Failure Analysis and Performance and Investigation of CVT for two wheeler auto gear vehicle

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Abstract:

Conventional transmissions allow for the selection of discrete gear ratios, thus limiting the engine to providing maximum power or efficiency for limited ranges of output speed. Because the engine is forced to modulate its speed to provide continuously variable output from the transmission to the load, it operates much of the time in low power and low efficiency regimes. A continuously variable transmission (CVT) is a type of transmission, however, that allows an infinitely variable ratio change within a finite range, thereby allowing the engine to continuously operate in its most efficient or highest performance range, while the transmission provides a continuously variable output to the load. The development of modern CVTs has generally focused on friction driven devices, such as those commonly used in off-road recreational vehicles, and recently in some automobiles. The thesis includes the CVT for auto gear of Automobile. CVT is very popular in four wheeler and failure analysis of critical component likes driven pulley and belt.

The analysis will include the belt and driven pulley modelling in Solid Work 2015 and check failure condition in different loading condition for driven pulley and modal analysis of belt for overcome belt slippage at high speed for final result concluded.

Keywords: CVT, Engine, Gear, Pulley, Belt drive.

1. Introduction

Continuously variable transmission (CVT) is an automatic transmission used to obtain infinite gear ratios between driver and driven shafts. The subsystem 'Front Seats' consists of two seats, the driver's seat and the passenger seat.

They are used in scooters, Baja vehicles etc. Engine power is transmitted from driver side to driven side (secondary) by means of a belt and pulleys. Infinite gear ratios are obtained by varying belt diameter over pulleys.

This research aims at reducing the surface temperature around the pulleys of a CVT. Work consists of design modification of CVT and changing material of the pulleys to increase heat flow rate. The temperature distribution is analyzed for different designs using steady state thermal analysis tool in ANSYS.

Mobility of humans and goods has been one of the central issues of technology. Even though the electric car has finally made an entrance into the vehicle market, we still heavily rely on prime movers for transportation.

2. Continuously Variable Transmission (CVT) System

Fig. 1 Engine

The component in question belongs to the continuously variable transmission (CVT) system, shown in the following Figure 1.
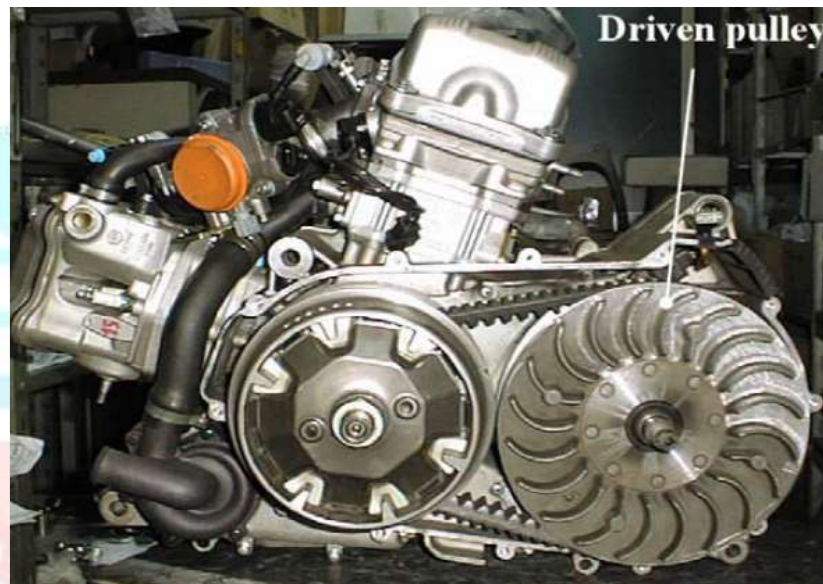

Fig.2. The CVT system

By means of an asynchronous belt, the CVT system transmits the motion from the crankshaft to a rear transmission, which in turn transmits the motion to the rear wheel of the vehicle. The driven pulley, highlighted in the last figure, is made of 2 halves, as shown in the following Fig.3.
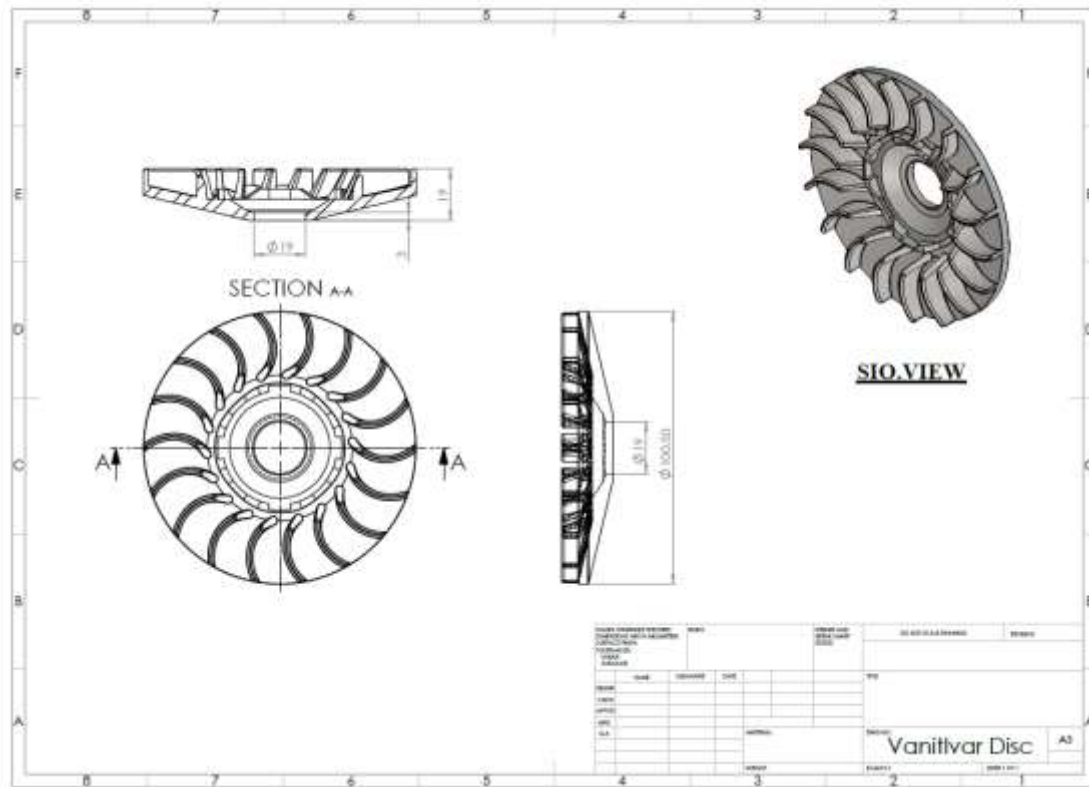
Fig. 3 Driven Pulley for CVT

3. CAD Tool-Solid Work 2016

Solid Works 2016 is 3D mechanical design system built with adaptive technology and solid modeling capabilities.

