한국기계가공학회지, 제19권, 제1호, pp.72～80(2020.01) ISSN 1598-6721(Print)
Journal of the Korean Society of Manufacturing Process Engineers, Vol. 19, No. 1, pp.72~80(2020.01) ISSN 2288-0771(Online)

https://doi.org/10.14775/ksmpe.2020.19.01.072

Structural Safety by Shape of Motorcycle Muffler

Moonsik Han*, Jaeung Cho**,#

*Department of Mechanical and Automotive Engineering, Keimyung UNIV.,
**Division of Mechanical and Automotive Engineering, Kongju National UNIV.

오토바이의 머플러 형상별 구조적 안정성

한문식*, 조재웅**,#

*계명대학교 기계자동차공학과, **공주대학교 기계자동차공학부

(Received 10 September 2019; received in revised form 18 September 2019; accepted 30 September 2019)

ABSTRACT

This study performs structural and vibrational analyses on three models of motorcycle mufflers, A, B, and C, due to the pressure of exhaust gases. Model A is the common model seen on motorcycles, model B is a model with a longer outlet, and model C is a model with some curved outlets. This research shows that all models have sufficient strength at the given loading condition, and model A has the highest durability against vibration among three models. The appropriate configuration can be determined to be the most efficient by applying this result to the design of motorcycle muffler.

Key Words : Motorcycle(오토바이), Muffler(머플러), Shape(형상), Structural Safety(구조적 안정성), Vibration (진동)

1. Introduction

When the exhaust gas does not get out of car, the car is out of order. This problem is often due to the muffler trouble. The main role of the muffler is to reduce noise. As the exhaust gas passes through various filters in the muffler, the noise is reduced[1-4]. Therefore, mufflers are sometimes called by main silences but a significant drop in the muffler's performance to increase power results in a roaring sound in the racing car[5-7]. The water drips from the muffler end of a driving vehicle. This is the normal water from the combustion of a mixture of air and fuel but this type of water contains the strong acidity which causes the muffler to corrode. As being noisy when it is shaken by holding the muffler, the corrosion can happen as well as the holes in its appearance. Recently, the tuning mufflers made of aluminum or titanium are also used. By using these mufflers, the exhaust gas maintains the good flow at high speed rotating area in the engine. Basically, the muffler is a good one, effectively reducing noise and allowing exhaust gas to get out[8,9]. The mufflers with good conditions for cars and motorcycles have been already commercialized, but this research will have to continue to produce better results. In this paper, the

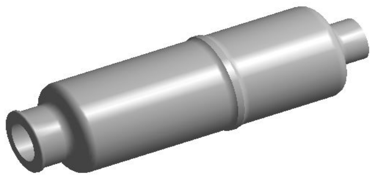
Corresponding Author : jucho@kongju.ac.kr
Tel: +82-41-521-9271, Fax:+82-41-555-9123

motorcycle mufflers are designed as three kinds of models. The structural analyses and natural frequency analyses[10,11] are carried out. Through the result of this study, the appropriate configuration can be determined to be the most efficient by applying this result to the design of motorcycle muffler.

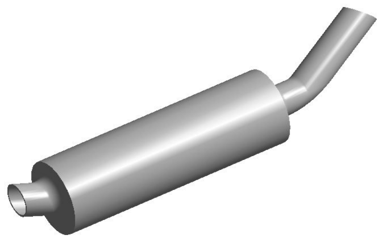
2. Study Models and Constraint Conditions

2.1 Study models

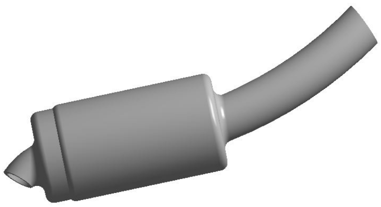
In this study, three types of mufflers were designed for each motorcycle by CATIA program. Fig. 1 shows models A, B and C for the analysis. The dimensions of models A, B and C are within 200mm in length and 63mm in diameter. Model A



(a) Model A



(b) Model B



(c) Model C

Fig. 1 Muffler shapes

Table 1 Material properties

Items	Values
Compressive yield strength	250 MPa
Poisson's ratio	0.3
Young's modules	2×10^5 MPa
Tensile Ultimate strength	460 MPa
Density	7850 kg/m^3
Tensile yield strength	250 MPa

Table 2 Numbers of elements and nodes at models

Model	Nodes	Elements
A	59244	32043
B	63229	32059
C	60198	33833

which is the typical model shape of a motorcycle. Model B has longer outlets in a conventional model and model C has the angles in the shape of the long-drawn outlet. The structural analyses[12-17] were used with ANSYS program.

