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The static structural analysis of torque converter material for better performance by changing the stator angle

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ABSTRACT

Torque converter is a commonly used machine device in automobiles to transmit the rotating power from a source like I.C engine, to a rotating driven load. It is widely used in automatic transmission vehicles to change the speed from the engine to the transmission and also multiply the torque. Effective modeling of torque converters leads to increase the performance and efficiency. The inlet and outlet blade angles take part in a significant role in determining the performance and efficiency of a torque converter. In this paper the performance of torque converter has been evaluated by changing the angle of stator blades by using ANSYS software. Four torque converter with different stator blade angle (15°, 25°, 35°, 40°) are designed and simulated to investigate the effects of blade angles on their overall performance and efficiency.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science.

1. Introduction

In a vehicle a basic requirement of transmission system is the capability to put up inconsistency between the angular velocity of an engine flywheel and the driven shaft connected to the transmission differentials. To address this, various type of mechanical clutches are commonly used in manual transmission which are physically engaged and disengaged from the rest of transmission [1–3]. Now a day's automatic transmission plays a major role in automobile industries. For achieving the automatic transmission a machine device known as the torque converter is commonly used as a coupling device [4]. The main use of this torque converter is to allow the engine to rotate even when the wheels are slowing down by means of fluid coupling [5–7] (Table 1).

1.1. Components of torque converter

The main and first part of the torque converter is Impeller which is commonly known as Pump. Pump is filled with fluid and it firmly connected to the engine flywheel. The more forces are created as the fluid flows through it when the impeller rotates faster [8–10].

The pump send the pressurized fluid into assemble of blades which is called Turbine. It is situated opposite to the pump and it rotates when the fluid pushes the turbine blade [11]. As the fluid flows to turbine from one section to another it is return back to impeller. This circulation happens constantly cause fluid coupling [12–15].

A stator is an element which reverses the fluid and drives it back to the impeller, thereby slowing the fluid. The stator is another device which has series of fins positioned stuck between the two turbines on the transmission shaft. Its blades are angled so that when the transmission fluid flows into them, it reverses direction and gets channeled back to the impeller [16–18].

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Table 1
Design parameters.

S. No	Parameters	Dimensions
1.	Outer radius of stator	72.42 mm
2.	Inner radius of stator	46.94 mm
3.	Pad length	22 mm
4.	Number of blades used	16
5.	Angles of the blades	15°,25°,35°,40°
6.	Length of the blade	26 mm
7.	Pump outer Radius	114.80 mm
8.	Pump inner Radius	100.88 mm
9.	Turbine outer radius	114.97 mm
10.	Turbine inner radius	100.84 mm

For this investigation, the design of a torque converter which detains the dynamics of components and the hydraulic fluid, (Hrovat and Tobler 1 and Hadi et. al.3).

1.2. Working of torque converter

The basic working principal of torque converter is that consider a fan is connected into wall with electric power and it blowing the air into another fan which is placed in front of first one and not connected with electric power. The air from the first fan hits on the blades of the second one and it also starts rotating approximately at the same speed to the first one. When the second fan is stopped, it does not stop the first one [19–21]. The first fan keeps rotating. The same principal applied for torque converter but the different is instead of air, it uses oil or transmission fluid flows around the three components such as impeller (or the pump), turbine and stator [22].

In torque converter the impeller or pump take action as first fan which is associated with the engine output and turbine act as the second fan which is connected to Gear box input shaft. When the engine runs, it rotates the impeller and due to the centrifugal force the oil inside the torque converter assembly heading for towards the turbine [23–26]. As it hits turbine blades, the turbine starts rotating. This makes the gear box shaft rotates and the wheels of the vehicle moves. When engine stops, the turbine also stops rotating but the impeller connected the engine keeps moving and this prevent the killing of engine [27,28].

In some of the torque converters use multiple stators blade with different angle and/or multiple turbines with different angle to provide a wider range of torque multiplication. Such multiple-element converters are more common in industrial applications than in automotive transmissions [29].

1.3. Objective

- One of the important objectives of this work is to evaluate and investigate the torque converter by changing the stator angle and analyzing the pressure and outlet velocity with existing torque converter.
- The torque converters with different angle blade are designed by using CREO V2.0 and analyzing by using ANSYS software and getting the result.
- Compare the result with existing torque converter.

2. Experimental details and proceduers

First create the 3D model of torque converters with different stator blade angles use of CREO software for the parameters mentioned below.

Then analyzing the each model by use of ANSYS software and plot the result in graph, then compares the result with existing torque converter as shown in Fig. 1.

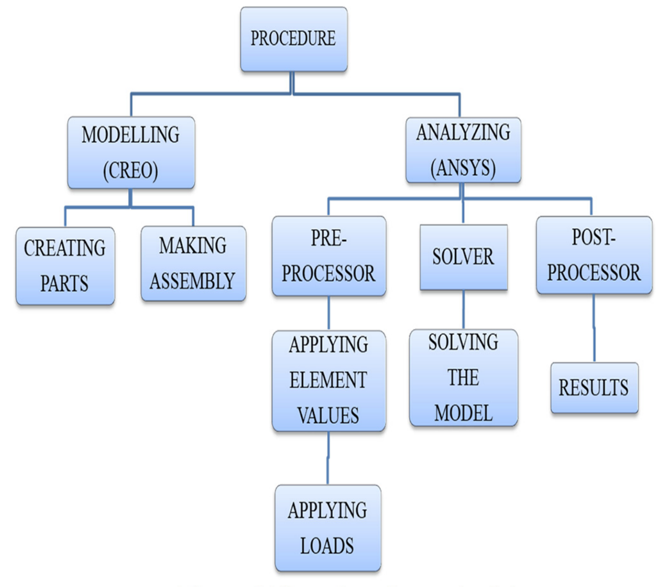

Fig. 1. Flow chart for methodology.