The Solid Works 2015 software includes features for 3D modeling, information management, collaboration, and technical support with DSS you can:

1. Create 3D models and 2D manufacturing drawings.
2. Create adaptive features, parts, and subassemblies.
3. Manage thousands of parts and large assemblies.
4. Use third-party applications, with an Application Program Interface (API).
5. Use VBA to access the Autodesk Inventor API. Create programs to automate repetitive tasks. On the Help menu, choose Programmer Help.
6. Import SAT, STEP, and AutoCAD and Autodesk Mechanical Desktop (DWG) files for use in Autodesk Inventor. Export Autodesk Inventor file to AutoCAD, Autodesk Mechanical Desktop, and IGES formats.
7. Collaborate with multiple designers in the modeling process.
8. Link to web tools to access industry resources, share data, and communicate with colleagues.
9. Use the integrated Design Support System (DSS) for help as you work.

4. Working with assemblies

- Turn off visibility of nonessential components. Access the parts we need and update graphics faster.

- Use design representations. Create design representations that highlight specific design problems or assembly subsystems, and apply them when opening the assembly model.
- Turn off part adaptivity. After we size components, turn off adaptivity to speed up solutions and prevent accidental changes.
- Assign different colors to components. Select colors from the Color list on the Standard toolbar.
- Use the browser to find components. Point to component in the browser to highlight in the graphics window.
- Use color to identify components groups. Using attributes, find components in specific subsystems or from specific vendors and color-code them in named representations.

Using part features creates all components of structure. All assemblies are created using various components (part) by constrained there relative motion.

Using part modeling environment to create structure.

First to make geometry of standard section pipe with respect their practical data to measure thickness of plate and amount of extruded part by using extrude command in feature operation.

Further using new sketch on base extruded component and draw sketch on existing extruded feature to identifying model width.

As shown in Figure 4 to 11, there are different orientations of CVT system **as** isometric view, front view, top view and side view.
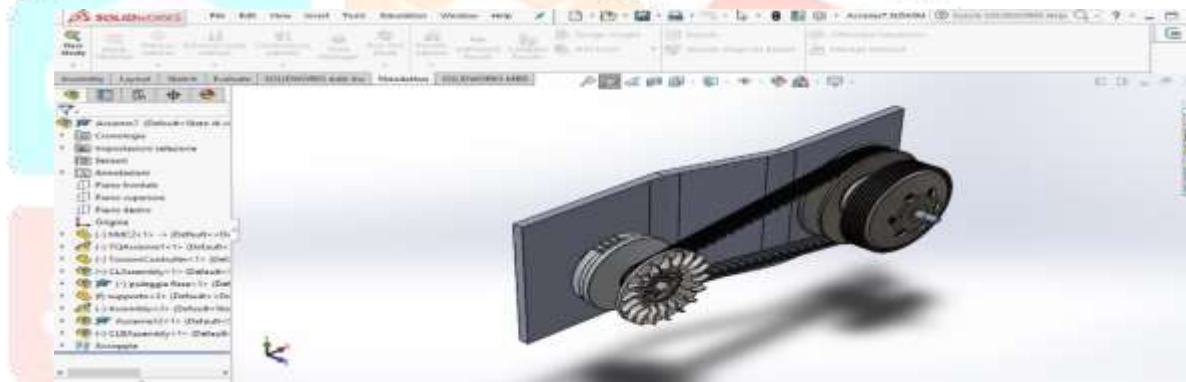

