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FEA Analysis on Motor Support Assembly of Window Air Conditioner

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ABSTRACT
The objective of this paper is to analyze and optimize the motor support assembly of the window air conditioner. The redesigned motor support assembly is the combination of multiple parts of the existing product. In the motor support assembly, motor support base part is optimized to reduce the weight of the component with maximum stiffness for the applied loads and constraints. The CAD model of motor support assembly is performed using Creo parametric 2.0. The static stress analysis is performed for the assembly using Autodesk fusion 360 software. The shape optimization of the motor support base is performed using Autodesk fusion 360 software. The outcome of the research is to reduce the weight of the product with maximum strength for the given loads and constraints.

Keywords: *Autodesk fusion 360, Creo parametric 2.0, maximum stiffness, motor support assembly, shape optimization, static stress analysis, window air conditioner.*

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INTRODUCTION

Fusion 360, a product introduced by Autodesk and integrating industrial design, structural design, mechanical simulation, and cam, turns out to be a design platform supporting collaboration and sharing both cross-platform and via the cloud. Fusion 360 comprises several working environments and modules: modelling, molding, surface patching, rendering, animation, simulation, CAM, drawings and so on [1]. Designing the shapes of products is the primary activity of the design process and the CAD/CAM systems used today for the designs provide limited facilities for the automatic optimization of surfaces. Shape or surface optimization is generally associated with structural optimization where the objective is to minimize the mass with constraints imposed on stress, displacement, buckling and natural frequency. There are three distinct classes of shape optimization problem (cross-sectional, geometrical and topological optimization [2].

METHODOLOGY

Generative design method will be used to reduce the mechanical weight. In this generative design method, forces and moments are used as input in simulation to generate structure based on the distribution of the strain and stress [3, 4]. Shape generator provides an intelligent strategy for maximizing part stiffness based on the constraints that have been specified [3, 4]. Shape generator produces a 3D mesh that can be used to guide the design refinement. The technology of the shape generator integrated into some CAD software [5]. The CAD model of the base part was prepared using Creo parametric 2.0. Later the CAD file is imported in IGES format to Autodesk fusion 360 for shape optimization. Then the optimized component is imported to Creo parametric 2.0 for assembly process. Then the whole assembly is imported to Autodesk fusion 360 for static stress analysis. Orthographic projection of motor support assembly is shown in Figure 1.

FINITE ELEMENT ANALYSIS

Material Selection

The selected material is steel and the safety factor is considered for yield strength. The density of the steel is 7.85E–06 kg/mm^3, Poisson's ratio is 0.3, Young's modulus is 210,000 MPa, yield strength is 207 MPa, ultimate tensile strength is 345 MPa, thermal conductivity is 0.0056 W/(mm C), thermal expansion coefficient is 1.2E–05 /C, and specific heat is 480 J/(kg C). Material properties of steel for motor support assembly are shown in Table 1.

Table 1. *Material properties of steel for motor support assembly.*

Component	Material	Safety factor
Motor support assembly	Steel	Yield strength
Properties		
Density	7.85E–06 kg/mm^3	
Young's modulus	210,000 MPa	
Poisson's ratio	0.3	
Yield strength	207 MPa	
Ultimate tensile strength	345 MPa	
Thermal conductivity	0.056 W/(mm C)	
Thermal expansion coefficient	1.2E–05 / C	
Specific heat	80 J/(kg C)	

Shape Optimization

Mesh

Linear element order is used for meshing the component. The maximum turn angle on curves is 60°. Maximum adjacent mesh size ratio is 1.5. Maximum aspect ratio is 10 and minimum element sizes (% of average size) are 20. The element order during meshing is parabolic. There are 3452 elements and 9930 nodes after meshing.

Mesh, constraints and loads of base part of motor support assembly are shown in Figure 2.

Constraints and Loads

Directions such as U_x, U_y, U_z are fixed. The magnitude of two bearing loads applied such as 25 and 28 N. The applied load in *Y*-direction is −25 and −28 N. The constraints and load cases 1 and 2 are shown in Figure 3.

