

**Investigation of Fluid Flow in a Torque Converter's  
Stator Using Computational Fluid Dynamics  
Methods.**

by

**Shoab Ahmed Talukder**

**A THESIS**

**Submitted to the  
University of Technology, Sydney.**

For the degree of  
Master of Engineering (Research)

2014

## **CERTIFICATE OF AUTHORSHIP/ORIGINALITY**

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Production Note:

Signature removed prior to publication.

-----  
**Shoab Ahmed Talukder**

**23/07/2014**

## ABSTRACT

An automotive torque converter is a widely used hydro-mechanical device for transferring engine power to the transmission in the modern automotive industries. The typical three-dimensional geometrical structures of the stator, pump and turbine made this torque converter very complex. The goal of this study is to gain a sound understanding of the complex three-dimensional fluid flow inside the stator. This study was performed using Computational Fluid Dynamics software. For the sake of gaining a sound understanding, all three elements of the torque converter were included in the simulation. The geometry for the torque converter used was a donation from Dr Mahesh Athavale (Manager, CFDRC). However, the construction of the geometry was thoroughly studied to gain a comprehensive understanding of the construction as well as making the necessary changes. The performance of the torque converter was compared with existing data. This was undertaken for the validation of the work. Then the fluid flow was studied for a changed stator blade number. Thus the variation of performance can easily be noticed with the change in the geometrical structure. The effect of pseudo plastic fluid and dilatant fluid was also studied in order to determine the performance characteristics. All these investigations would lead to a clearer realization of the fluid flow inside the stator and thus help to increase the performance of the torque converter. Out of this research studies on torque converter two publications have been produced.

1. IMECE2011-65078: Effects of Number of Stator Blades on the Performance of a Torque Converter, which was published by the ASME conference 2011, held on November 11-17, 2011, Denver, Colorado, USA.

2. 18<sup>th</sup> AFMC-2012: Numerical Study of Performance of a Torque Converter Employing a Power-Law Fluid, which was published by the AFMC on its 18<sup>th</sup> conference, held on December 3-7, 2012, Launceston, Tasmania, Australia.

## **ACKNOWLEDGMENTS**

I would like to thank a number of people whose effort and support allowed me to reach this stage in my career. My supervisor, Dr Phuoc Huynh, and co-supervisor, Dr Peter Watterson, gave me continuous support and helped in every possible manner. Without their proper guidance, advice, assistance, encouragement and ideas this thesis wouldn't have been completed. I shall be ever thankful to Dr Mahesh Athavale (Manager, CFDRC), who's donation helped considerably to overcome the difficulties that we were facing. I also would like to take the opportunity to thank all the CFDRC customer support crews, who helped us with tips and professional advice and led us to this completion.

I would like to thank my wife Tahmina, son Zarif, my parents and my younger brother Dr. Jonayed and sister Annie for their tremendous amount of mental support over the years and that they continue to give to this day. I would like to take the opportunity to thank Matt Gaston and Peter Brady for their help and support. I also would like to thank the Director of Research Programs and all research administration Officers, for their patient support throughout my candidature.

And I also would like to thank my friends for all that they have done for me. Above all I would like to mention my gratefulness to almighty for his kindness and blessings.

## TABLE OF CONTENTS

A THESIS .....	i
ABSTRACT .....	ii
ACKNOWLEDGMENTS .....	iii
CHAPTER 1: INTRODUCTION .....	1
1.1 Engineering significance .....	2
1.2 Problem Statement .....	3
1.3 Torque Converter Description, Principles and Function.....	4
1.4 History and Review of Previous Torque Converter Studies .....	7
1.5 Computational Research .....	10
CHAPTER 2: CFD FACILITIES .....	12
2.1 Computational Fluid Dynamics .....	12
2.2 Specifications of the torque converter.....	13
2.3 Construction of the geometry.....	14
CHAPTER 3: SIMULATION PROCEDURE.....	19
3.1. Configuring the program for simulation .....	19
3.1.1. Problem Type (PT).....	20
3.1.2. Model Option (MO).....	20
3.1.3. Volume Condition (VC).....	21
3.1.4. Boundary Condition (BC).....	22
3.1.5. Additional Input for Mixing-plane.....	23
3.1.6. Initial Condition (IC) .....	23
3.1.7. Solver Control (SC).....	24
3.1.8. Output (out).....	25
3.1.9. Run (Run).....	25
CHAPTER 4: FLUID FLOW INVESTIGATION. ....	28
4.1 Angle measurement:.....	28
4.1.1 Validation and verification.....	29
4.2 Effect of a different number of stator blades on the Torque Converter's performance.....	43
4.2.1 Geometric construction procedure for changing the stator blade number.....	43
4.2.2 Performance comparison with the change of numbers of stator blades. .....	46
4.3 Performance Investigation of a Torque Converter Using Non-Newtonian Fluids.....	57
CHAPTER 5: CONCLUSIONS .....	67
Summary and Conclusions.....	67
CHAPTER 6: RECOMMENDATIONS FOR FUTURE WORK .....	70
BIBLIOGRAPHY .....	71
My publications.....	79