2.1. Modeling of torque converter

Designing of any product or device is uncomplicated by creating the model by using CAD systems because it reduce the paper work and time saving. It has the following significant reason for choosing,

- It used to reduce the time and increase in the productivity.
- To produce the quality of the mechanical design.
- To get the model with uniform design standards.
- To create the manufacturing process sequence and programming.
- To eliminate failures due to hand-copying of drawings and indiscretion between Drawings.

This system includes the exact specifications for a part production. The part drawings are commonly used to give the information of production process and the sequence of process. In this work the part drawings were created with all views in the CREO 4.0 PARAMETRIC. All the individual parts are established in the part drawing module and all the parts were assembled in the assemble module by inserting all the components in assemble module. The different view of assemble and part drawings are listed below as figures.

2.2. Modeling of torque converter with different blade angle

In the modeling of torque converter the Figs. 2, 3, 4 and 5 represents the stator with blade angle 15^{O}, 25^{O}, 35^{O}, and 40^{O} respectively.

Following to the modeling of stator, the pump and turbine created that has been shown by Figs. 6 and 7.

2.3. Torque converter assembly

After modeling the stator with different blade angles, the turbine and pump assemble with stator made by software that reveals in the Figs. 8–12.

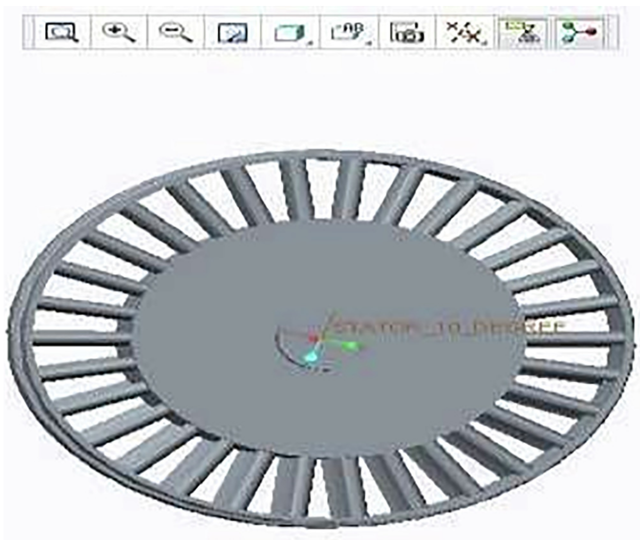

Fig. 2. Stator with blade angle 15°.

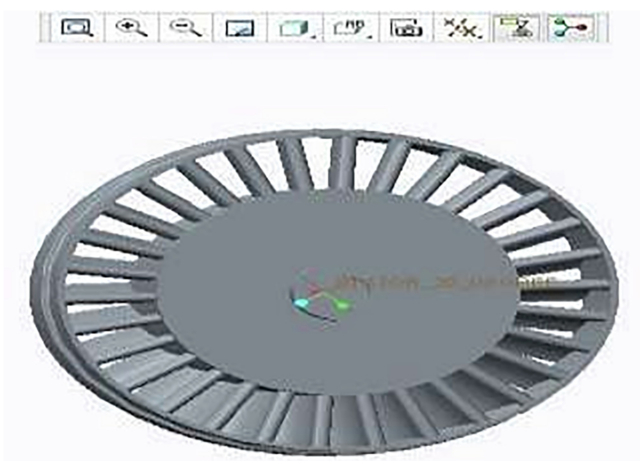

Fig. 3. Stator with blade angle 25°.

2.4. Analysis of torque converter

2.4.1. Analysis software

To study the linear, nonlinear and dynamic analysis in FEA, ANSYS Structural analysis is a significant tool. The solution for the given problem from the software deals with behavior of the element and material module for many type of mechanical design analysis. This software also incorporates with thermal analysis, dynamic analysis, thermo-electrical and thermo-structural problems.

ANSYS Workbench come up with a inclusive software suit that the whole range of physics, giving contact to practically any field of engineering model and simulation that the design process requires.

For a common engineering simulation the world wide organizations are believes that the ANSYS workbench has deliver the best value for their problem.

In this work the software used for simulation of blades is ANSYS 14.0.

2.4.2. Software overview

2.4.2.1. Ansys 14.0. ANSYS software is constructing for user friendly and make clearly as much as possible to keep the user as much as

Fig. 4. Angle of stator blade 35°.

friendly and making simple. The ANSYS software provide us to give any types of load to any types of component and to see the types of stresses and strain acting at every points of the solid component. It also shows the maximum load which a solid component can carry. By analyzing the given solid model diagram which is drawn using creo, the stresses and strain acting in that model was identified.

3. ANSYS work bench

ANSYS workbench combines the potency of the product solvers with product management tools required to manage the project workflow. In this workbench, analysis is creating as systems, which is combined into this paper. This work has driven by representational sequence of process that controls the connection between the systems. From the representational it can be interact with application that are inhabitant to ANSYS workbench and you can initiate the application that are data in targeted with ANSYS workbench, meaning the boundary remains separate.

4. Types of module

- Engineering Data (Materials)
- Geometry Module
- Model/mesh module
- Setup module
- Solution module
- Results and publish

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Fig. 5. Angle of stator blade 40°.