Shape Optimization Criteria

The target mass applied is lesser than or equal to 10%, and the maximum stiffness is considered during optimization. The mating region of various parts during assembly such as fasteners and rivets is considered as preserved region during optimization process. The preserved region during shape optimization is shown in Figure 3.

Static Stress Analysis

Mesh

Linear element order is used for meshing the component. The maximum turn angle on curves is 60°. Maximum adjacent mesh size ratio is 1.5. Maximum aspect ratio is 10 and minimum element sizes (% of average size) are 20. There are 73,821 elements and 134,169 nodes after meshing. The meshed component is shown in Figure 8. The element order during meshing is parabolic. Meshing, constraints and loads of motor support assembly are shown in Figure 4.

Constraints and Loads

Directions such as U_x, U_y, U_z are fixed. The magnitude of two bearing loads is applied, such as 25 and 28 N. Forces applied in Y-direction are −25 and −28 N in Y-direction.

RESULTS AND DISCUSSIONS

Shape Optimization

The mass of the component before optimization is 6.161 kg. Mass of the component after optimization is 554.369 g. The mass ratio of the optimized component is 10.06%. In Figure 5, the distribution of stress and strain on the base part of motor support assembly is shown when target mass is 100%. Figure 6 shows weight reduction on the structure of the base part of motor support assembly when target mass is l0.06%. The final optimized shape of CAD model of the component is shown in Figure 7.

Static Stress Analysis

The static stress analysis is performed using Autodesk fusion 360 software. The surface plots of safety factor, von Mises stress, total displacement and reaction force is shown in Figures 8–10.