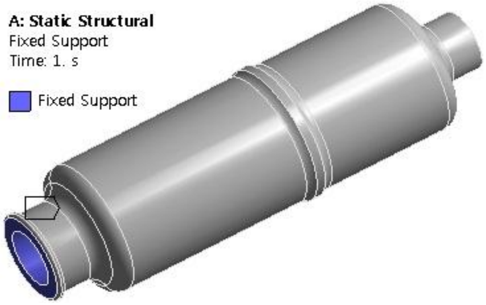
Table 1 shows the material properties of structural steel and Table 2 shows the numbers of elements and nodes on all models.

2.2 Constraint conditions of models

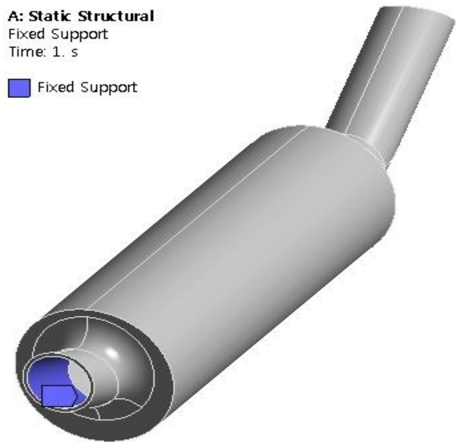
The fixed part is supposed as the side of muffler at the actual motorcycle. As shown in Fig. 2, the part is in contact with the inlet of the muffler. Since the direction in which vibration and shock are transmitted usually rises from the ground when the motorbike is in operation, the same force on all three models is applied in the lower direction that comes from the ground. The boundary conditions of fixed supports and loads are established as shown by Fig. 2 and Fig. 3.