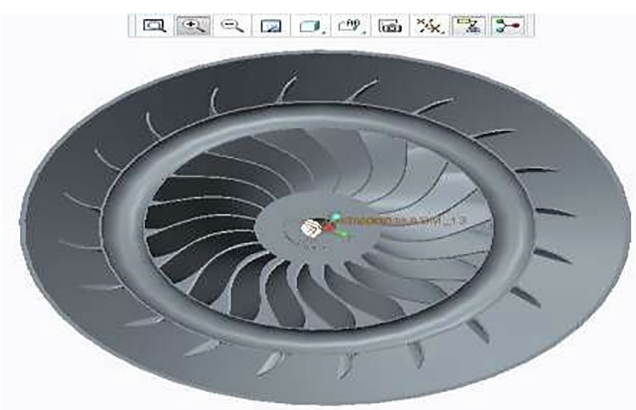

Fig. 6. Pump impeller.

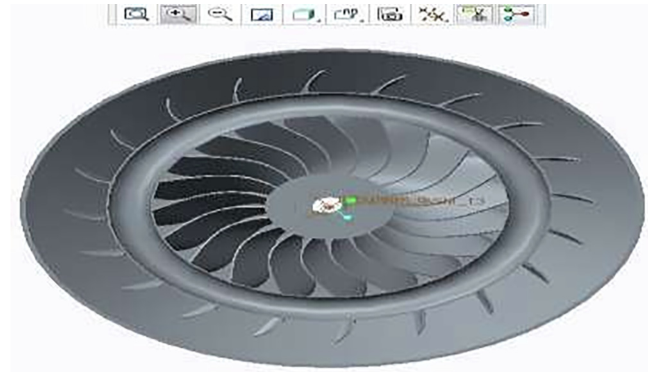

Fig. 7. Turbine.

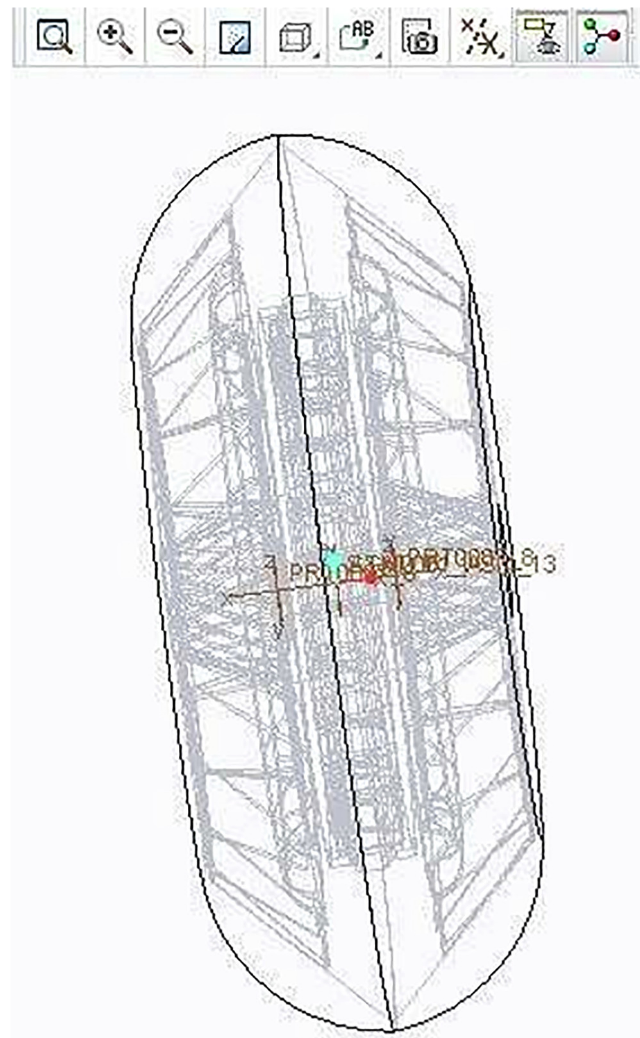

Fig. 8. Sectional view of torque converter.

5. Getting started to ANSYS

STEP 1: To initiate the ANSYS Workbench, click the icon in the start menu.

STEP 2: After the workbench is launched it will show the tool box then Go to the analysis system fluid flow (cfx) and click double click.

STEP 3: After that double click on the geometry for getting the required geometry read into the software; before start the geometry confirms that imported geometry has no Problem; next window has a title progress.

STEP 4: After the window is lively the geometry, it will get a window to specify working Units for the model dimensions choose the unit as meters and press ok. Box Size dimension lead to finer mesh which is used to give the more accurate is the Captured data.

STEP 5: Then import external geometry file by choosing the file from data base.

