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Durability Analysis due to Design Shape of Pinion Gear

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자동차용 피니언 기어의 설계 형상에 따른 내구성 해석

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ABSTRACT

The structural analyses were conducted with three models of pinion gears connected to the rack gear which is driven by the steering axle at an automobile. Three models 1, 2 and 3 are designed as the different pinion gears due to the vehicle type. The lower the value of maximum stress, the better the durability of model. Model 3 has the best durability among three models. Models 1 and 2 are expected to require the adjustment in order to improve the durability better. By the utilization of this study result, it is thought to apply at designing the pinion gear with durability at the automobile.

Keywords : Pinion Gear(피니언 기어), Design Shape(설계 형상), Structural Analysis(구조 해석), Maximum Stress(최대 응력), Durability(내구성)

1. Introduction

The role of a gear at the machinery industry becomes important. First, the gear is a mechanical device consisting of the tooth parts, which mesh together in order to transmit rotational motion to the shaft. The driving pinion gear transmits the power inputted into the longitudinal reduction gear into the ring gear and the deceleration is operated at the same time. The differential pinion gear is worked in conjunction with the side gear in order to facilitate the rotation. And the pinion gear transmits the rotational force of the steering handle into the rack gear or transmits the rotational force from the starting motor to the engine. Also, the pinion gear and the planetary gear for the automatic transmission rotate the upper rotor of the constructional machine[1-6]. In this study, the structural analysis[7-10] was conducted with the model of pinion gear connected to the rack gear which is driven by the steering axle in an automobile. Three models 1, 2 and 3 are designed as the different pinion gears due to the vehicle type. By the utilization of this study result, it is thought to apply at designing the pinion gear with durability at the automotive industry[11-16].

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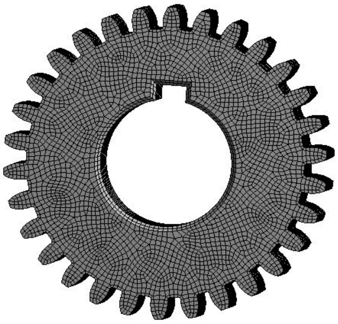
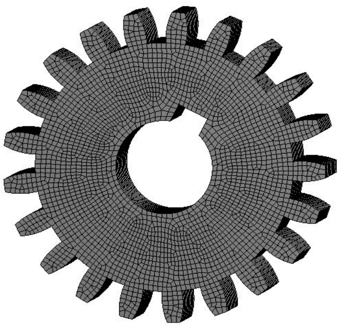
2. Models and Boundary Conditions

2.1 Study models

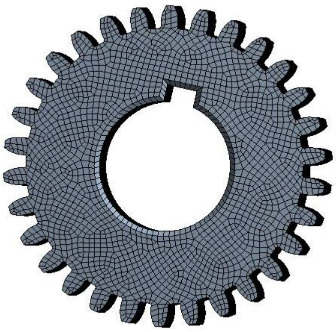
Three pinion gear models 1, 2 and 3 with different dimensions as shown by Table 1 were designed according to the direction of gear alignment. Fig. 1 shows the meshes of all models.



(a) Model 1



(b) Model 2



(c) Model 3

Fig. 1 Meshes of models 1, 2 and 3(unit: mm)

Table 1 Model dimensions

	Diameter	Thickness
Model 1	64mm	10mm
Model 2	40mm	10mm
Model 3	64mm	20mm

Table 2 Number of nodes and at models 1, 2 and 3

Model	Nodes	Elements
Model 1	146068	31614
Model 2	159125	35334
Model 3	163150	35460

Table 3 Material property

Young's Modulus (GPa)	96
Poisson's Ratio	0.36
Density (kg/m^3)	4620
Tensile Yield Strength (MPa)	930
Tensile Ultimate Strength (MPa)	1070

Table 2 shows the numbers of nodes and at pinion gear models of 1, 2 and 3. Table 3 shows the material property of Titanium Alloy used as the pinion gear.

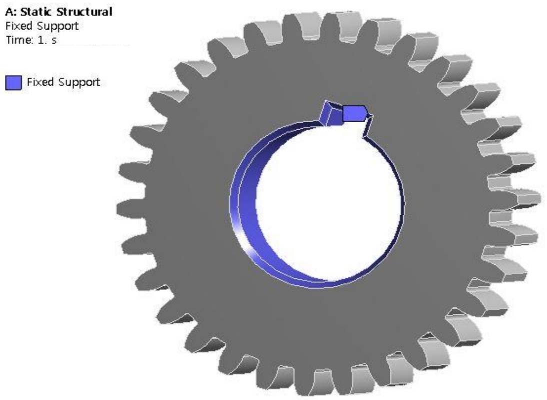
2.2 Boundary conditions of models

The bearing key is secured and attached to the steering axis. As the boundary conditions of three models, the fixed conditions are as shown in Fig. 2.

