

# Design Optimization of Planner Machine Mechanism

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**ABSTRACT:** A gear is a rotating machine part having teeth or cogs, which mesh with another toothed part in order to transmit torque. In this project a defect existing in a planner machine is identified and new methods were used to reduce the effects of the existing defect. In the existing planner mechanism force required for the movement of the rack and pinion mechanism of the planner is transmitted through a shaft connected to the pinion. Thus when the cutting forces reach above a particular value the tooth of the spur gear gets broken. In order to rectify this defect a new mechanism using two bevel gears placed at right angles is used to transmit forces to the pinion and both the mechanisms are compared using Ansys 17.0 to evaluate the improvements in performance. Then the material of the modified design is optimized by comparing the performances of three different materials such as Grey cast iron, Stainless steel and AISI 4140.

**KEYWORDS:** Planer machine, Stainless steel, Bevel gear, AISI 4140

## I. INTRODUCTION

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a non-rotating toothed part, called a rack, thereby producing translation instead of rotation. The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping. When two gears of unequal number of teeth are combined, a mechanical advantage is produced, with both the rotational speeds and the torques of the two gears differing in a simple relationship. In transmissions which offer multiple gear ratios, such as bicycles and cars, the term gear, as in first gear, refers to a gear ratio rather than an actual physical gear. The earliest known reference to gears was circa A.D. 50 by Hero of Alexandria, but they can be traced back to the Greek mechanics of the Alexandrian in the 3<sup>rd</sup> century B.C. were greatly developed by the Greek polymath Archimedes (287-212B.C.). A planer is a type of metalworking machine tool that uses linear relative motion between the workpiece and a single-point cutting tool to cut the work piece. A planer is similar to a shaper, but larger, and with workpiece moving, whereas in a shaper the cutting tool moves.

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## II. DESIGN PROCEDURE

This section deals with the process of modeling. Model is a representation of an object, a system, or an idea in some form other than that of the entity itself. Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. Generally, a model intended for a simulation study is a mathematical model developed with the help of simulation software. Softwares commonly used for modelling are SolidWorks, Creo, Catia, Unigraphics etc. In this project SolidWorks 2016 edition is used for the modelling process.

### Design of gear mechanism

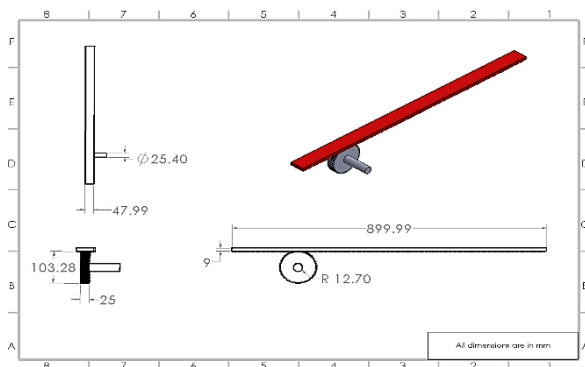


Fig.1 Designed model

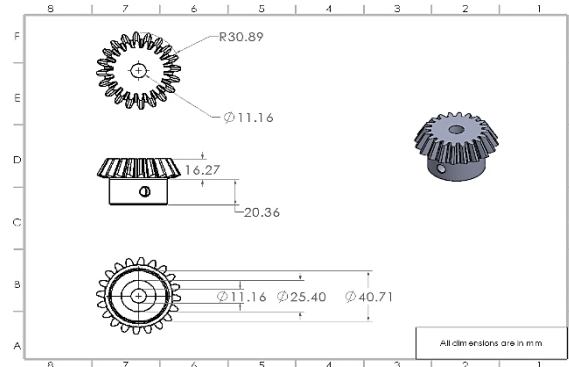


Fig.2 Bevel gear

## III. ANSYS PROCEDURE

This section deals with the analysis of the designed model. The model that is in STEP format is analysed. Static structural analysis of both stabilizer bar link and suspension system is performed by applying the working load and number of supports used is two. The model is imported to Ansys and meshing is performed. The mesh size used is 4.4 mm. From the results obtained optimal design is selected. Suitable materials are applied to three different models of stabilizer bar link and modal analysis is performed. Different softwares such as Comsol, Radioss solver, Abaqus, Hypermesh, Ansys etc. are used for analysis. In this project Ansys R15.0 is used for design analysis.

### Design Analysis of existing design

The figure shown below represents the meshed model, analysis setup and total deformation of existing design.