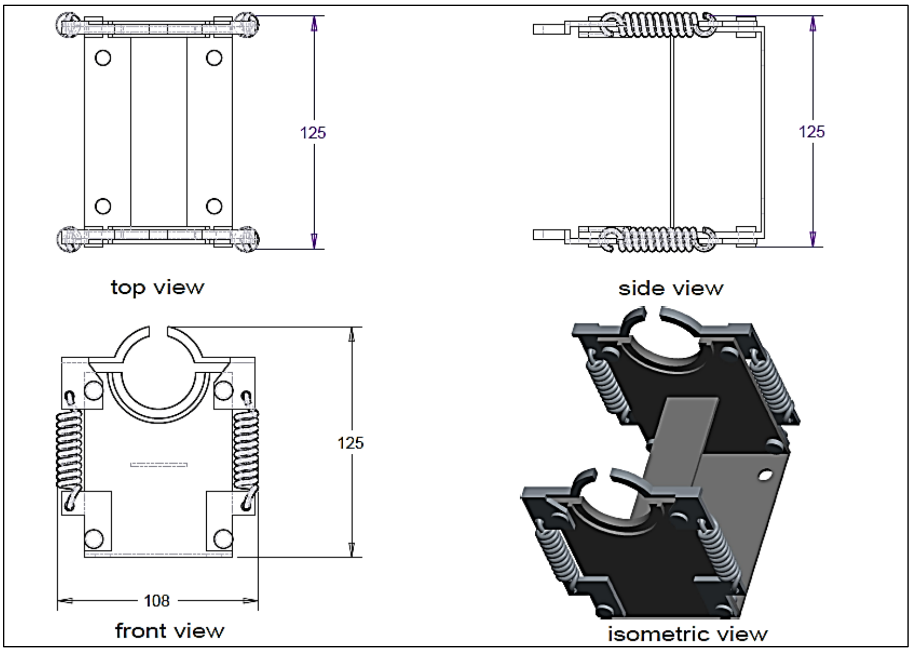

Fig. 1. *Orthographic projection of motor support assembly.*

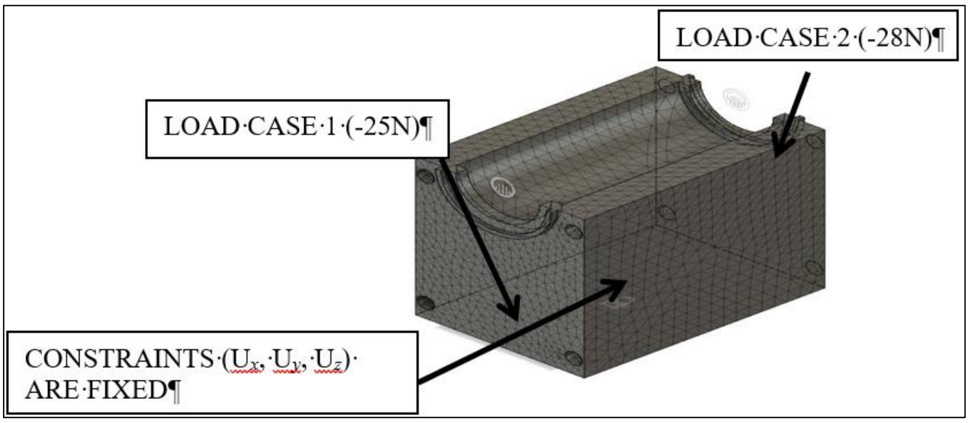

Fig. 2. *Mesh, constraints and loads of base part of motor support assembly.*

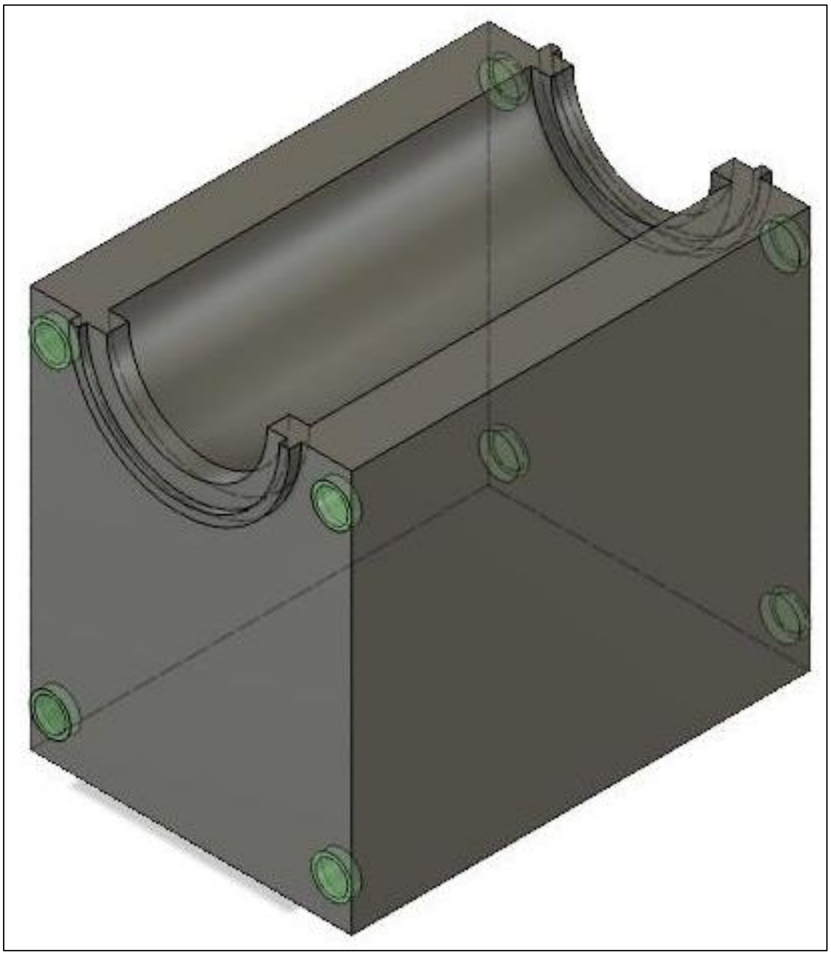

Fig. 3. *Preserved region for shape optimization of base part of motor support assembly.*