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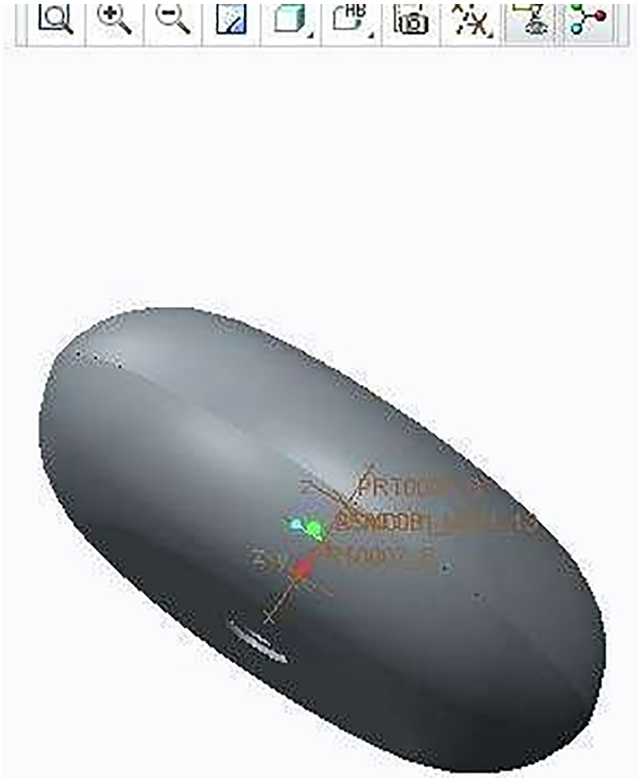

Fig. 9. Solid section.

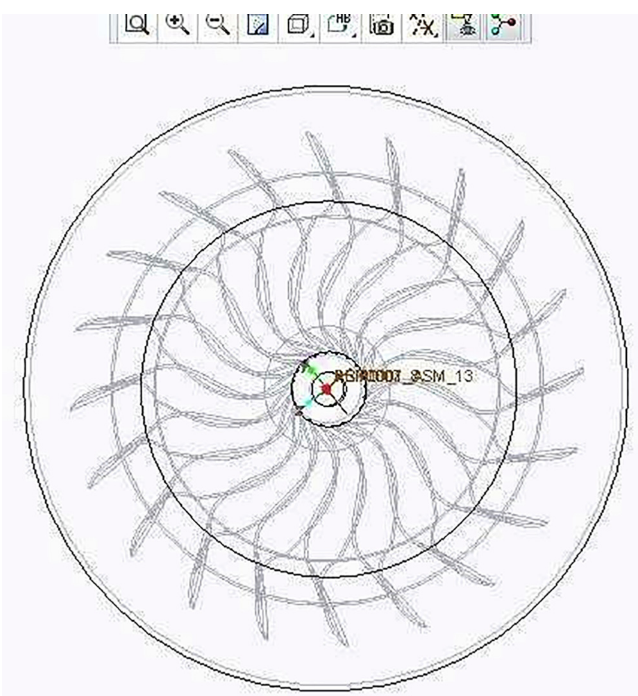

Fig. 10. Sectional front view.

STEP6: A window having a title open will be able to be seen to the user, choose file type para solid after that go to the folder that has required file.

STEP7: While seeing the design modeler window, we can't able to see the imported Geometry yet, so press the generate icon that is characterized by a Yellow thunder icon.

STEP 8: Go to view and choose wireframe.

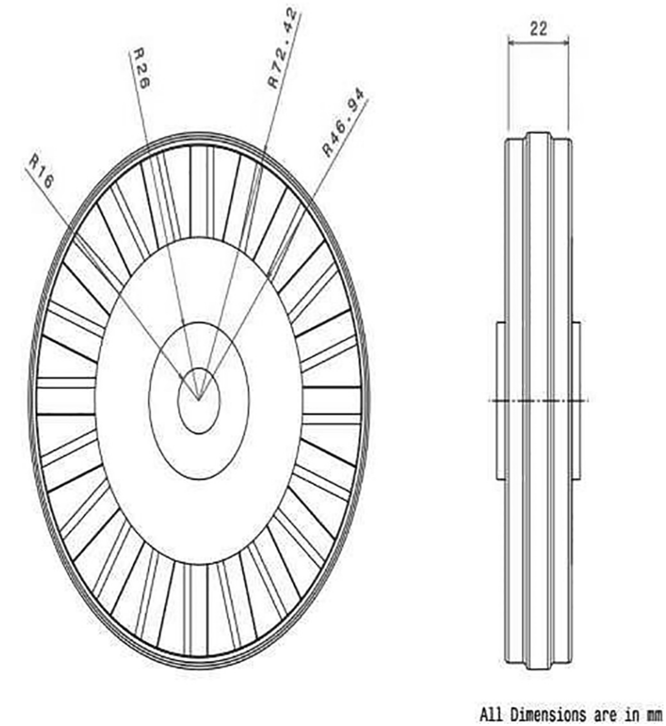

Fig. 11. Design of stator.

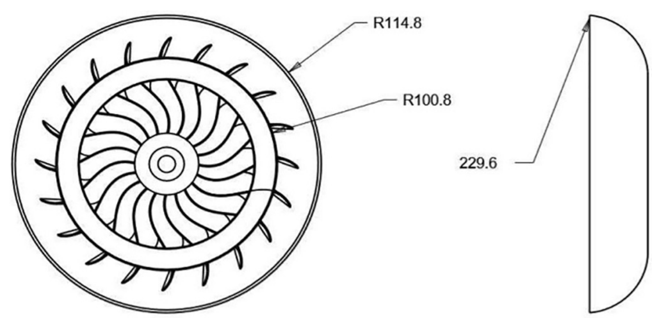

Fig. 12. Pump design.