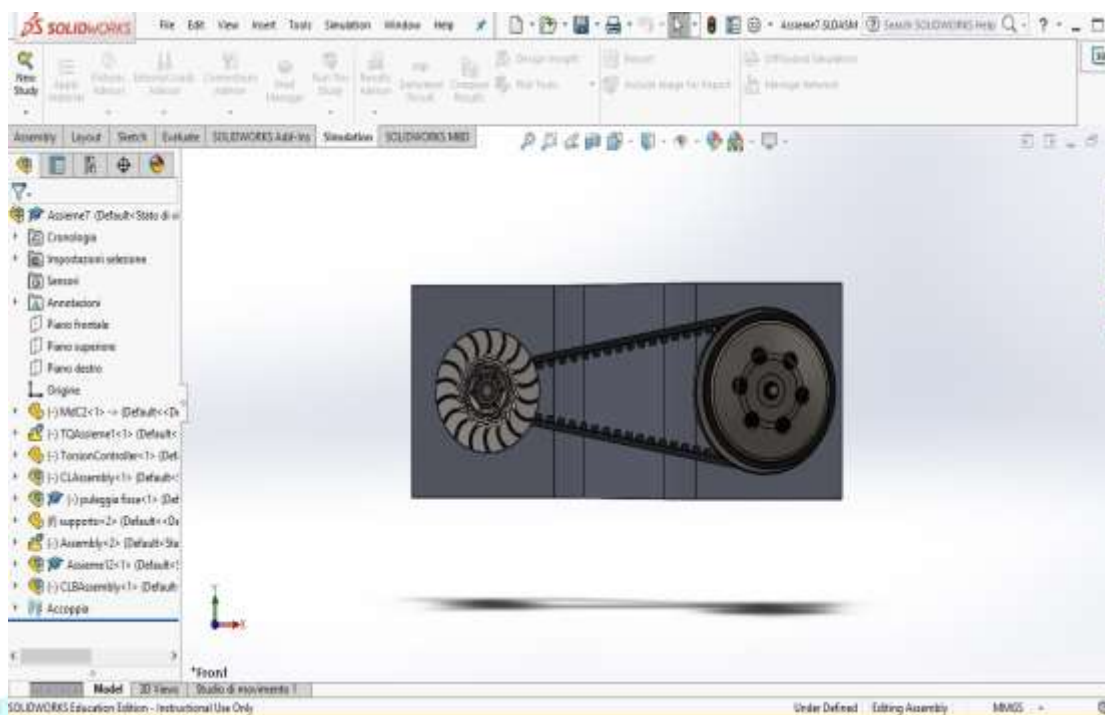**Fig.4 Isometric view of CVT System**
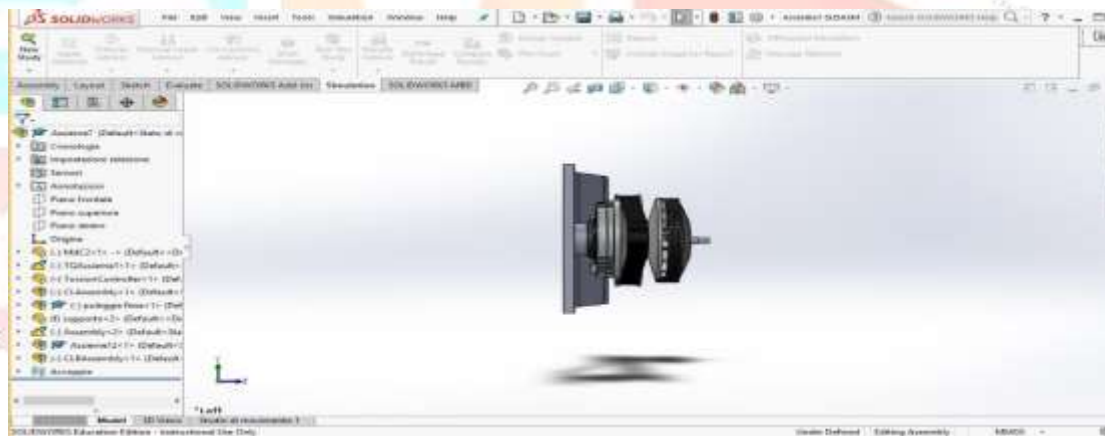
Fig.5 Front view of CVT System
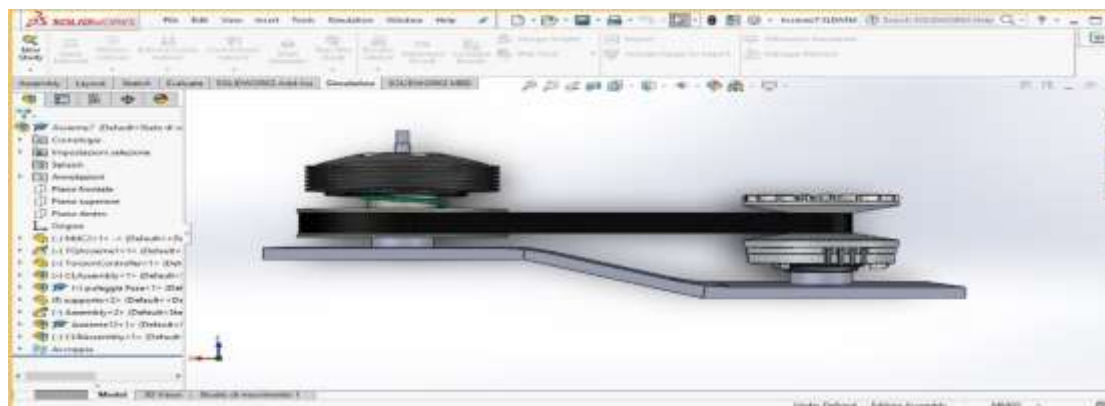

Fig.6 Side view of CVT System

Fig.7 Top view of CVT System

As per data from research paper to identified different dimension to make 3 D model in Solid Work 2016 to justified different component for assembly level and important in operation condition for CVT System. By applied different feature and geometrical parameter in CAD tool to make such 3 D Model for checking critical components failure analysis.

4 Finite Element Method

The Finite Element Method (FEM) is a numerical technique for analyzing engineering designs. FEM is accepted as the standard analysis method due to its generality and suitability for computer implementation. FEM divides the model into many small pieces of simple shapes called elements effectively replacing a complex problem by many simple problems that need to be solved simultaneously. The following figure shows CAD and its FEA model.

Elements share common points called nodes. The process of dividing the model into small pieces is called meshing. The behavior of each element is well-known under all possible support and load scenarios. The finite element method uses elements with different shapes. The response at any point in an element is interpolated from the response at the element nodes. Each node is fully described by a number of parameters depending on the analysis type and the element used.

For example, the temperature of a node fully describes its response in thermal analysis. For structural analyses, the response of a node is described, in general, by three translations and three rotations. These are called degrees of freedom (DOFs). Analysis using FEM is called Finite Element Analysis (FEA). Software programs formulate the equations governing the behavior of each element taking into consideration its connectivity to other elements. These equations relate the response to known material properties, restraints, and loads. Next, the program organizes the equations into a large set of simultaneous algebraic equations and solves for the unknowns