3. Analysis Result

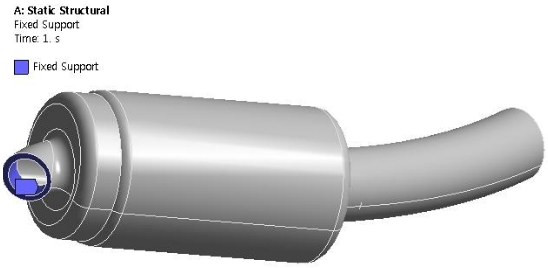
3.1 Structural analysis



(a) Model A

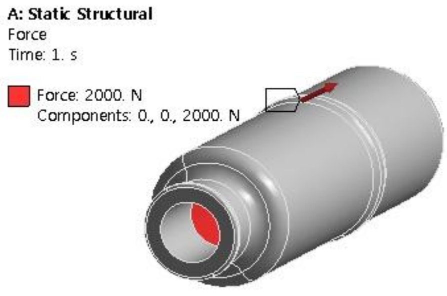


(b) Model B

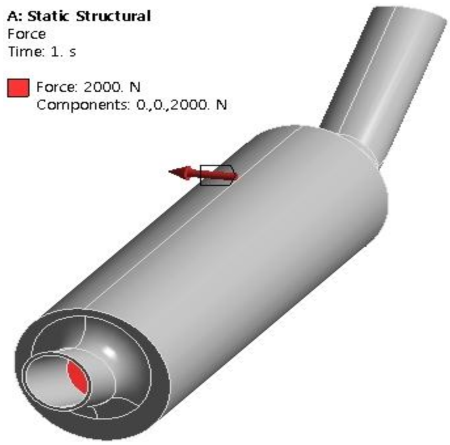


(c) Model C

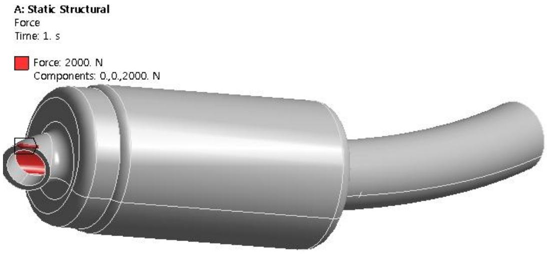
Fig. 2 Fixed supports at each model



(a) Model A



(b) Model B

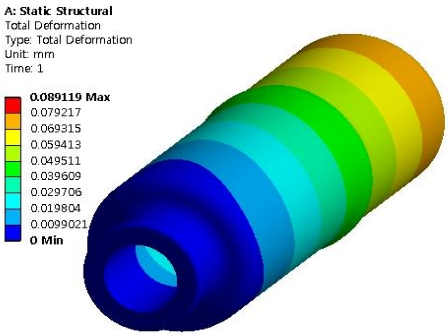


(c) Model C

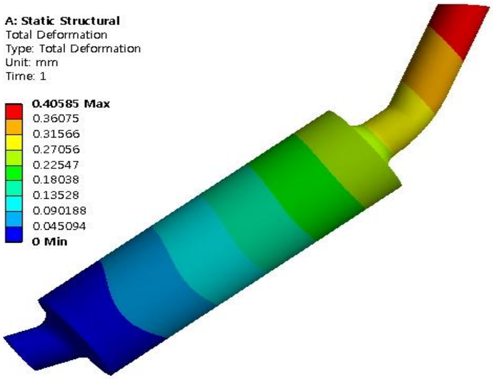
Fig. 3 Forces applied at each model

By the structural analysis, Fig. 4 and Fig. 5 show the contours of total deformations and equivalent stresses at each model.

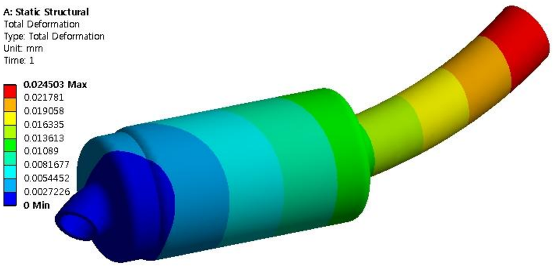
As shown by Fig. 4, the maximum total deformations on models A, B and C show 0.089119mm, 0.40585mm and 0.024503mm respectively. Model C was shown to have the least value as compared with the maximum total deformations of models A, B and C. As shown by Fig. 5, the maximum equivalent stresses on models A, B and C show 101.6 MPa, 139.12 MPa and 46.409 MPa respectively. Model C was shown to have the least value as compared with the maximum equivalent stresses of models A, B and C. The



(a) Model A

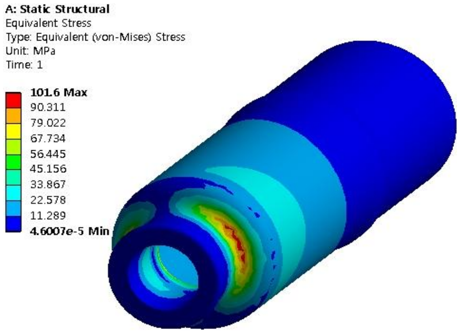


(b) Model B

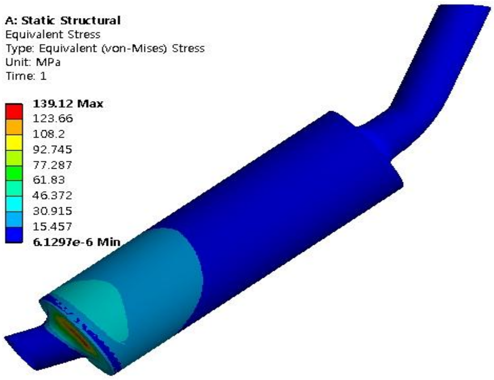


(c) Model C

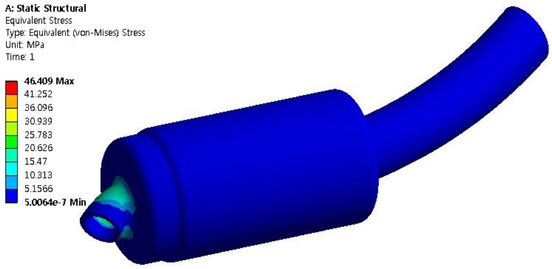
Fig. 4 Contours of total deformations at each model