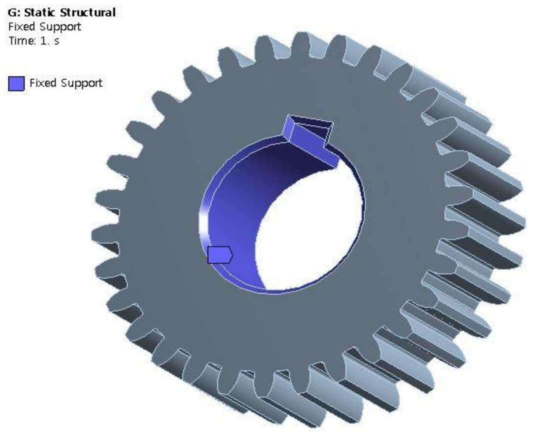
The force of 435N is applied to the sides of the gear teeth of three models at Fig. 3. At all three models as shown by Fig. 4, the momentum of 200 N-mm is applied to the tangential direction on which the gear rotate.

3. Study Results

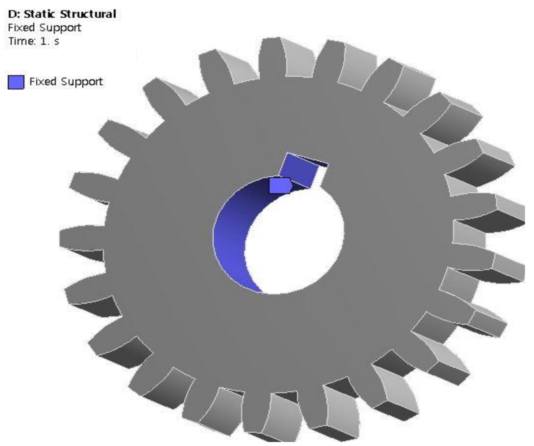
Fig. 5 shows the contours of total deformations at models 1, 2 and 3. At Fig. 5, the maximum deformations of 0.0068263mm, 0.0085686mm and 0.001613mm are shown at models 1, 2 and 3,