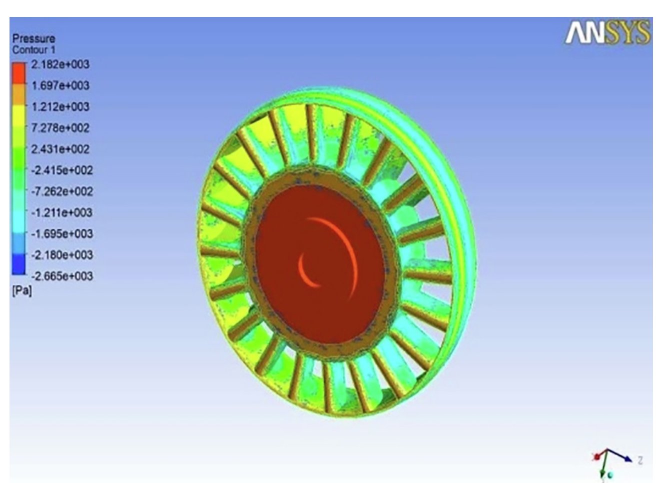

Fig. 13. Pressure on the stator blade at 15̊.

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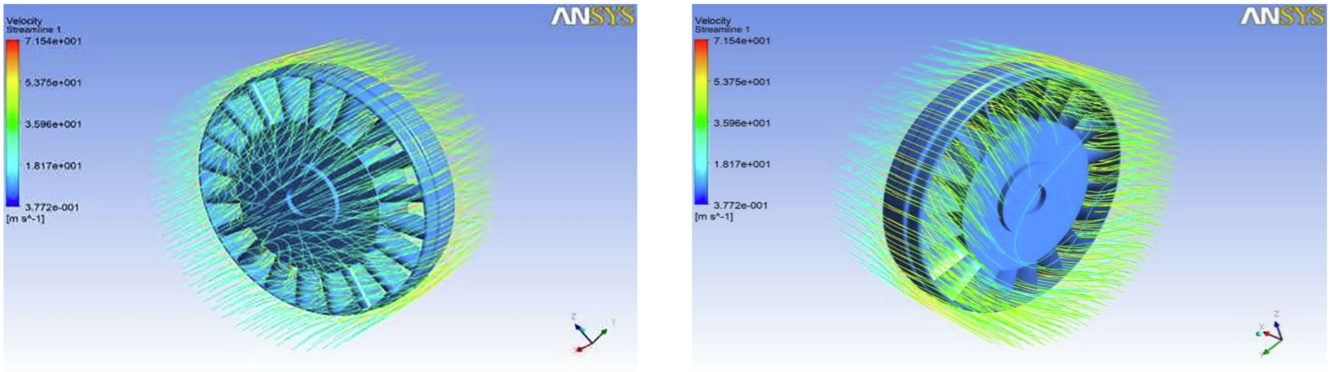

Fig. 14. Velocity streamline at blade angle 15°.

Table 2
Stator with blade angle 15° output parameter.

Max. pressure	Inlet velocity	Outlet velocity
2182 Pa	0.3772 m/s	71.54 m/s

Table 3
Stator with blade angle 25° output parameter.

Max. pressure	Inlet velocity	Outlet velocity
2270 Pa	0.05489 m/s	72.77 m/s

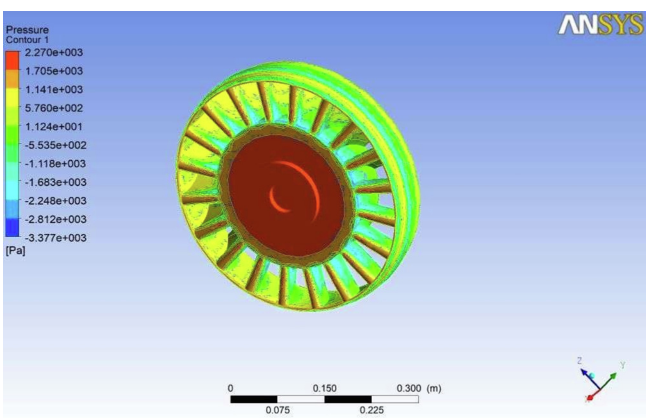

Fig. 15. Pressure on the stator blade at 25°.

STEP 9: Once we finished that stage means we have finished from Designer model and have to proceed to meshing part.

STEP 10: In the meshing part the project has started, notice at the side of Mesh they are yellow thunder icon.

STEP 11: Send to technique and prefer tetrahedrons.

STEP 12: Send to the algorithm and prefer patch independent.

STEP 13: Press the update icon and then press on the generate mesh.

STEP 14: Click on mesh, now it is visible to the user the generated mesh.

STEP 15: Go to the work bench, now there is green tick next to the mesh congratulation you can now proceed to setup.

Any types of load can to apply to the solid model and after meshing all now the stresses acting at each point are indicated by the diagram and colour variation is shown between various types of stresses.

6. Analysis of torque converter

In this paper the static structural and modal analysis has been done on the Torque converter. The boundary condition for the static structural analysis is loads are applied at the tip of the tooth and all DOF condition at the top.