## LIST OF FIGURES

Figure 1: Cross-sectional view of a typical torque converter (Lui, Y. PhD thesis, 2001). .....	3
Figure 2: Torque converter fluid flow path (Liu, Y. PhD thesis, 2001). .....	5
Figure 3 : Dimensions of the Torque converter (in millimetres) (TKN=Thickness of the blade).....	17
Figure 4: The frame of the stator blade in the Geom. ....	19
Figure 5: Stator blade after grid generation and surface shading.....	20
Figure 6: Stator blade (primary position of the construction of the channel with grid). .....	20
Figure 7: Stator channel after revolution and deletion. ....	21
Figure 8: Complete stator channel with grid generation.....	22
Figure 9: IJK co-ordinates reorientation. ....	23
Figure 10: CFD—ACE (U) working window. ....	24
Figure 11: Sample of a Residual plotter.....	32
Figure 12: Angle Measurement.....	34
Figure 13: Inlet, Mid-chord and Exit plane of a stator.....	37
Figure 14: Torque ratio and efficiency curve for 2350 rpm at different speed ratios.....	38
Figure 15: Capacity factor curve for 2350 rpm at different speed ratios. ....	39
Figure 16: Efficiency and torque ratio vs. speed ratio curve plotted from simulations at 313K. ....	40
Figure 17: "Numerical Investigation of the Pump Flow in an Automotive Torque Converter" (SAE Tech paper series 1999-01-1056). ....	41
Figure 18: Fluid flow at the stator pressure side near the stator blade for 2350 rpm at 0.065 SR. ....	43
Figure 19: Fluid flow at the stator suction side near the stator blade for 2350 rpm at 0.065 SR.....	44
Figure 20 : Fluid flow at the stator mid-plane for 2350 rpm at 0.065 SR.....	45
Figure 21 : Fluid flow at the stator outlet for 2350 rpm at 0.065 SR.....	45
Figure 22: Efficiency comparison for different temperatures.....	46
Figure 23: Fluid flow in the stator inlet at 313K.....	47
Figure 24: Fluid flow in the stator outlet at 313K.....	47
Figure 25: Fluid flow in the stator inlet at 373K.....	48
Figure 26: Fluid flow in the stator outlet at 373K.....	48
Figure 27 : Stator blade without face and block. ....	52
Figure 28 : Stator channel with shaded stator blade and face formed in one side of the channel. ....	53
Figure 29 : 13—blade stator channel with one side extension.....	54
Figure 30 : 13—blade stator channel with the indication of increased dimension. ....	54
Figure 31 : Stator with 13 blades. ....	55
Figure 32: Efficiency comparison between the torque converters with 13, 18, 19 and 16 stator blades.....	56

Figure 34 : Axial flow at the 19—blade stator inlet at 0.2 speed ratio with 1000 rpm pump speed. ....	48
Figure 35 : Axial flow at the mid—plane of the 19—blade stator at 0.2 speed ratio with 1000 rpm pump speed. ....	49
Figure 36 : Axial flow at the outlet of the 19—blade stator at 0.2 speed ratio with 1000 rpm pump speed. ....	49
Figure 37 : Axial flow plotted with pressure contour at the pressure side of the 19—blade stator for 1000 rpm pump speed at 0.2 speed ratio. ....	50
Figure 38 : Axial flow plotted with pressure contour at the suction side of the 19—blade stator for 1000 rpm pump speed at 0.2 speed ratio. ....	50
Figure 39 : Axial flow at the 13—blade stator inlet at 0.2 speed ratio with 1000 rpm pump speed. ....	51
Figure 40 : Axial flow at the mid—plane of the 13—blade stator at 0.2 speed ratio with 1000 rpm pump speed. ....	51
Figure 41 : Axial flow at the outlet of the 13—blade stator at 0.2 speed ratio with 1000 rpm pump speed. ....	52
Figure 42 : Axial flow plotted with pressure contour at the pressure side of the blade, of the 13—blade stator for 1000 rpm pump speed at 0.2 speed ratio. ....	52
Figure 43 : Axial flow plotted with pressure contour at the suction side of the blade, of the 13—blade stator for 1000 rpm pump speed at 0.2 speed ratio. ....	53
Figure 44: Pressure contour with axial flow, very close to the suction side of the 18—blade stator wall for 1000 rpm pump speed at 0.2 speed ratio. ....	53
Figure 45 : Pressure contour with axial flow, very close to the pressure side of the 18—blade stator wall for 1000 rpm pump speed at 0.2 speed ratio. ....	54
Figure 46: Turbine efficiency vs. power law index graph at 313K temperature. ....	59
Figure 47: Turbine torque ratio vs. power law index graph at 313K temperature. ....	59
Figure 48: Turbine efficiency & torque ratio vs. power law index graph at 373K temperature. ....	60
Figure 49: Efficiency curve comparison for temperature 313K and 373K. ....	60
Figure 50: Fluid flow in the pressure side at the inlet plane of the stator at 313K. ....	61
Figure 51: Flow in the suction side at the inlet plane of the stator at 313K. ....	62
Figure 52: Velocity vectors with pressure contour in the pressure side and suction side at the inlet plane of the stator at 313K. ....	63
Figure 53: Fluid flow in the pressure side and suction side at the outlet plane of the stator at 313K. ....	64
Figure 54: Fluid flow at the inlet of the stator for temperature 373K. ....	65
Figure 55: Fluid flow at the stator outlet for temperature 373K. ....	65

## LIST OF TABLES

1. Specification of Torque Converter. .... Page 18
2. Specifications for the simulating Torque Converter..... Page 36
3. Specifications of the TC used in SAE paper series 1999-01-1056, by Shin, Chang and Mahesh. ....Page 36
4. The comparison table for torque ratio between the study simulation result and Shin, Chang, Athavale (1999) result (for the impeller speed of 2350rpm) at different speed ratio. .... Page 38
5. The comparison table for efficiency between the study simulation result and Shin, Chang, Athavale (1999) result (for the impeller speed of 2350rpm) at different speed ratio. .... Page 39
6. Presentation of Speed Ratio and Torque Ratio in a table form from Figure 17;(SAE-1999-01-1056). ....Page 41
7. Presentation of Speed Ratio and Torque Ratio in a table form for the impeller speed of 2000, achieved from our simulation. .... Page 42
8. Presentation of the difference between the study simulation data and data extracted from the graph (Figure 17). .... Page 42