(a) Model 1

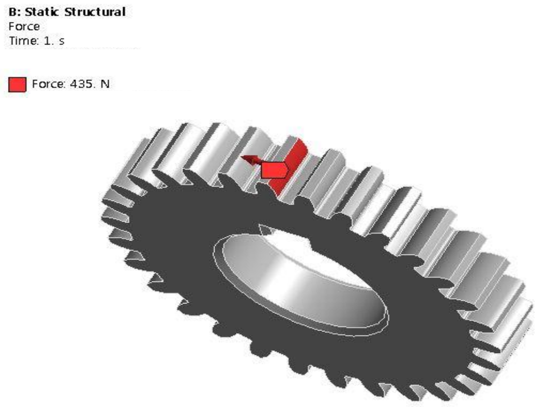


(b) Model 2

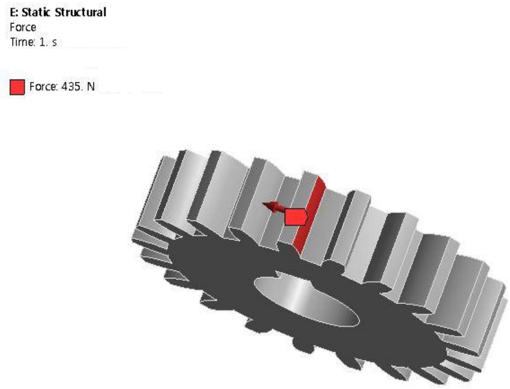


(c) Model 3

Fig. 2 Fixed conditions of models



(a) Model 1



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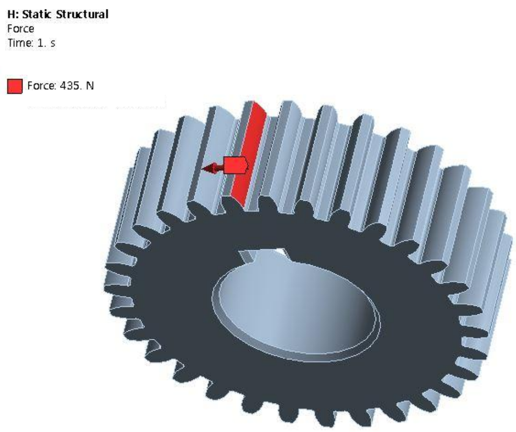
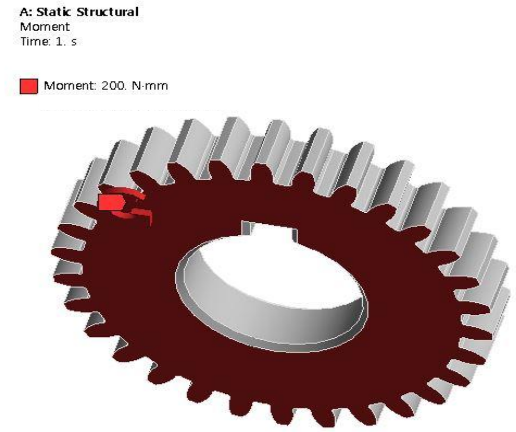
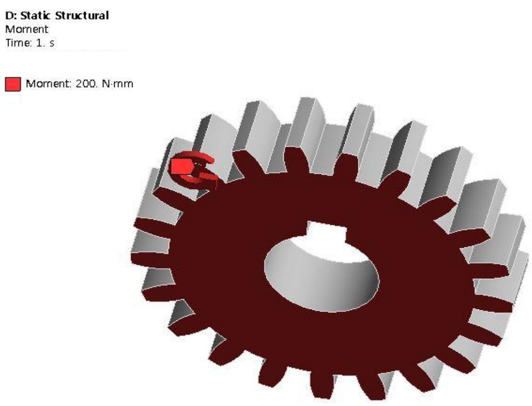


(c) Model 3

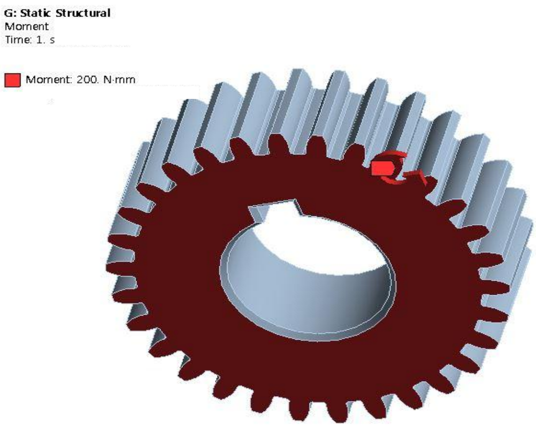
Fig. 3 Forced conditions of models



(a) Model 1

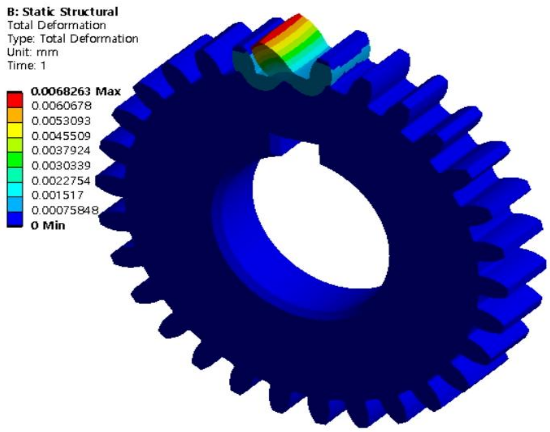


(b) Model 2

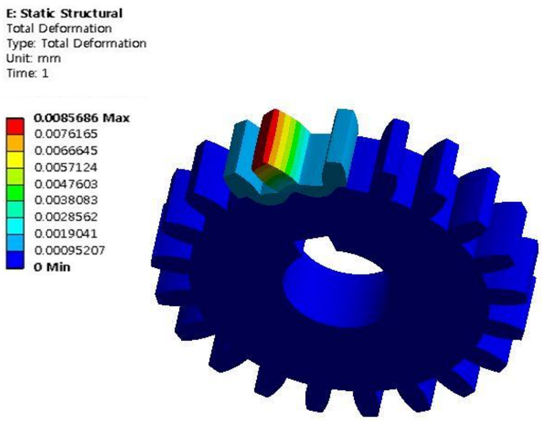


(c) Model 3

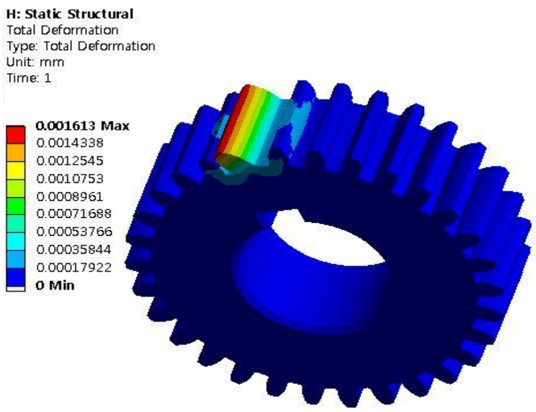
Fig. 4 Momentum conditions applied to models