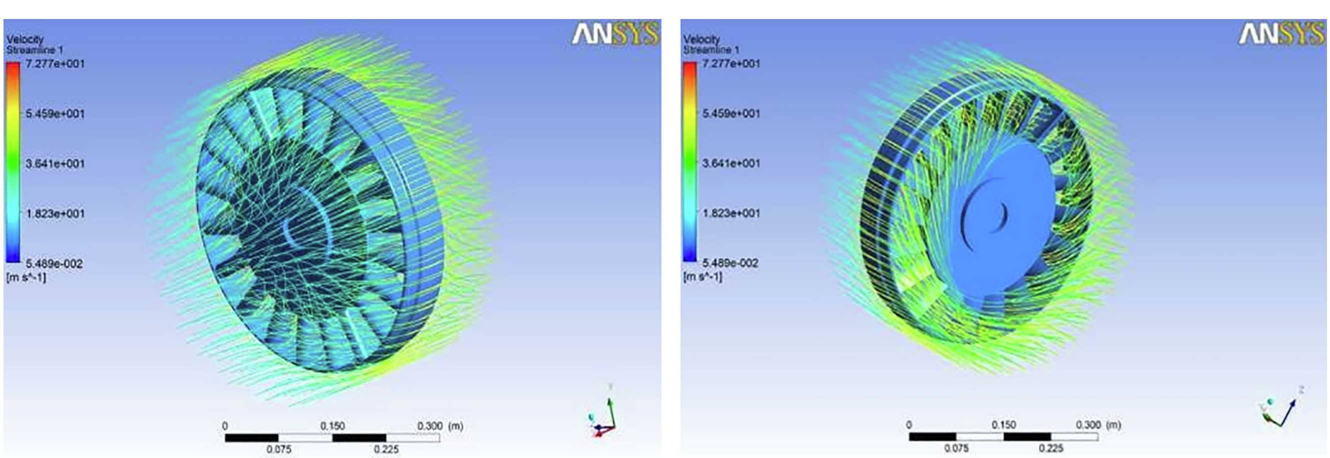

Fig. 16. Velocity streamline at blade angle 25°.

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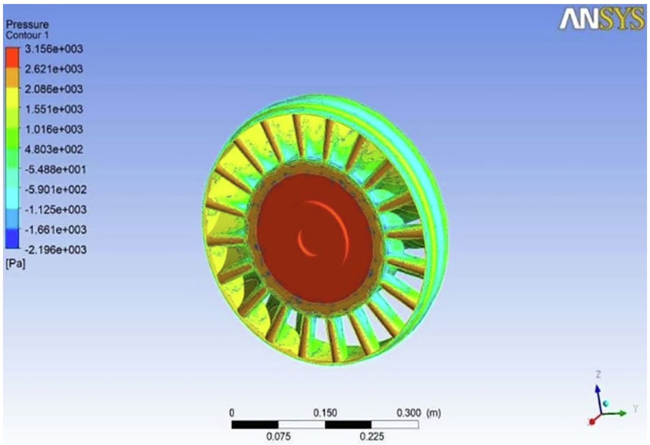

Fig. 17. Pressure on the stator blade at 35̊.

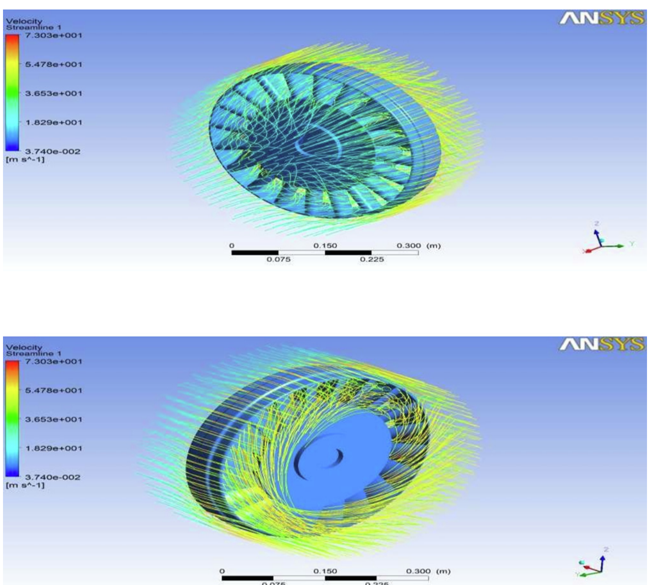

Fig. 18. Velocity streamline at blade angle 35̊.

Table 4
Stator with blade angle 35° output parameter.

Max. pressure	Inlet velocity	Outlet velocity
3156 Pa	0.0374 m/s	73.03 m/s

7. Results and discussion

7.1. Stator with blade angle 15°

The Pressure and velocity analysis of stator with blade angle 15^{O} was done by ANSYS shown in Figs. 13 and 14 respectively with the inlet boundary condition and the result has been taken and plot in the Table.2.

7.2. Stator with blade angle 25°

The Pressure and velocity analysis of stator with blade angle 25^{O} was done by ANSYS shown in Figs. 15 and 16 respectively with

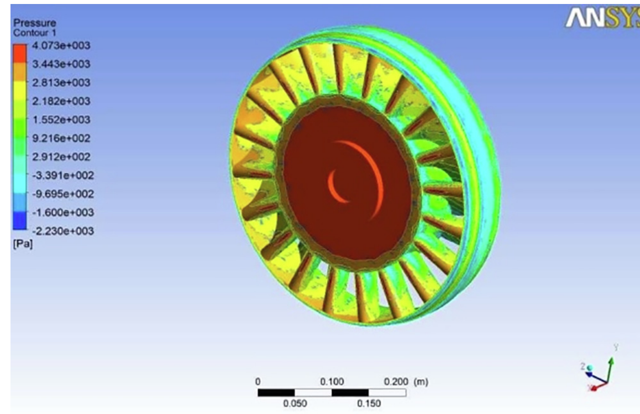

Fig. 19. Pressure on the stator blade at 40̊.