4.1 Proposed Study

In this analysis work, by taking actual data from research paper for geometrical parameter for analysis. By tire and error method we have to different loading condition on driven pulley likes 1000N, 1500N, 2000N, 2500N and 3000N for checking stress value and deformation as per material concern.
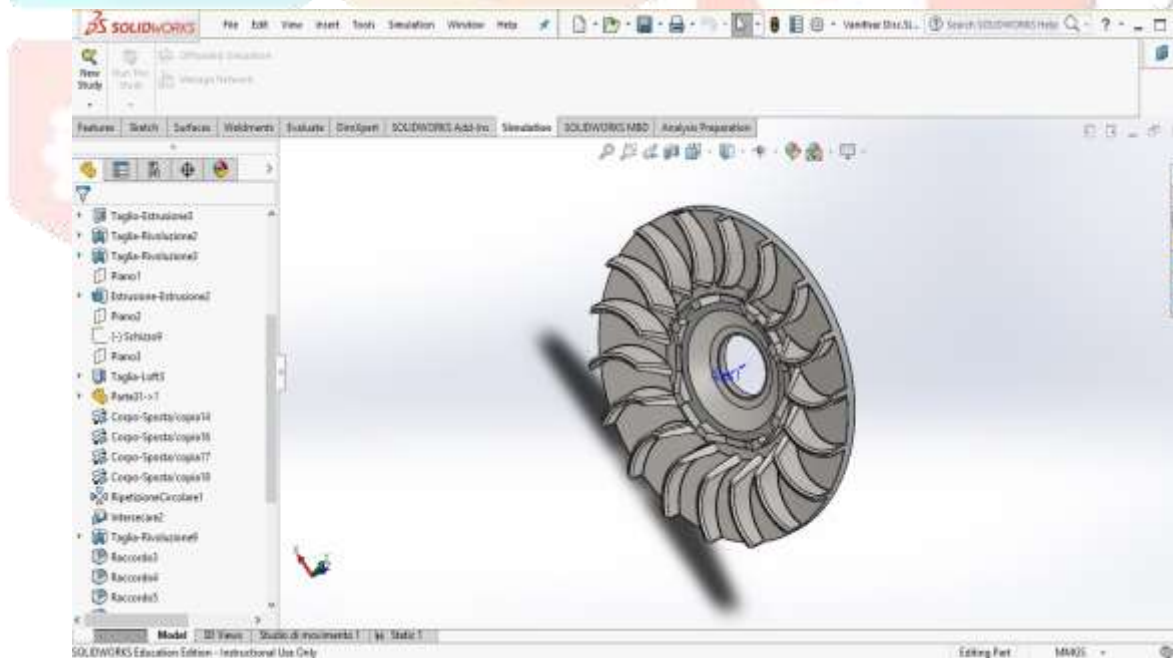

Fig. 8 Geometry of Driven Pulley using static analysis

4.2 Driven Pulley

As shown Figure 8 which having tropical geometrical parameter to satisfied meshing of geometrical with respect to element size and shape. Driven pulley is critical component in CVT for transmission power form input to output.

4.3 Computation Strategy for FEA

Finite element method is the best and prescribed for large deformation non-linear simulation like this metal forming process. Solid Work 2016 is one of the best explicit solvers available in the market; Solid Work 2016 integrates this solver for all type of explicit solution.

4.4 Meshing Setup for FEA

Quad and Tetra elements were chosen for the meshing. Since Solid Work 2016 automatically selects the meshing algorithm and type of element required for the analysis model, it is easy to concentrate with the mesh density for accurate analysis.
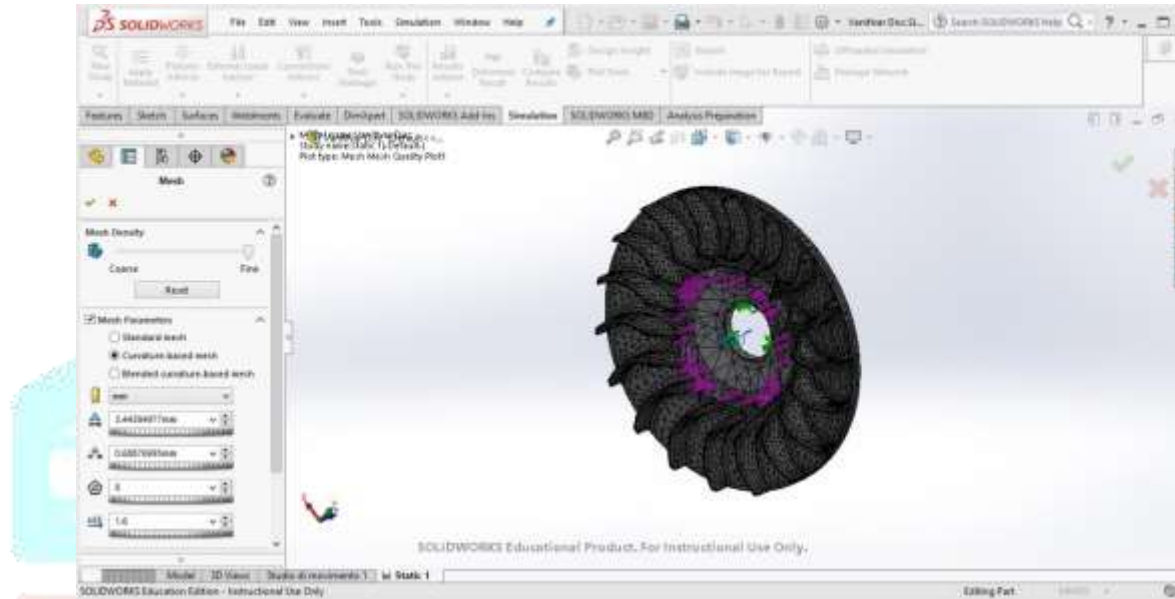
Fig. 9 Meshing of Driven Pulley using static analysis