(a) Model 1

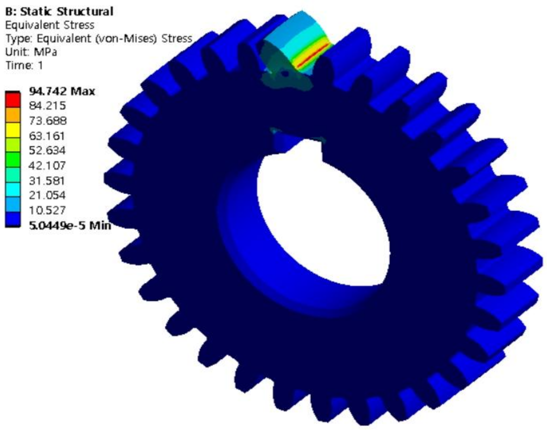


(b) Model 2

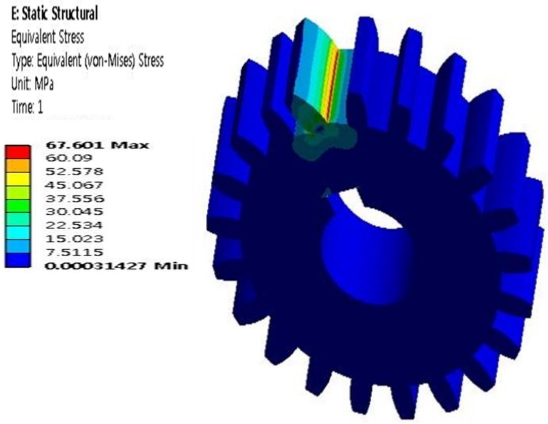


(c) Model 3

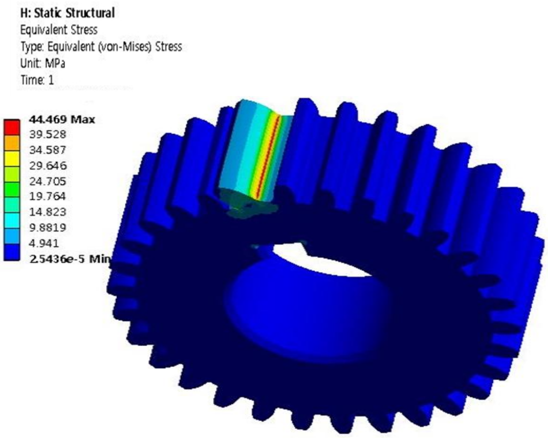
Fig. 5 Contours of total deformations at models



(a) Model 1



(b) Model 2



(c) Model 3

Fig. 6 Contours of equivalent stresses at models

respectively. As all these deformations by the applied load can be seen to be minor at models 1, 2 and 3, the damage due to the deformation has seldom effect on the durability.

Fig. 6 shows the contours of equivalent stresses at models 1, 2 and 3. At Fig. 6, the maximum equivalent stresses of 94.742MPa, 67.601MPa and 44.469MPa are shown at models 1, 2 and 3. respectively. The lower the value of maximum stress, the better the durability of model. Certainly, the thicker the gear teeth are, the more durable they are. The maximum equivalent stress of model 1 becomes more than two times compared with that of model 3. And model 3 is shown to have the least stress. Therefore, model 3 has the best durability among three models. At the design of gear, models 1 and 2 are expected to require the adjustment in order to improve the durability.

4. Conclusion

In this study, the structural analysis was conducted with the model of pinion gear connected to the rack gear which is driven by the steering axle in a automobile. Three models 1, 2 and 3 are designed as the different pinion gears due to the vehicle type. The result of this study is as follows;

1. As these deformations by the applied load can be seen to be minor at all models, the damage due to deformation has seldom effect on the durability.
2. The lower the value of maximum stress, the better the durability of model. Model 3 has the best durability among three models.
3. At the design of gear, models 1 and 2 are expected to require the adjustment in order to improve the durability better.
4. By the utilization of this study result, it is thought to apply at designing the pinion gear with durability at the automotive industry.

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