(a) Model A



(b) Model B



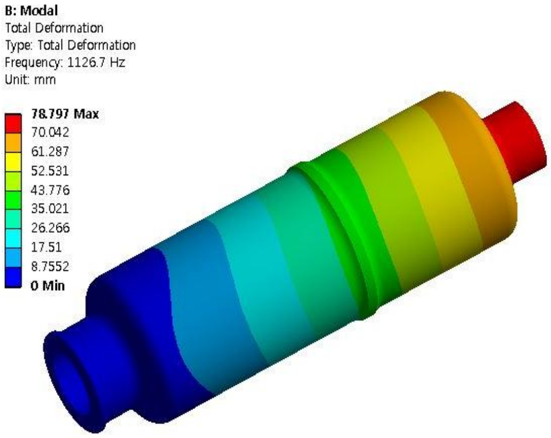
(c) Model C

Fig. 5 Contours of equivalent stresses at each model

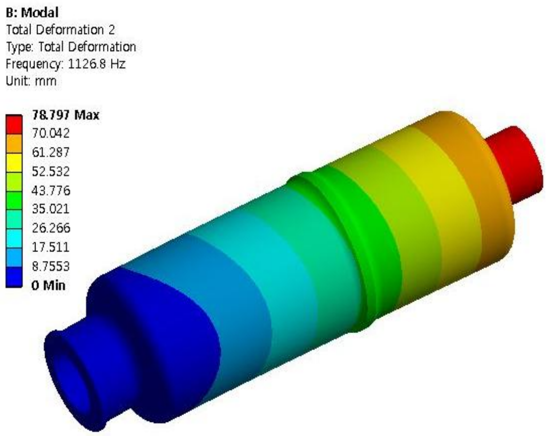
maximum equivalent stress of model C is higher than model A or model B. But, as the maximum equivalent stresses of models A, B and C are lower than the yield stress of this material, all models are thought to have the sufficient strength at this loading condition.

3.2 Natural frequency analysis

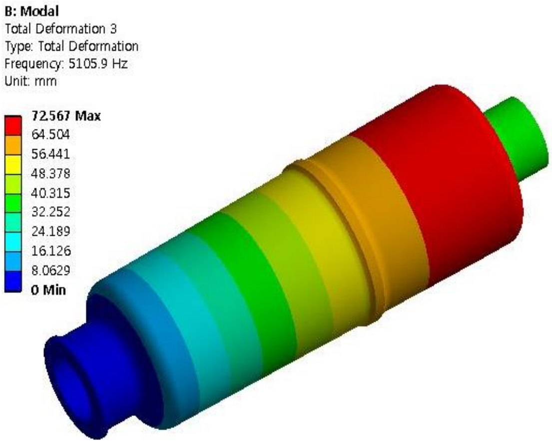
At the muffler models, the natural frequencies on high probability of fracture due to resonance are investigated. The constraint conditions are identical with the fixed supports as shown by Fig. 2. These analyses are carried out with modes 1 to 6 at models A, B and C. Figs. 6, 7 and 8 show the contours of total deformations due to natural frequencies at modes 1 to 6 of models A, B and C