4.5 Material Property for FEA

Proper explicit model of the plain carbon steel is selected for sheet model and tool steel is applied for die and punch. The material library in the Autodyne software allows us to select the required material model. Proper hardening law is used for the material model; all the models are collected by the software from different research work of different scholars all around the globe. The hardening of the materials after the yield is an important factor for any forming process and not limited to this only for any plastic flow models. Different research works have been conducted to explore the material property after the yield limit and algorithm are formulated for identifying the hardening factors of the material.
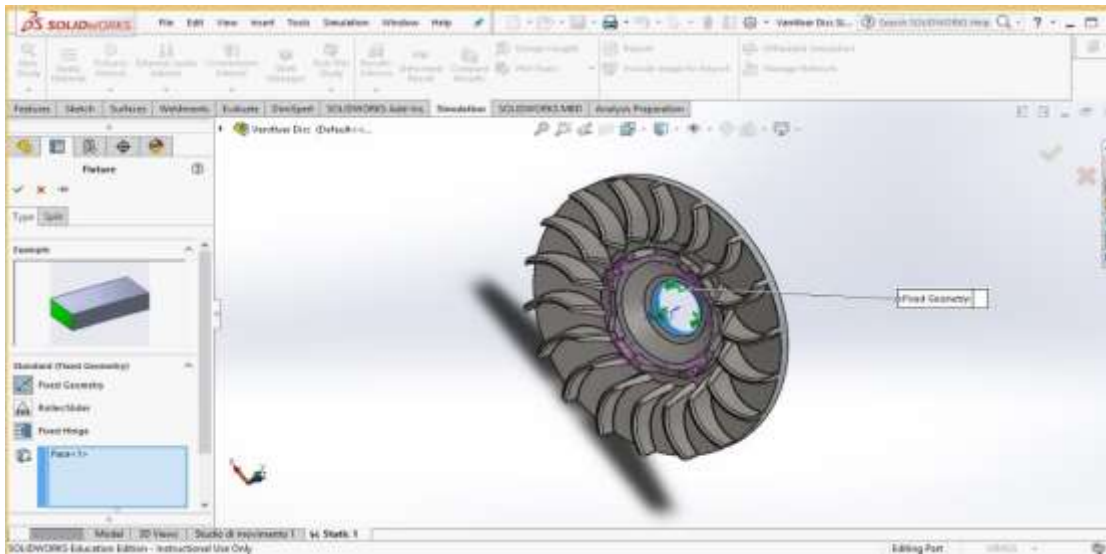
Fig. 10 Boundary Condition of Driven Pulley using static analysis

4.6 Loading details for FEA

The loads for the model with respect to the radius of the driven pulley are calculated as force as are given in Figure 11 Based on the force applying on the driven pulley, to force for easier application in to finite element solution. We have considered different force condition 1000N, 1500N, 2000N, 2500N and 3000N.
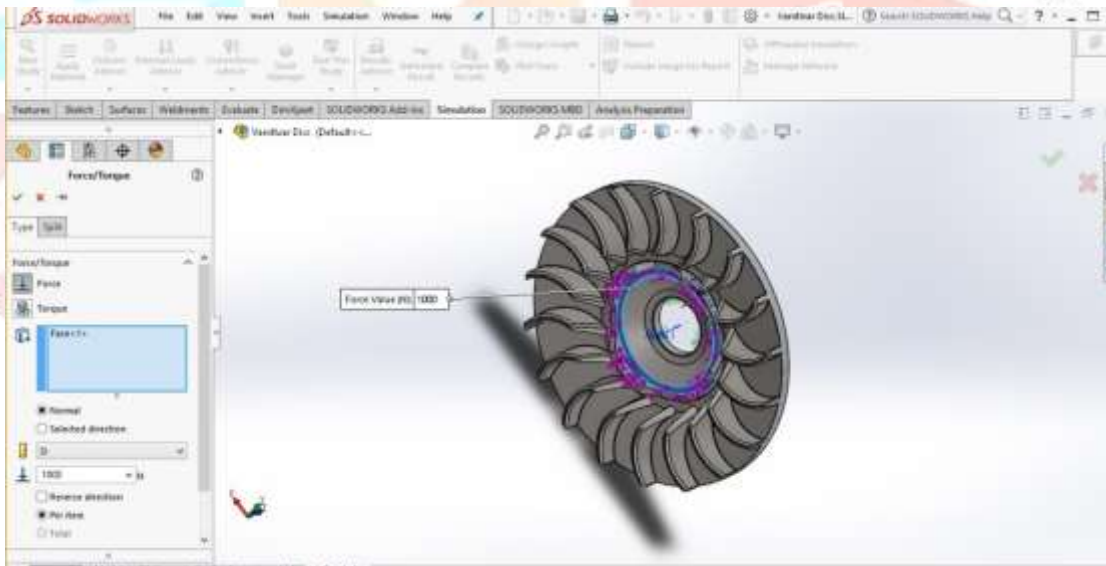

Fig. 11 Loading Condition of Driven Pulley using static analysis
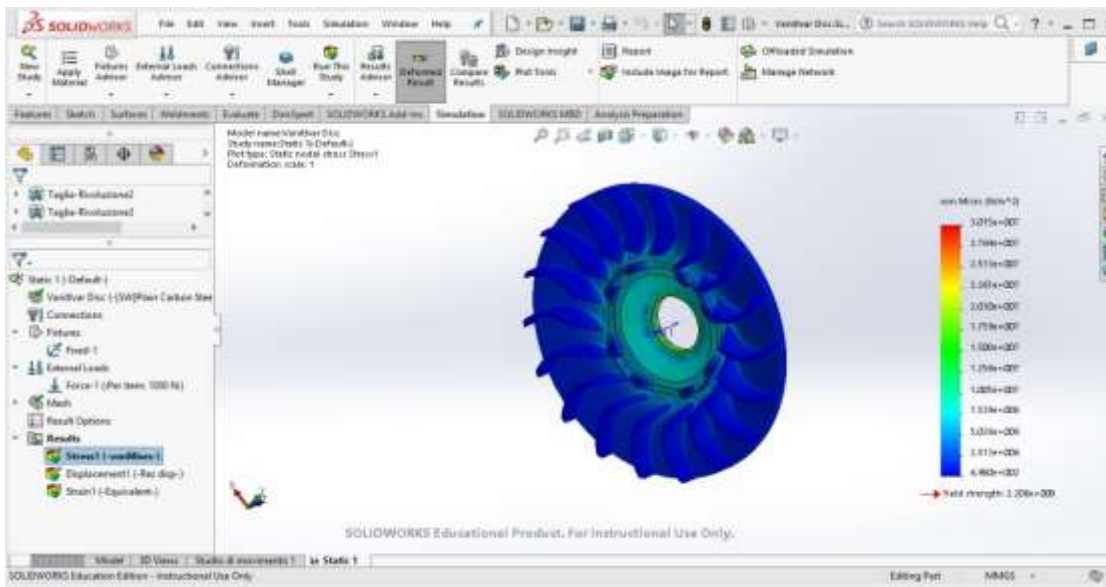
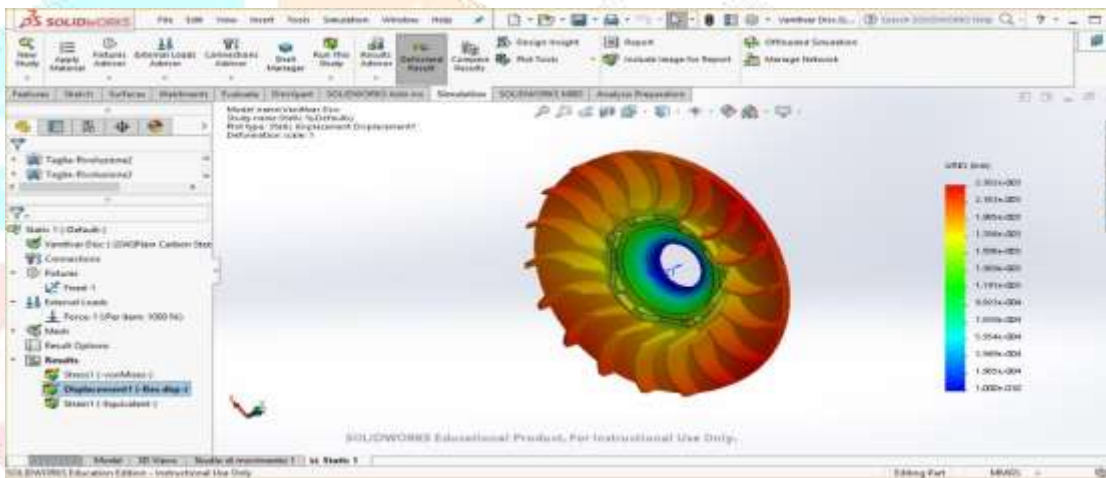## 4.7 Results

