the width of bellows was 2mm, it shows more unstable flow compared to 5mm width and the form is more complexly formed due to the narrower width and as a result, smooth flow is not made. In other words, more turbulence occurs, and in the discharge section, it is shown with faster velocity and more unstable flow, and it is thought that these turbulences are one of the causes that generate more pressure loss.



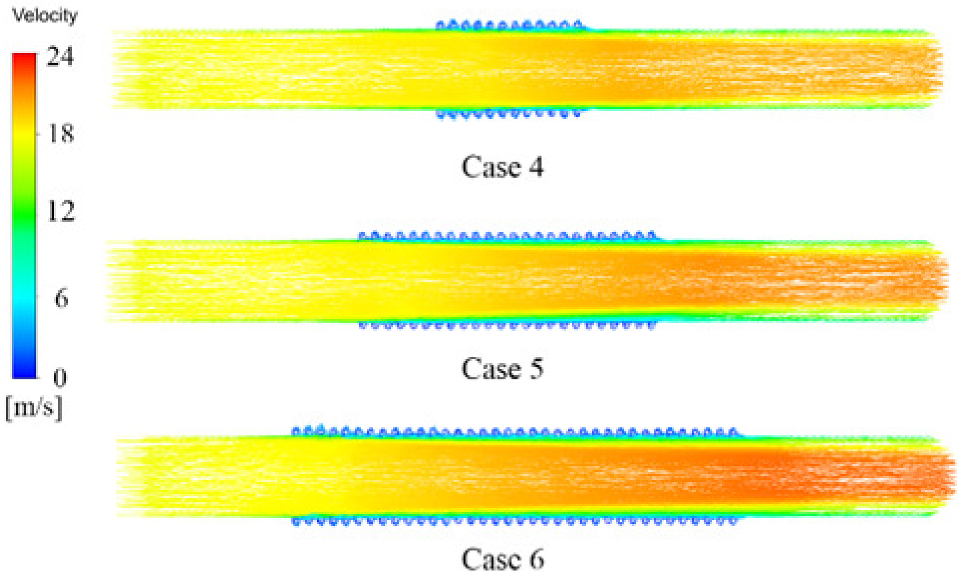


Figure 5 Velocity vector with the change in number of bellows for each case

5. CONCLUSION

In this research, the study about the effects influenced towards flow by each bellows factor through setting factors at bellows which can be used in the intake system is as follows.

- Among the factors of bellows, when the width of the bellows changes, it influenced the flow more than other factors.
- When the number of bellows increases, the total length of bellows increases, so it could be observed that the pressure loss becomes larger and flow becomes unstable due to turbulence.
- Even though the width of the bellows becomes larger and the number of bellows increases, it did not show a sharp flow change.
- The shorter the length of bellows of bellows, the less influence it gave to the flow.

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REFERENCES

[1] Kim. A Study on Structural Analysis for the Bellows of Automotive Exhaust System. Korea Academy Industrial Cooperation Society, 11(4), 2010, pp.1192-1196

[2] S.W. Lee and C.H. Yang. A Study on Automated Design and Structure Analysis of Bellows. The Korean Society of Automotive Engineers, 2014, pp.1070-1076

[3] J.W. Ryu and Y.H. Noh. An Optimized Design of Intake System Verification with CAE Simulation and Performance Test. The Korean Society of Automotive Engineers, 13(2), 2016, pp.866-871.

[4] Vikash Kumar and Laljee Prasad, Experimental investigation on heat transfer and fluid flow of air flowing under three sides concave dimple roughened duct, International Journal of Mechanical Engineering and Technology 8(11), 2017, pp. 1083–1094

[5] David A. Crolla. Automotive Engineering: Powertrain, Chassis System and Vehicle body. Butterworth-Heinemann is an imprint of Elsevier, 2009, pp.762-773

[6] J.S. Sa, H.G. Kim and C.H Yang. Understanding Car Vibration Noise. Cheong-Mun-Gak, 2016, pp. 302-311