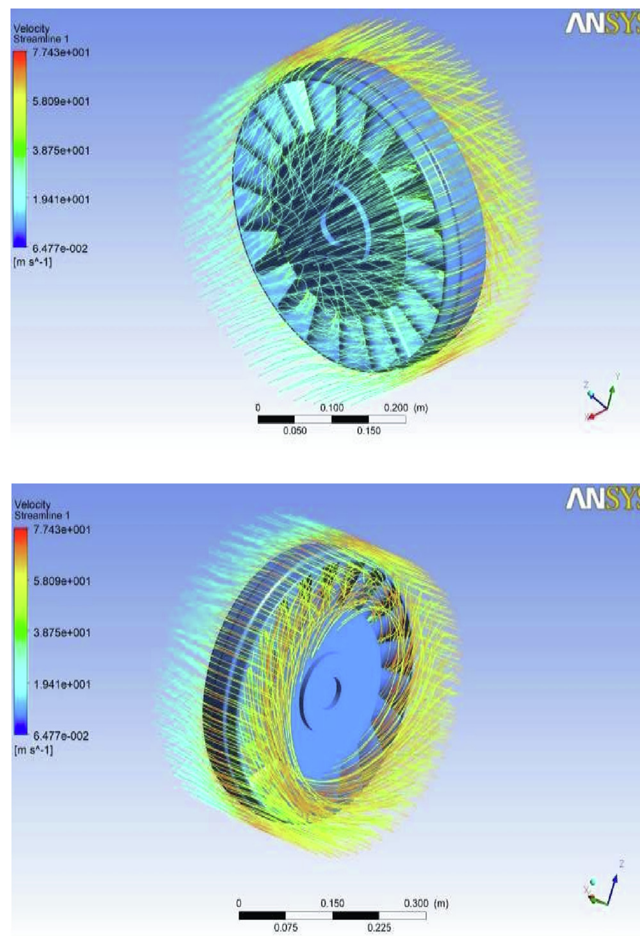

Fig. 20. Velocity streamline at blade angle 40̊.

Table 5
Stator with blade angle 40° output parameter.

Max. pressure	Inlet velocity	Outlet velocity
3156 Pa	0.0374 m/s	73.03 m/s

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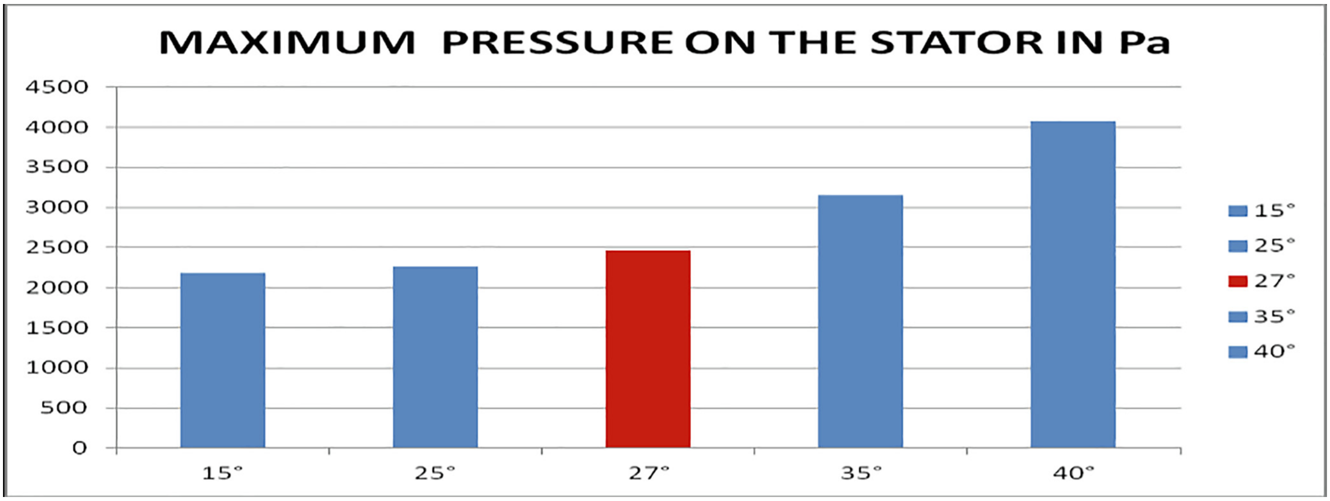

Fig. 21. Comparison of blade angles vs max. Pressure.

Table 6
Results and discussion.

Stator blade angle	Maximum pressure on the Blade	Inlet velocity	Outlet velocity
15°	2182 Pa	0.3772 m/s	71.54 m/s
25°	2270 Pa	0.05489 m/s	72.77 m/s
35°	3156 Pa	0.0374 m/s	73.03 m/s
40°	4073 Pa	0.064 m/s	77.43 m/s

the inlet boundary condition and the result has been taken and plot in the Table.3.

8. Velocity streamline

8.1. Stator with blade angle 35°

The Pressure and velocity analysis of stator with blade angle 35^{O} was done by ANSYS shown in Figs. 17 and 18 respectively with the inlet boundary condition and the result has been taken and plot in the Table.4.

9. Velocity streamline

9.1. Stator with blade angle 40°

The Pressure and velocity analysis of stator with blade angle 40^{O} was done by ANSYS shown in Figs. 19 and 20 respectively with the inlet boundary condition and the result has been taken and plot in the Table.5 (Fig. 21).

10. Velocity streamline

The analysis for the different blade angle was done and plot the output result that Maximum pressure on the plate and Outlet velocity in the Table.6.

From the above table the main parameters such as Maximum pressure, inlet velocity and outlet velocity have been noted and the comparisons of all values with different angles were plotted in the following graphs (Fig. 22).