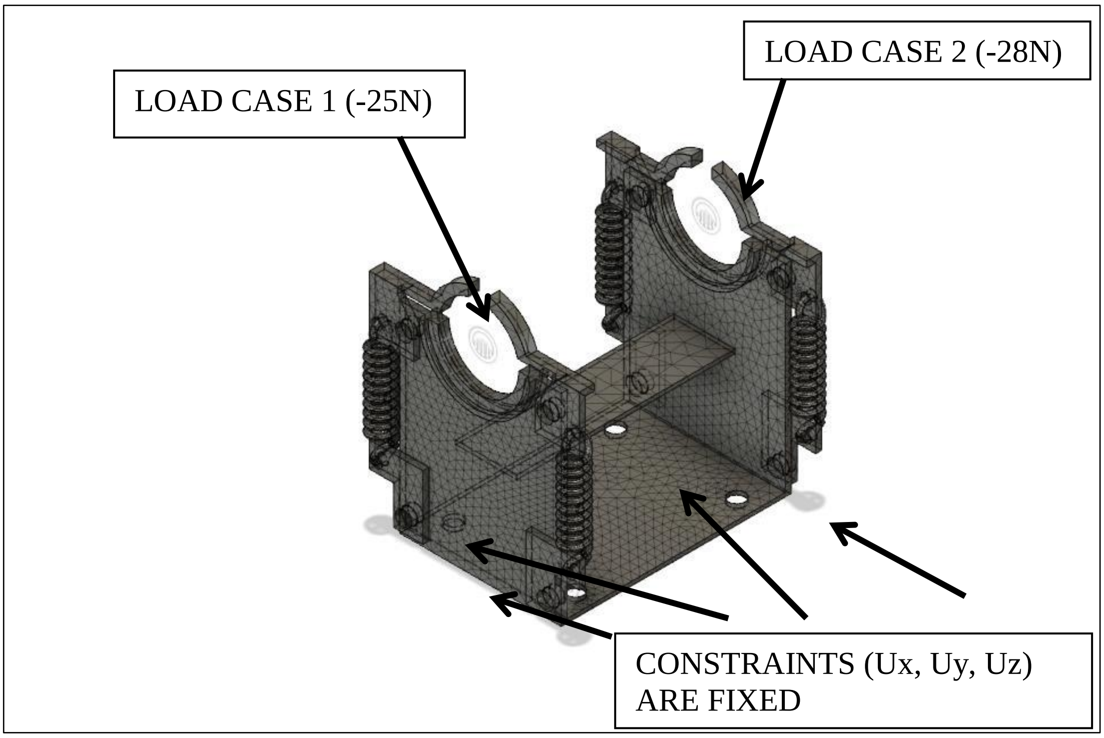

Fig. 4. *Meshing, constraints and loads of motor support assembly.*

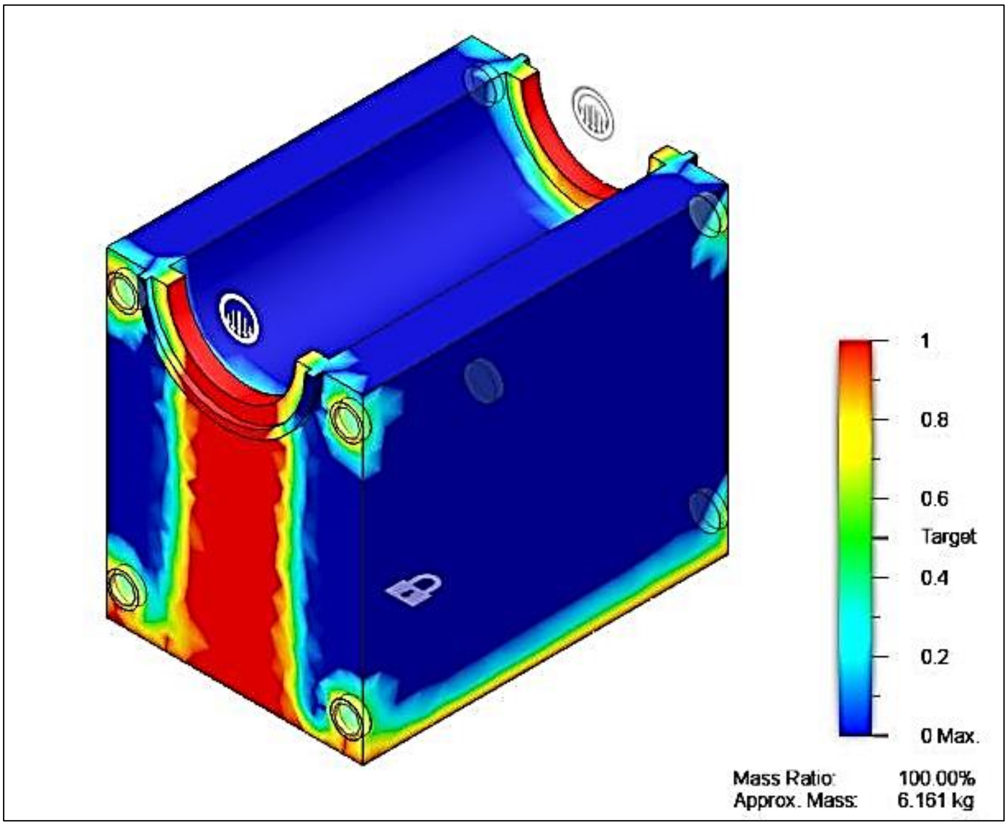

Fig. 5. *The distribution of