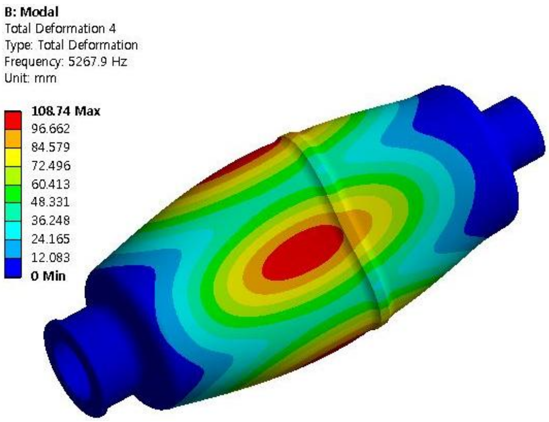
(a) Mode 1



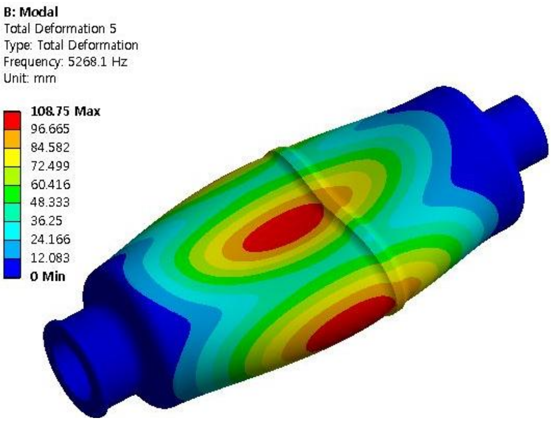
(b) Mode 2



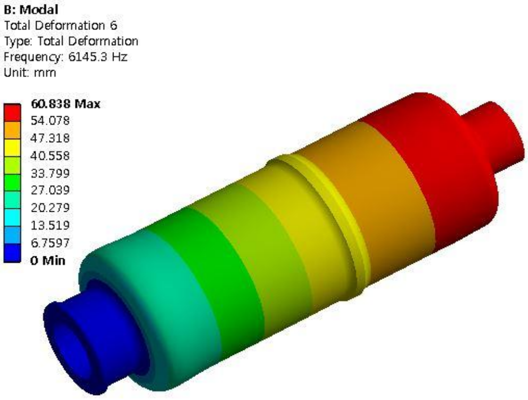
(c) Mode 3



(d) Mode 4

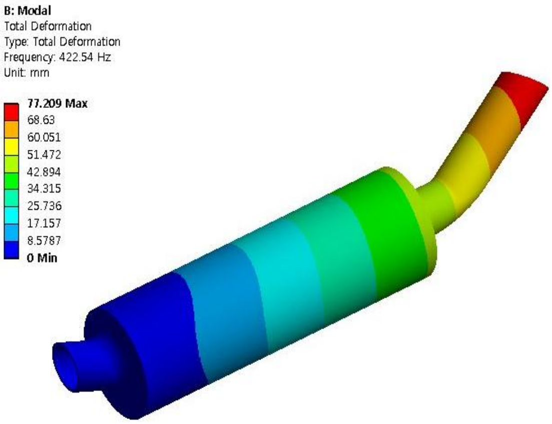


(e) Mode 5

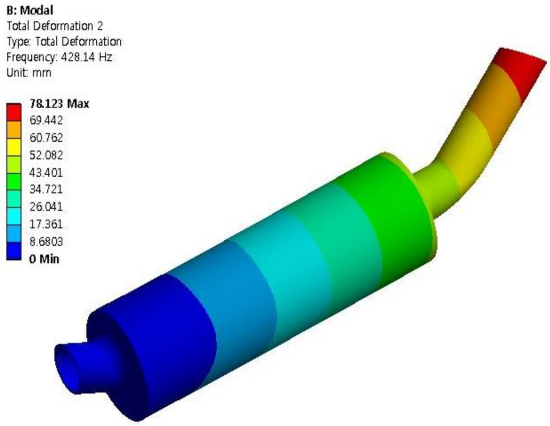


(f) Mode 6

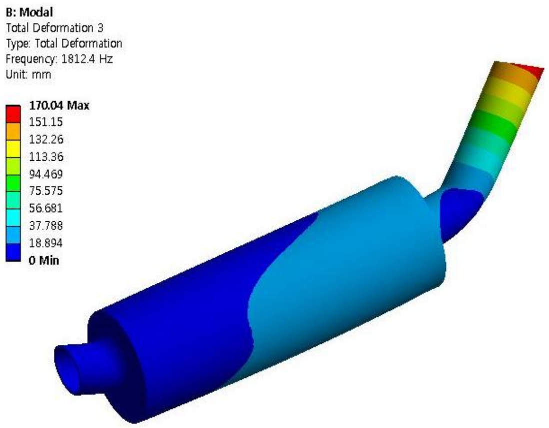
Fig. 6 Total deformation at natural frequencies of model A