Fig.12 Von mises Stress Result for 1000N

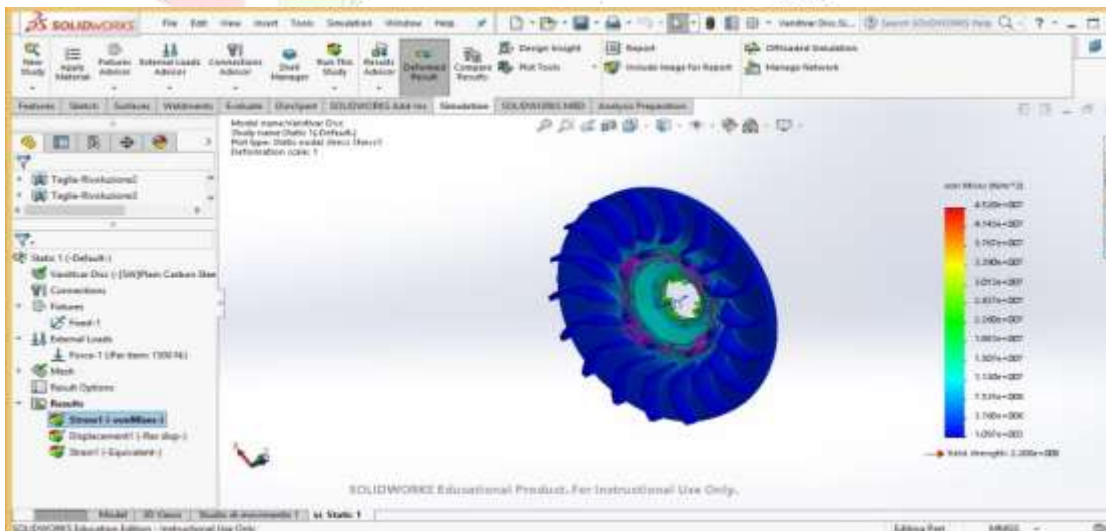**Fig. 13 Deflection Result for 1000N**

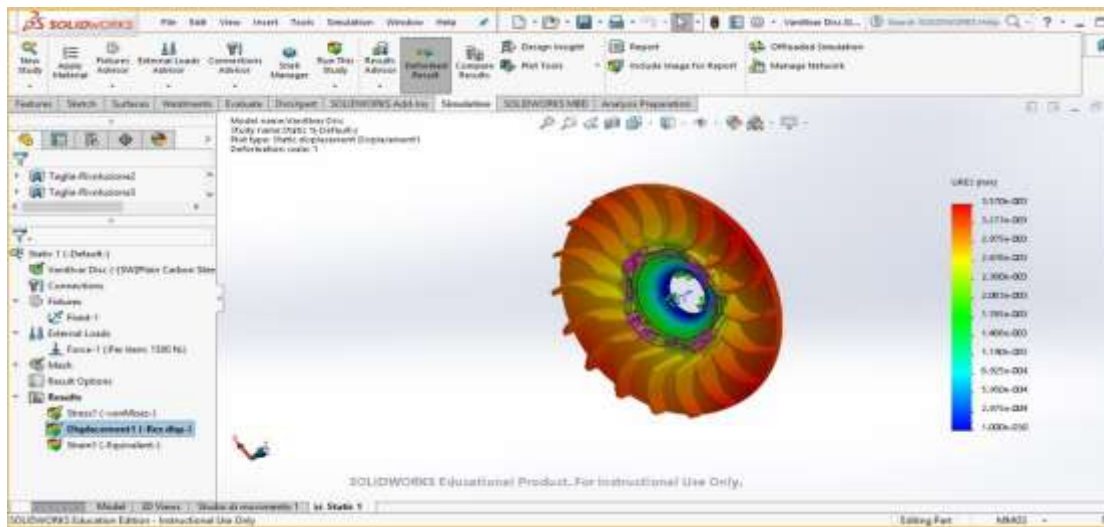**Fig.14 Von mises Stress Result for 1500N**