stress and strain on base part of motor support assembly.*

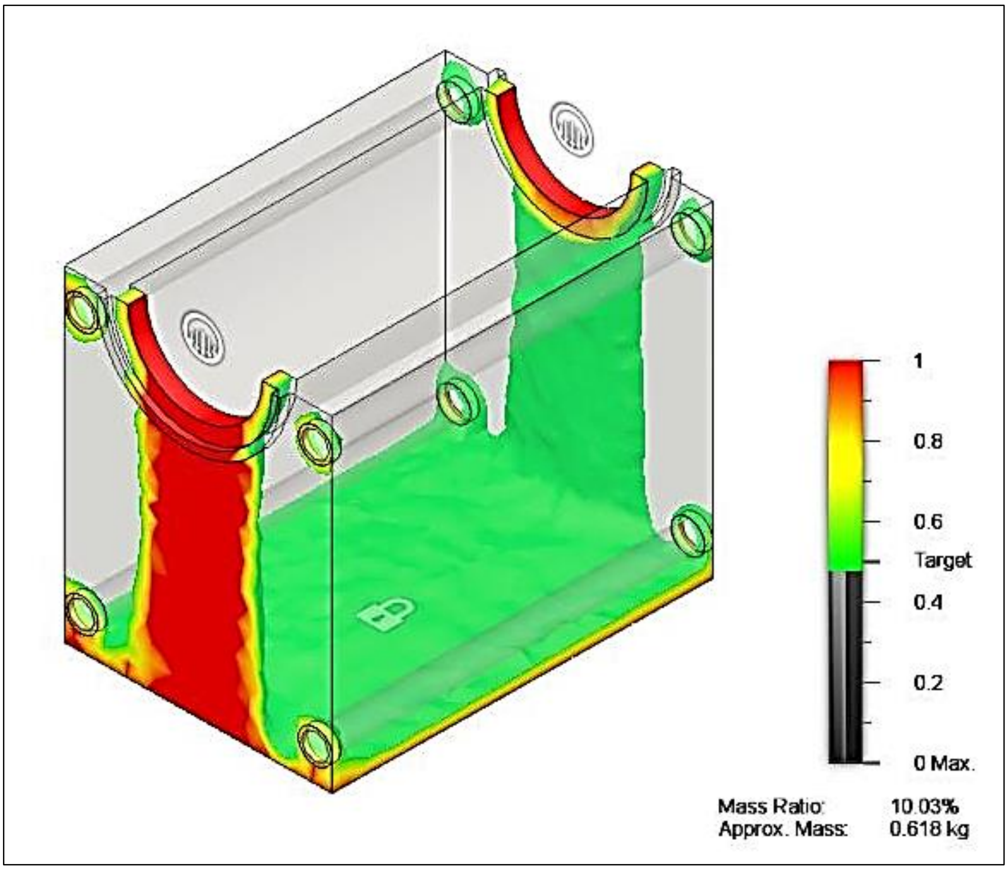

Fig. 6. *Weight reduction on the structure of base part of motor support assembly.*