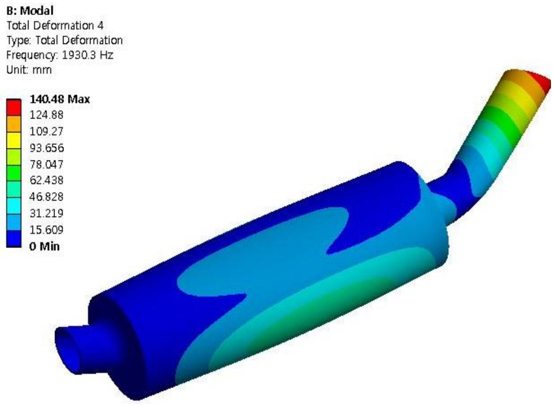
(a) Mode 1



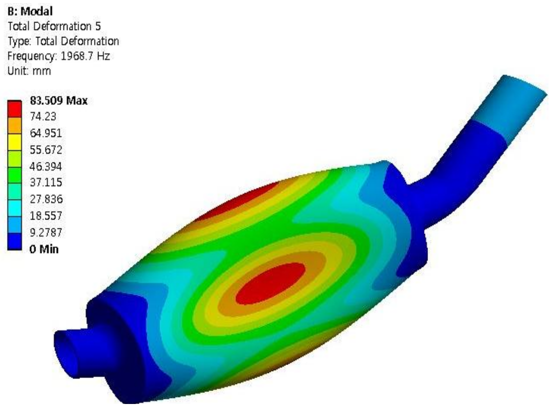
(b) Mode 2



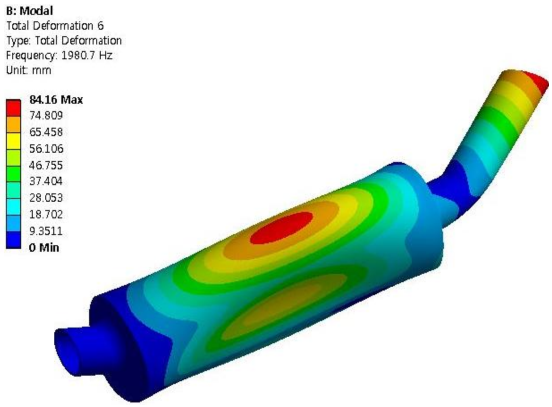
(c) Mode 3



(d) Mode 4

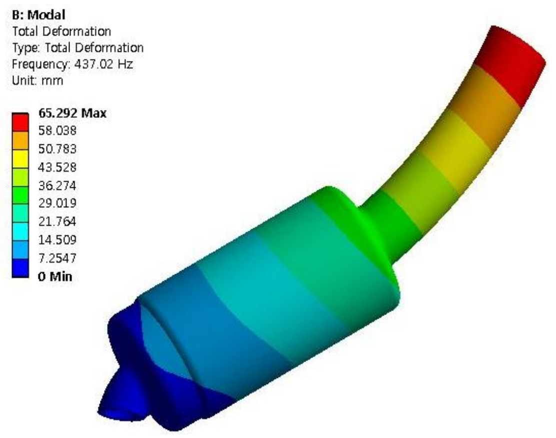


(e) Mode 5

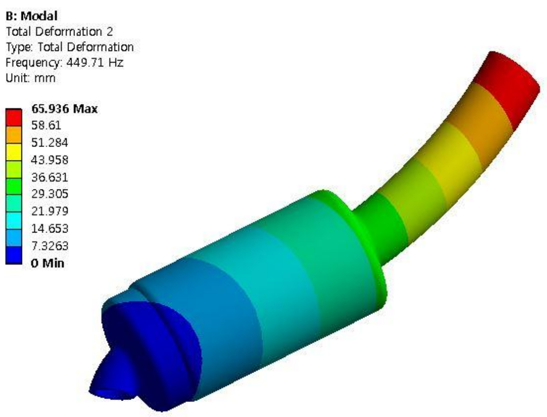


(f) Mode 6

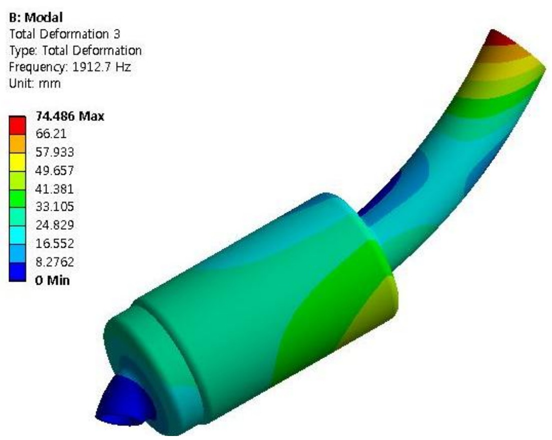
Fig. 7 Total deformation at natural frequencies of model B