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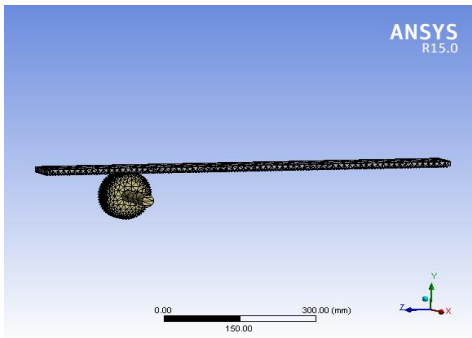


Fig.3 Meshed model of existing design

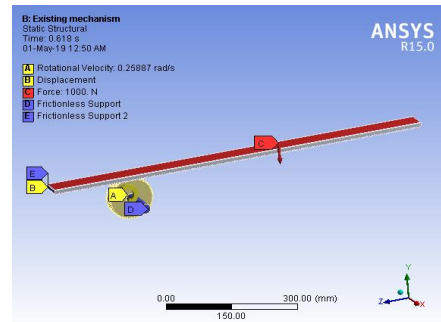


Fig.4 Analysis setup of the existing design

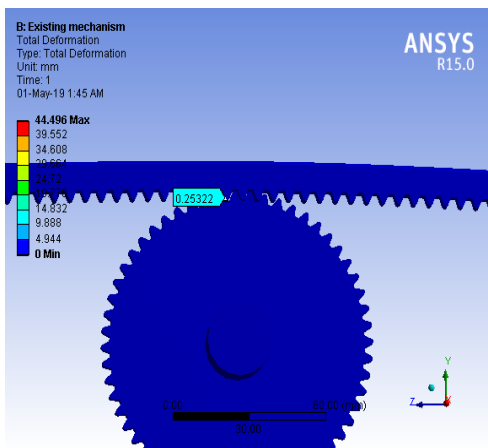


Table 1 Overview of analysis results of existing design

Property	Max	Min
Total deformation (mm)	0.25322	0
Equivalent elastic strain	0.003453	$8.3543e^{-8}$
Equivalent stress (MPa)	359.77	0.0015714
Normal stress (MPa)	95.138	-87.425

Table 1 above represents the total deformation, equivalent elastic strain, equivalent stress and normal stress of the existing design.

### Design analysis of modified design.

The figure shown below represents the analysis setup and total deformation of modified design.

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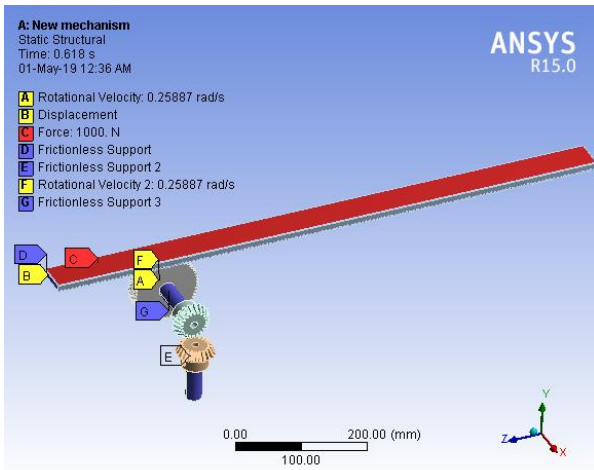


Fig.6 Analysis setup of modified design

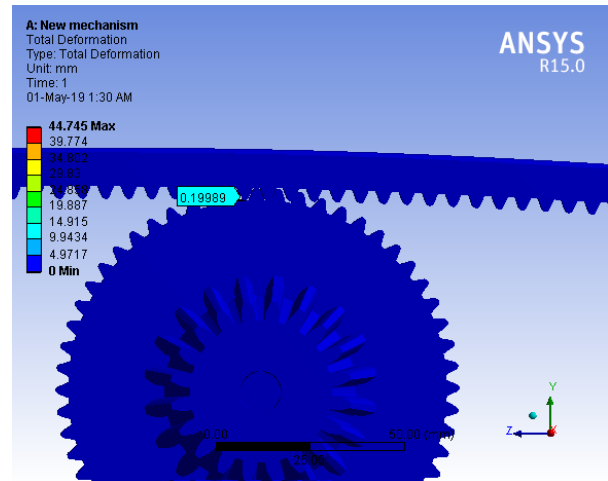


Fig.7 Total deformation of the modified design

Table 2 Overview of analysis results

Property	Max	Min
Total deformation (mm)	0.19989	0
Equivalent elastic strain	0.0034397	$3.9575e^{-11}$
Equivalent stress (MPa)	358.34	$4.3533e^{-8}$
Normal stress (MPa)	94.969	-87.62

Table 2 above represents the total deformation, equivalent elastic strain, equivalent stress and normal stress of the modified design. From the analysis results it can be concluded that the modified design has the least value of maximum total deformation. Hence the modified design is selected as the best suitable system.