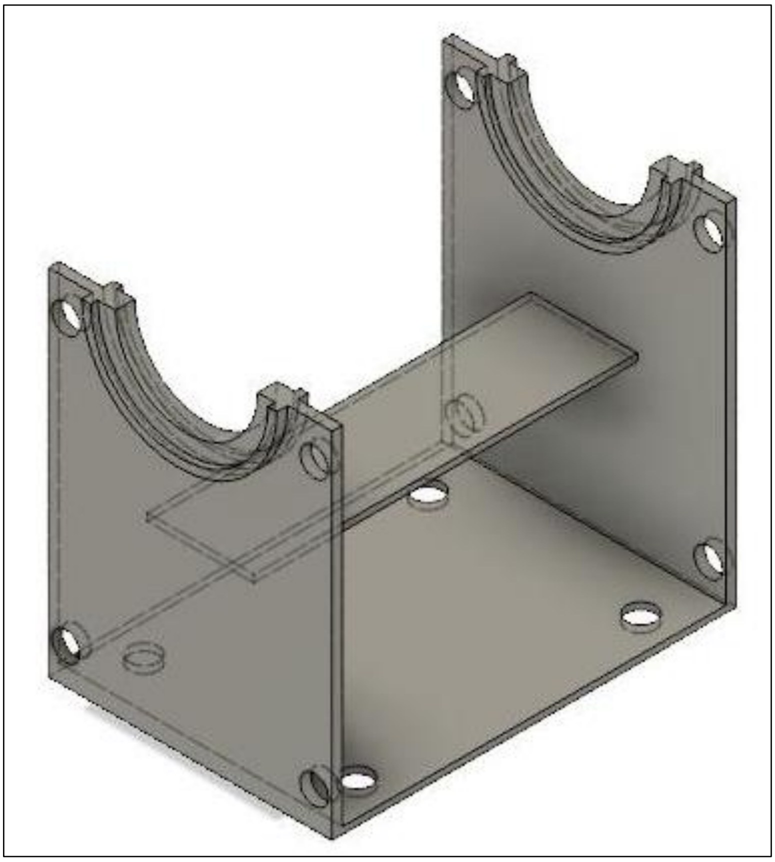

Fig. 7. *Final shape optimized base part of motor support assembly.*

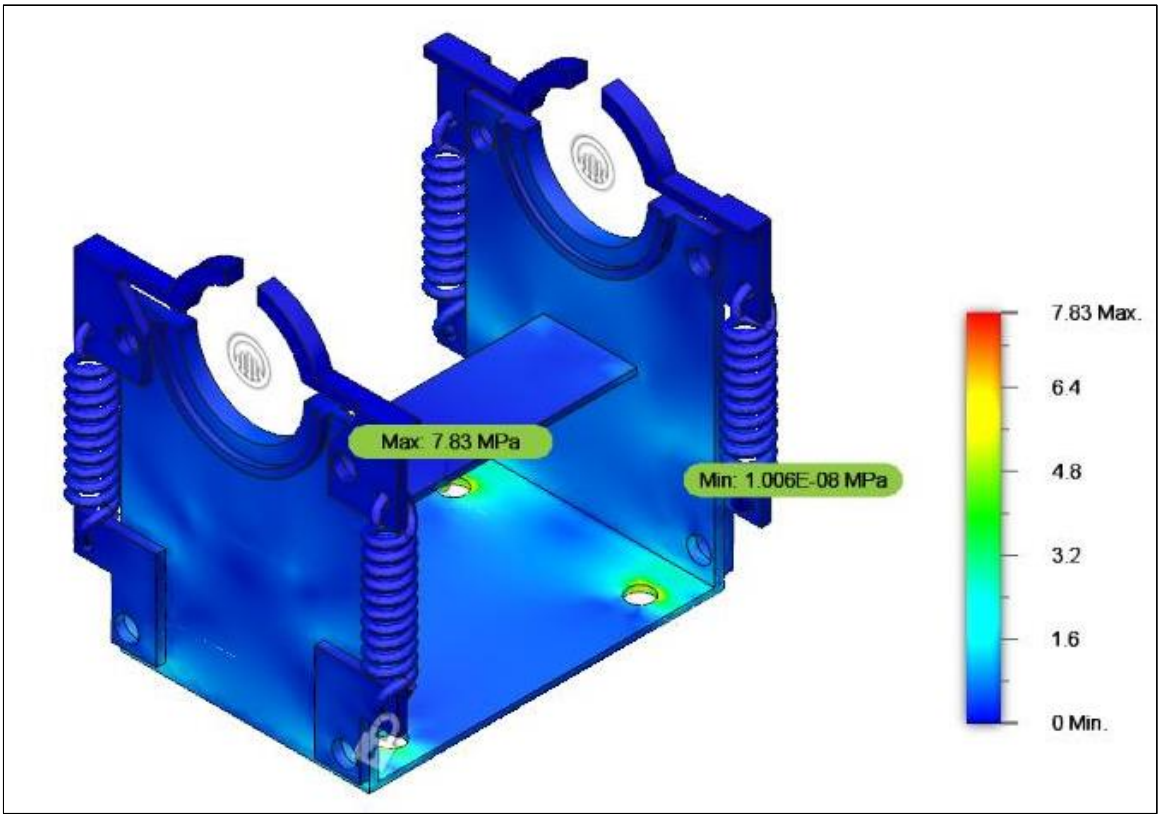

Fig. 8. *von Mises stress.*

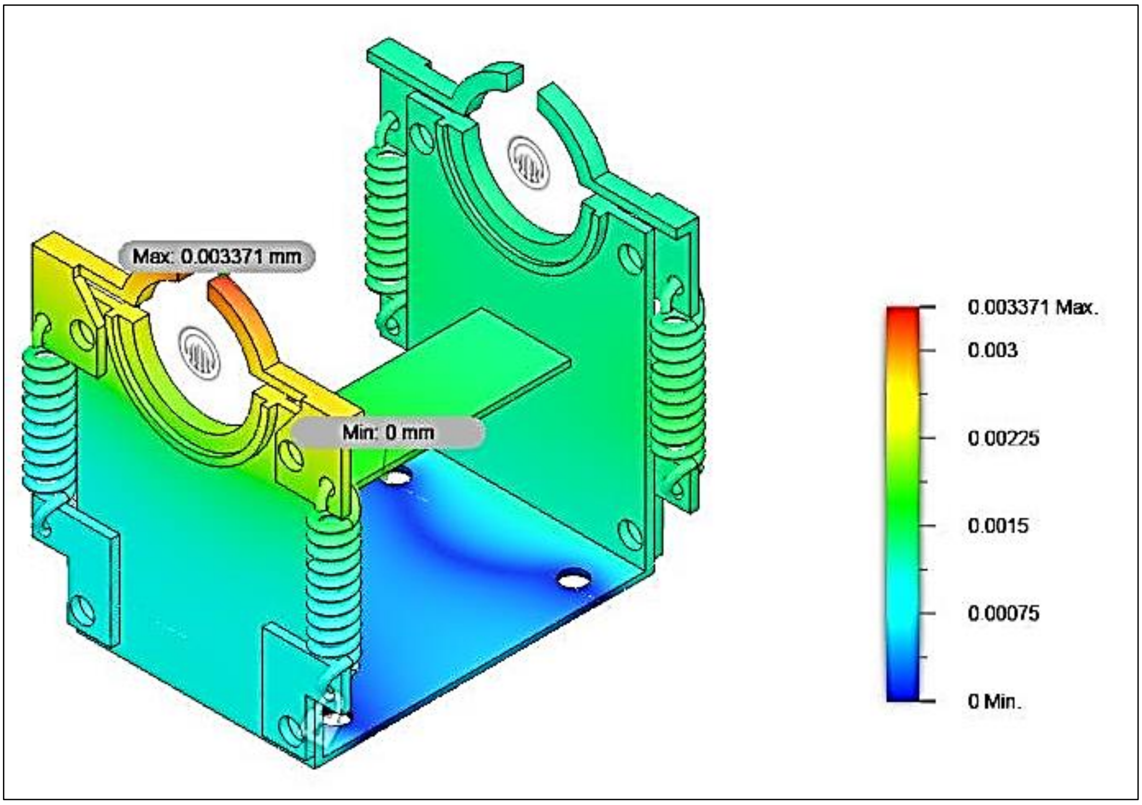

Fig. 9. *Total displacement.*

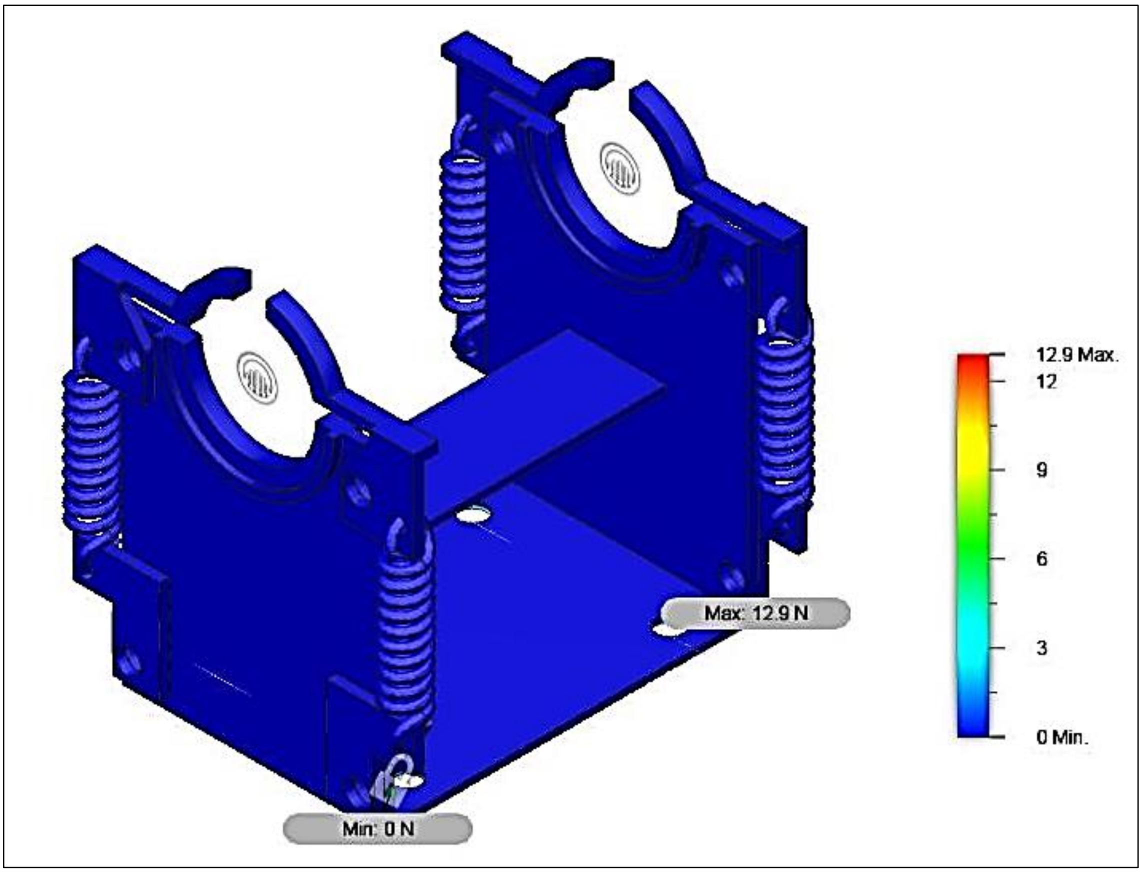

Fig. 10. *Reaction force.*

CONCLUSION

Finite element analysis is successfully conducted for shape optimization of the base part of motor support assembly and also static stress analysis for motor support assembly. More than 90% of the weight is reduced in shape optimization process using Autodesk fusion 360 software. The stress–strain distribution is analyzed from static stress analysis using Autodesk fusion 360 software. The minimum and maximum von Mises stresses are 1.006E–08 and 7.83 MPa. The total maximum displacement is 0.003371 mm. The total maximum reaction force is 12.9 N.

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