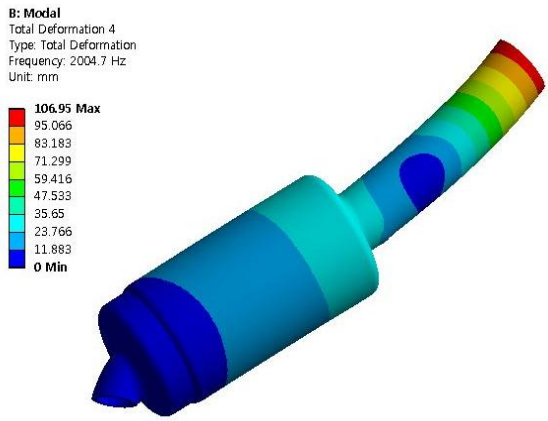
(a) Mode 1



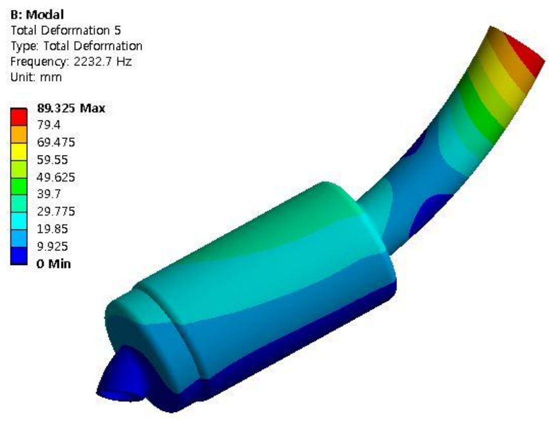
(b) Mode 2



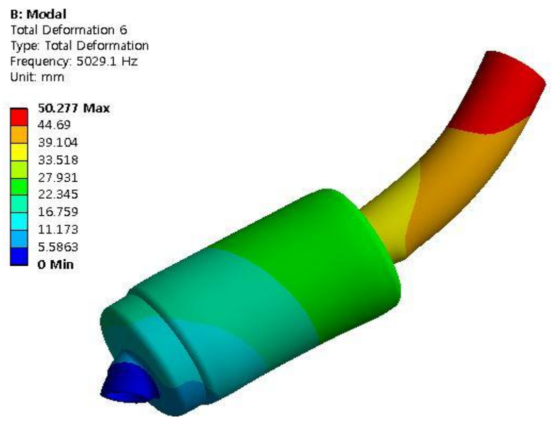
(c) Mode 3



(d) Mode 4



(e) Mode 5



(f) Mode 6

Fig. 8 Total deformation at natural frequencies of model C

respectively. The maximum total deformations of all modes are 108.75mm, 170.04mm, and 106.95mm at models A, B and C. Model A and model C have nearly the same values and these values of the maximum total deformations are lower than model B. Also, the minimum frequencies of all modes are 1126.7 Hz, 422.54 Hz, and 437.02 Hz at models A, B and C. Model A has the highest value as compared with the minimum natural frequencies of models A, B and C. So, it is thought that model A has the highest durability against vibration as compared with the maximum total deformations of models A, B and C.

4. Conclusion

In this paper, the motorcycle mufflers are designed as three kinds of models. The structural analyses and natural frequency analyses are carried out. The following results are derived;

1. At the structural analysis, the maximum equivalent stress of model C is higher than model A or model B. But, as the maximum equivalent stresses of models A, B and C are lower than the yield stress of this material, all models are thought to have the sufficient strength at this loading condition.
2. The natural frequencies on high probability of fracture due to resonance are investigated. The maximum total deformations of all modes are 108.75mm, 170.04mm, and 106.95mm at models A, B and C. Model A and model C have nearly the same values and these values of the maximum total deformations are lower than model B.
3. The minimum frequencies of all modes are 1126.7 Hz, 422.54 Hz, and 437.02 Hz at models A, B and C. Model A has the highest value as compared with the minimum natural frequencies of models A, B and C. So, it is thought that model A has the highest durability against vibration as compared with the maximum total deformations of models A, B and C. Through the result of this study, the appropriate configuration can be determined to be the most efficient by applying this result to the design of motorcycle muffler.