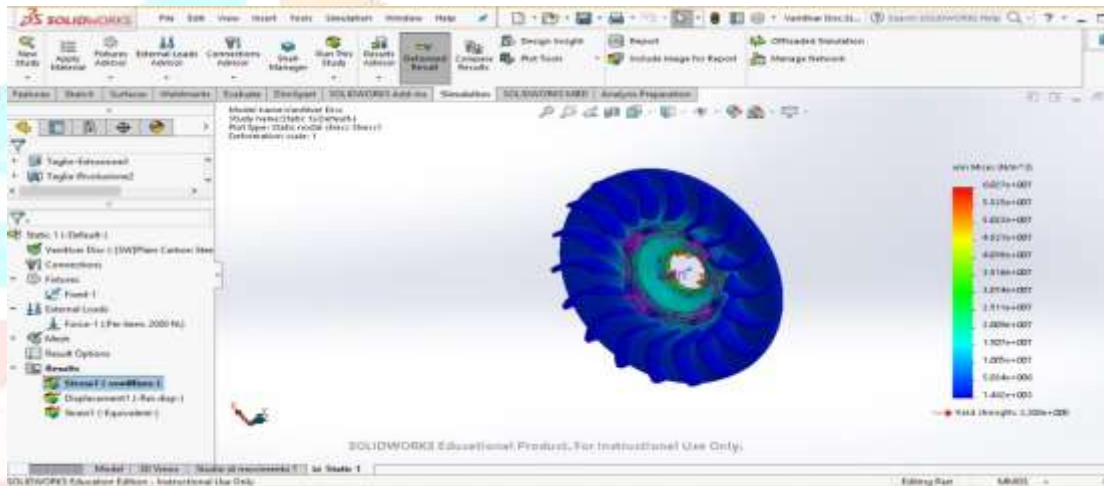**Fig.15 Deflection Result for 1500N**

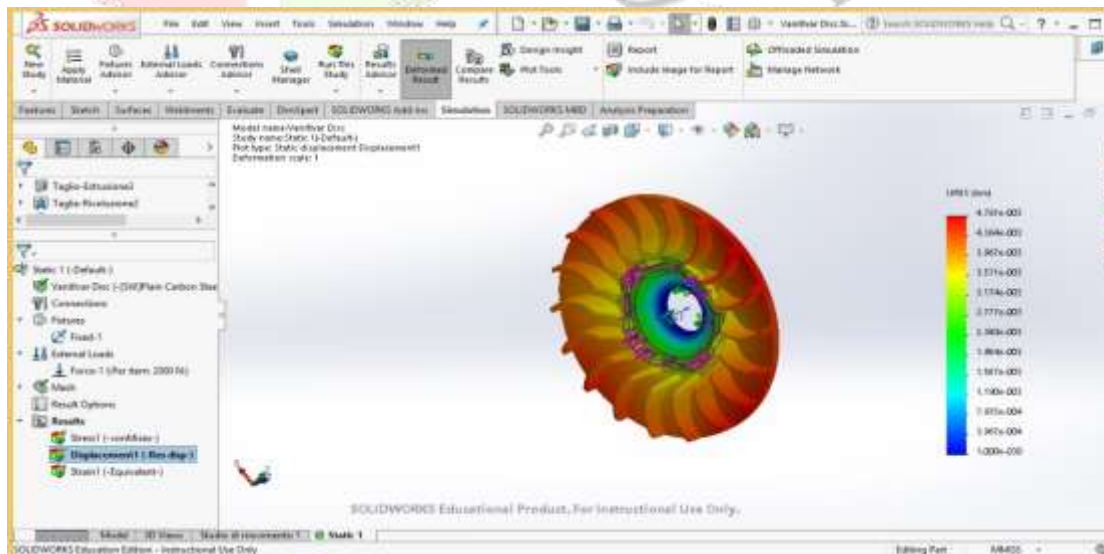**Fig.16 Von mises Stress Result for 2000N**