The above results and graphs (Graph 1, 2 and 3) show that the maximum outlet velocity is obtained at 40° of stator blade angle. The standard angle for the stator blade is 27° and the outlet veloc-

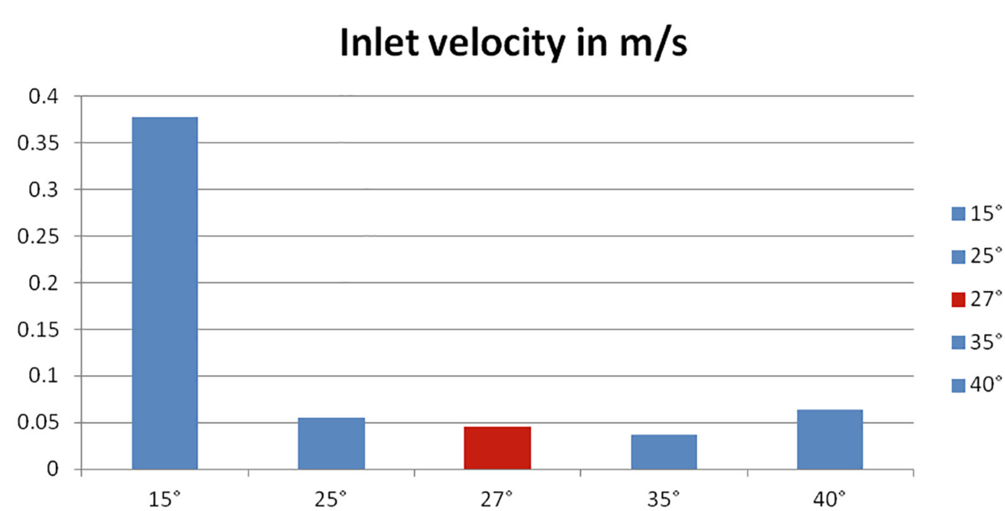

Fig. 22. Comparison of blade angles vs inlet velocity.

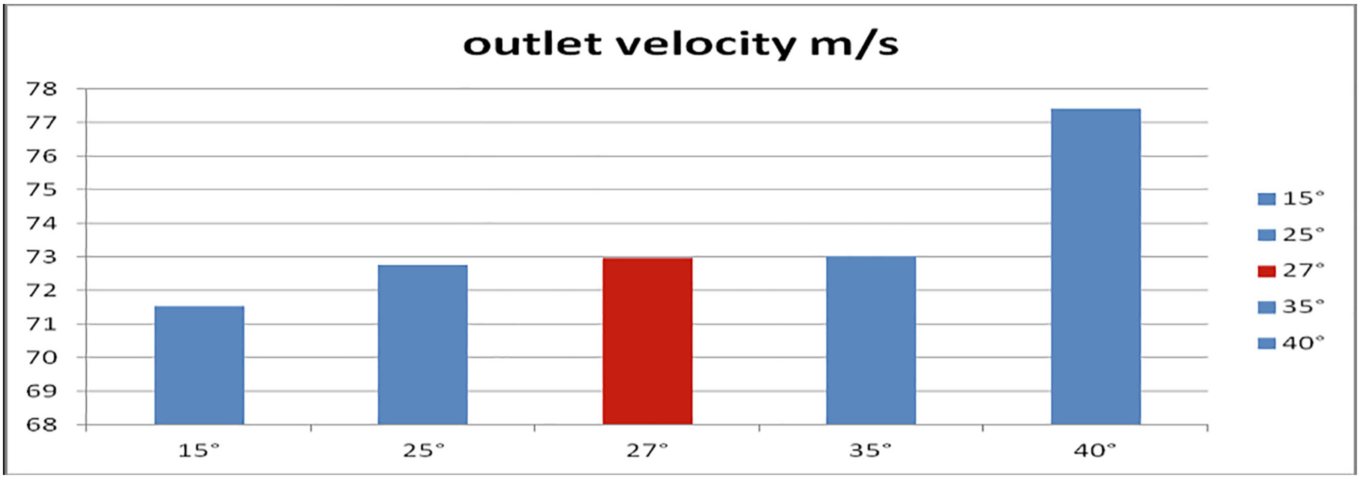

Fig. 23. Comparison of blade angles vs outlet velocity.

ity is 72.89 m/s. The outlet velocity at 35° is 73.03 m/s (i.e.,) only negligible growth in outlet velocity. At 40° stator angle the pressure experienced by the blade is 4073pa. After 40° of stator angle the pressure exerted on the blade gets too increased. Therefore 40° of stator angle is considered as effective one (Fig. 23).

11. Conclusion

This work gives the Computation fluid dynamic Analysis of the Stator in the torque converter by means of computer software ANSYS 17. According to improve the performance and efficiency of the Torque converter, an investigation was carried out and the suitable blade angle for stator has been found.

- The results obtained from above study leads to the following conclusion:
- The outlet velocity (77.43 m/s) of the fluid passing through the stator is higher when the blade angle is 40°.
- The pressure experienced by the blade is high (4073pa) when the blade angle is 40°.
- The outlet velocity of the fluid passing through the stator is 71.54 m/s when the blade angle is 15°.
- After 40° of stator angle the pressure exerted on the blade gets too increased. Therefore 40° of stator angle is considered as effective one.

From above discussion we can conclude that the suitable blade angle for the stator is 40°. The static structural analysis gives us the result that the stator experiences negligible stress and deformation. The material used for static structural analysis is Aluminum Alloy.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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