References

1. Kim, J. Y., You, K. J., Gao, J. C. and Jung, Y. S., “Simulation of Structural Analysis of Fiber Guide for 4C MM Optical Fiber”, The Korean Society of Manufacturing Process Engineers, Vol. 16, No. 6, pp. 75-80, 2017.
2. Choo, S. W. and Jeong, S. H., “Structural and Dynamic Characteristic Analysis of a Feeder for an Automatic Assembly System of an LED Convergent Lighting Module”, Journal of the Korean Society of Manufacturing Process Engineers, Vol. 16, No. 1, pp. 124-133, 2017.
3. Choi, D. S., “Structural Analysis and Design of Small Wind Turbine Blade”, The Korean Society of Manufacturing Process Engineers, Vol. 14, No. 1, pp. 85-91, 2015.
4. Cho, S. J., Han, J. W., Park, Y. J. and Lee, G. H., “Structural Analysis of a Planetary Gear Carrier in the Slewing Reducer for Tower Crane”, The Korean Society of Manufacturing Process Engineers, Vol. 13, No. 5, pp. 1-7, 2014.
5. Choi, S. Y., Kwon, D. G., Park, I. S., and Wang, D. H., “A Study on the Cutting Forces and Tool Deformation when Flat-ended Pocket Machining”, Journal of the Korean Society of Manufacturing Process Engineers, Vol. 16, No. 2, pp. 28-33, 2017.
6. Park, C. W., “Injection Molding and Structure Analysis of Inline Skate Frames Using FEA”, Journal of the Korean Society of Mechanical Technology, Vol. 35, No. 11, pp. 1507-1514, 2011.

7. Chun, S. Y., Seong, K. W., Park, H. I., Kim, I. S. and Kang, S. K., "Structure-Vibration Analysis of Electric Scooter Frame", Journal of the Korean Society of Manufacturing Process Engineers, Vol. 15, No. 1, pp. 116-121, 2016.
8. Lee, J. S., "Structural Analysis of a 24 Person Elevator Emergency Brake", Journal of the Korea Convergence Society, Vol. 9, No. 12, pp. 189-194, 2018.
9. Lee, J. H. and Cho, J. U., "Study on Convergence Technique through Structural Analysis due to the Height of the Walker", Journal of the Korea Convergence Society, Vol. 6, No. 2, pp. 19-24, 2015.
10. Her, Y. Y. and Yang, Y. J., "Structural Analysis on Development of Roller Jig for Peeling Machine", Journal of the Korean Society of Mechanical Technology, Vol. 19, No. 2, pp. 242-248, 2017.
11. Cha, J. M., Byun, S. J. Wang, Z. H. and Kwon, Y. C., "Study on Structural and Fatigue Analysis according to Shape change of Automatic Press", Journal of the Korean Society of Mechanical Technology, Vol. 19, No. 2, pp. 156-161, 2017.
12. Lee, D. H. and Cho, J. U., "Convergence Study on Damage of the Bonded Part at TDCB Structure with the Laminate Angle Manufactured with CFRP", Journal of the Korea Convergence Society, Vol. 9. No, 12. pp. 175-180, 2018.
13. Park, J. W., "Structural Analysis of a Tractor Cabin Considering Structure Production Error," Journal of the Korea Convergence Society, Vol. 8, No. 5, pp. 155-160, 2017.
14. Ryu, J. M., Park, K. C. and Kang, T. W., "A Study on the Structural Design for Safety Improvement of the Winch Mount of an Armored Recovery Vehicle", Journal of the Korean Society of Manufacturing Process Engineers, Vol. 16, No. 1, pp. 58-62, 2017.
15. Ko, J. H. and Kang, D. M., "CAE Analysis on Strength and Fatigue of Rear Door of Passenger Car", Journal of the Korean Society of Manufacturing Process Engineers, Vol. 13, No. 3, pp. 63-69, 2014.
16. Kim, D. B., Lee, G. T., Lee, I. H. and Cho, H. Y., "Finite Element Analysis for Fracture Criterion of PolyJet Materials", Journal of the Korean Society of Manufacturing Process Engineers, Vol. 14, No. 4, pp. 134-139, 2015.
17. Ha, S. H., Kim, S. J. and Song, J. I., "Structure Analysis and Torque Reduction Design of Industrial Ball Valve", Journal of the Korean Society of Manufacturing Process Engineers, Vol. 13, No. 6, pp. 37-45, 2014.