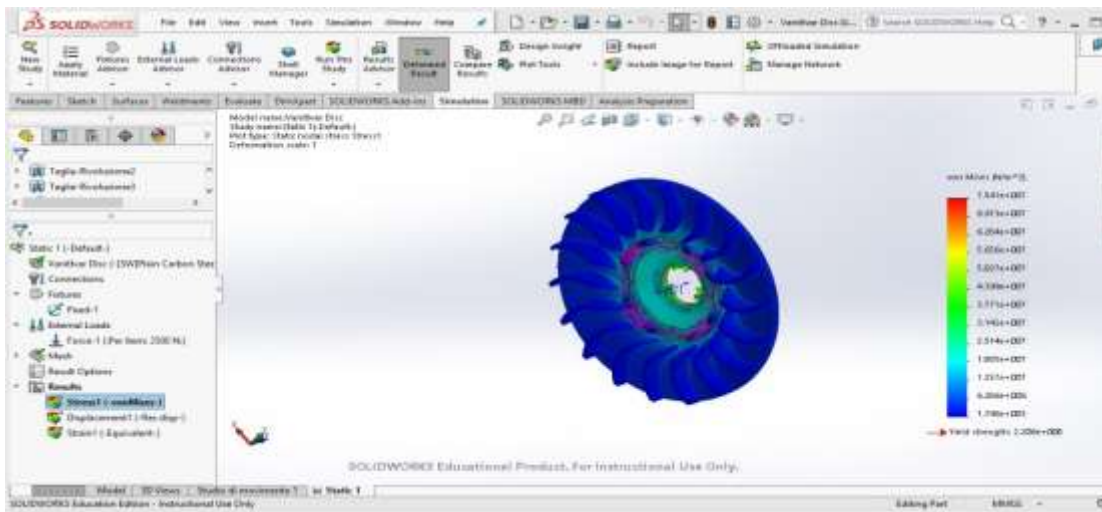**Fig. 17 Deflection Result for 2000N**

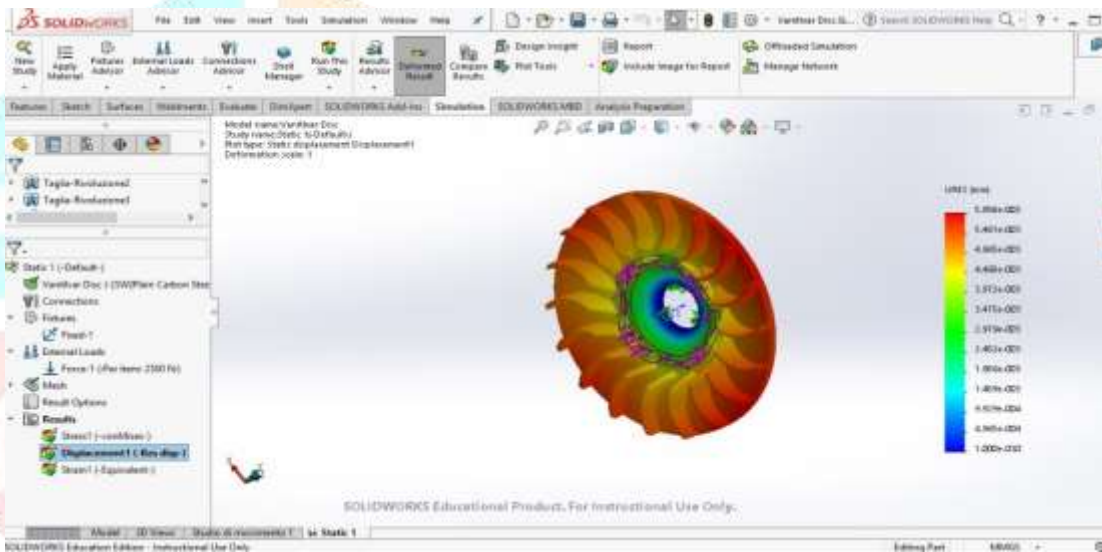**Fig.18 Von mises Stress Result for 2500N**
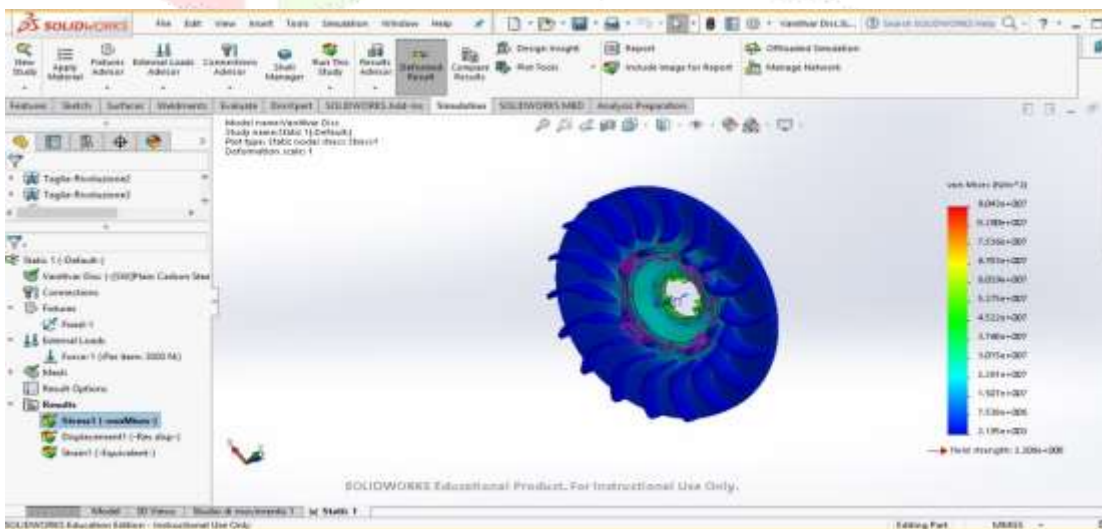

Fig.19 Deflection Result for 2500N

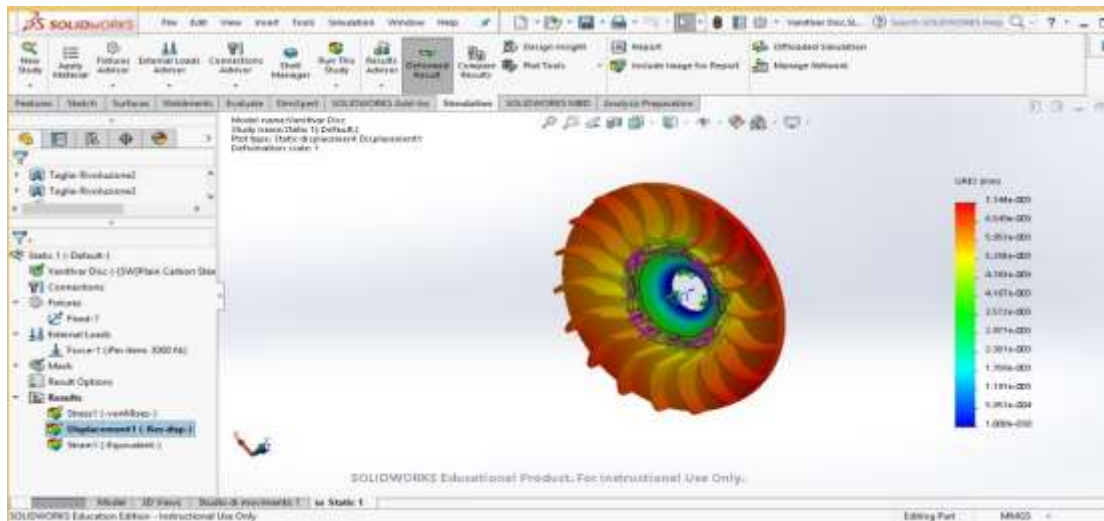**Fig.20 Von mises Stress Result for 3000N**

Fig.21 Deflection Result for 3000N

4.6 Result and Discussion for Driven Pulley Analysis

Table 1 Result and Discussion

Driven Pulley Analysis (Loading Condition)	Von mises Stress in N/m²	Deflection in mm
1000	3.015×10^7	0.02382
1500	4.520×10^7	0.03570
2000	6.027×10^7	0.04761
2500	7.541×10^7	0.05958
3000	9.043×10^7	0.07144

5. Conclusion

As shown in Table 1 reflected that when load increase from 1000N to 3000N, von mises stress should be increase from 3.015×10^7 N/m² to 9.043×10^7 N/m² which having 33% increase from initial reading to final reading of load. Deformation should be varies from 0.02382 mm to 0.07144 mm which having 49% decrease from initial reading to final reading of load.

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