#### IV. MATERIAL OPTIMISATION

As per the results obtained, the modified design is selected as the optimized design and is applied with three different materials such as Grey cast iron, Stainless steel and AISI 4140. Then the model is analysed to verify the results.

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Table 3 Summary of analyses results of modified design applied with different materials

Material	Total deformation (mm)
Grey cast iron	0.19989
Stainless steel	0.10325
AISI 4140	0.10488

From Table 3 it can be clearly understood that stainless steel exhibits the least value of total deformation among the three materials selected for comparison. Hence stainless steel is selected as the final material of the modified design.

### V. RESULTS AND DISCUSSION

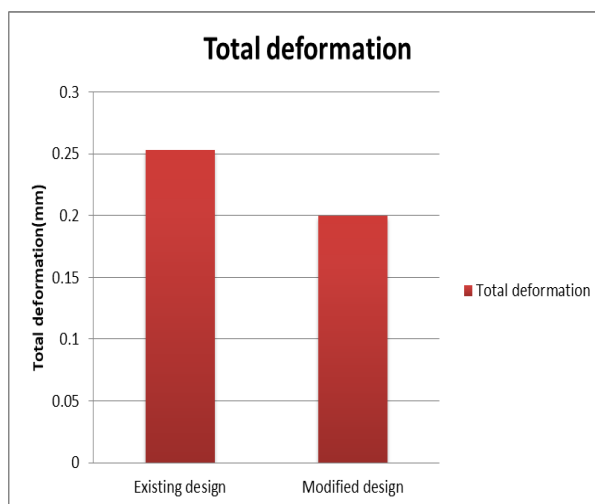


Fig. 8 Variation in the total deformation values of both the designs

Thus from the results it is clear that modified design is a better design as compared to the existing design and hence it was selected for further analysis. Then to select the most suitable material among three materials such as Grey cast iron, Stainless steel and AISI 4140, these materials were applied and analyses were carried out in a sequential order. From the analysis results it was clear that the total deformation value was the lowest for Stainless steel. Hence stainless steel was selected as the final material of the modified design and different parameters of the modified design applied with stainless steel such as equivalent elastic strain, equivalent stress and normal stress were analysed.

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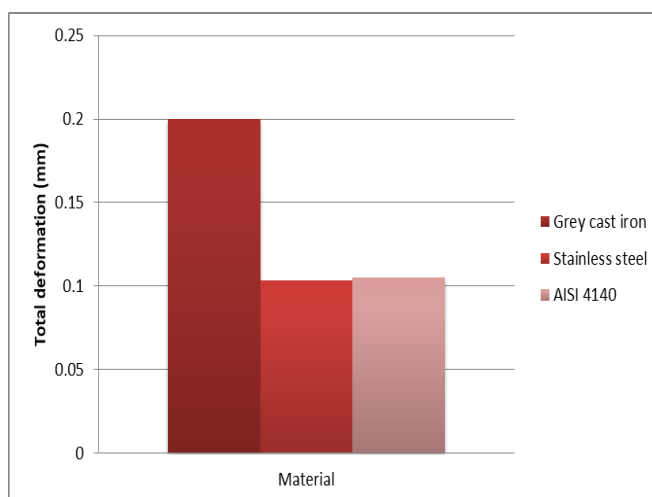


Fig 9 Comparison of total deformation values of different materials

Hence, modified chassis applied with stainless steel will reduce the total deformation from 0.25322 to 0.10325. The percentage reduction in total deformation is 59.22% as compared to the existing design.

### VII.CONCLUSION

In this project the rack and pinion mechanism of a planner machine has been optimised by using an arrangement consisting of two bevel gears. Then the design was modified and the force is transmitted through a set of bevel gears onto the pinion. This has reduced the total deformation value from 0.25322 mm to 0.19989 mm. Also different characteristic properties of both the mechanisms such as equivalent stress, equivalent elastic strain, normal stress and normal elastic strain were analysed and results were compared. From these results it is clear that the new mechanism is a significantly better mechanism as compared to the older mechanism. Then three different materials such as Grey cast iron, Stainless steel and AISI 4140 were applied and the total deformation values were compared. It was found out that the modified design applied with stainless steel has the least value of total deformation.

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