# Flow Analysis over a Ceiling Fan Blade

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*Abstract*— **Current work intends on Parametric study of Ceiling Fan blades by generating 3-D fan assemblies and conducting flow analysis. Flow Analysis is performed to evaluate the variations in Air Delivery Rate, Operational Torque and Power required, Energy Efficiency with changes in Blade shape, Root Angle at different rotational speeds. A fan is a complex assembly of parts joined through fasteners and requires high end modelling software. The solid model of the assembly is developed in SOLIDWORKS V-2015. Flow Analysis is carried on Fan assemblies using SOLIDWORKS Flow simulation. A comparison analysis is done on these models and graphs for the Velocity and Torque were plotted and analysed.**

*Keywords*— **Flow Analysis, Air Delivery Rate, Torque, Power, Energy Efficiency, SOLIDWORKS.**

## I. INTRODUCTION

With increasing population and luxurious trends, the consumption rate of resources has been drastically increasing. This results in rising demand for these resources which primarily include Food, clothing etc., which are again affected both directly and indirectly by Electricity. So, it can be clearly understood that the driving force for development of a nation is its power generating capacity. At present, the available sources for energy production are

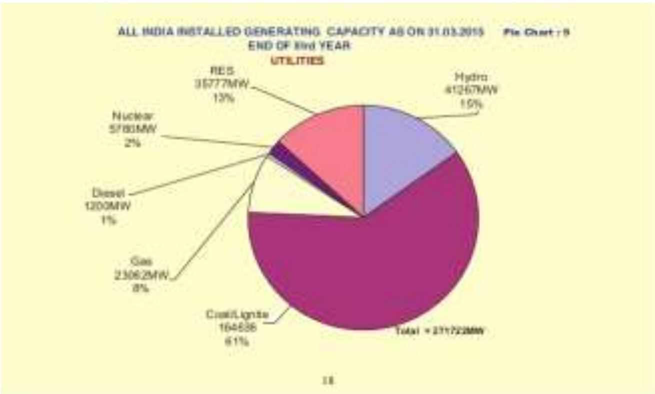


**Fig.1 Power Generation sources**

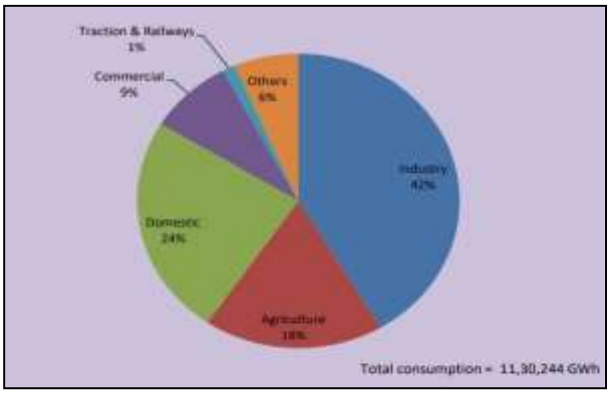


**Fig.2 Sector-wise Power Consumption**

After production, the developed power is utilised by every sector of the nation for operating various devices. Due to this, every country strives for attaining a state of Independency in terms of power generation. From the above pie diagram, it can be clearly seen that most of the power is obtained from coal plants which are the unavoidable polluting industries run for almost all the day to meet the ever-rising electricity demand. Reducing the electricity demand can decrease the operational time for these industries which can decrease the rising pollutants level. This reduction in electricity demand can be achieved by decreasing the excess energy losses incurred due to the usage of old and obselete machinery. In this situation, research is being carried for developing energy efficient designs for replacing the existing machinery. And this research can be performed starting from the devices which are mass produced and used widely such as home appliances like air circulation equipment, lighting devices etc., One such device which contributes for maximum consumption of electricity is the Ceiling fan, which is found almost in every house and used throughout the day. The present work aims to study the variation of Air Delivery Rate and Torque requirement of fan with change in blade material and other design parameters.

## II. MODELLING

As a part of Analysis, the required blade models are made using SOLIDWORKS V-2105 software. To model a Fan assembly, each part is modelled separately and assembled altogether. The dimensional data required for generating the models is given below:

Table.1 Dimensional Specifications

| | AOA at Tip deg. | AOA at Root deg. | Root Width mm. | Tip Width mm. | Length of Blade mm. | Swept Length mm. |
|---|---|---|---|---|---|---|
| Forward swept | 8 | 8,12 | 133.54 | 116.55 | 443.35 | 50 |
| Backward swept | 8 | 8,12 | 133.54 | 116.55 | 443.35 | 50 |
| Straight | 8 | 8,12 | 133.54 | 116.55 | 443.35 | 0 |

The following fan assemblies are made:

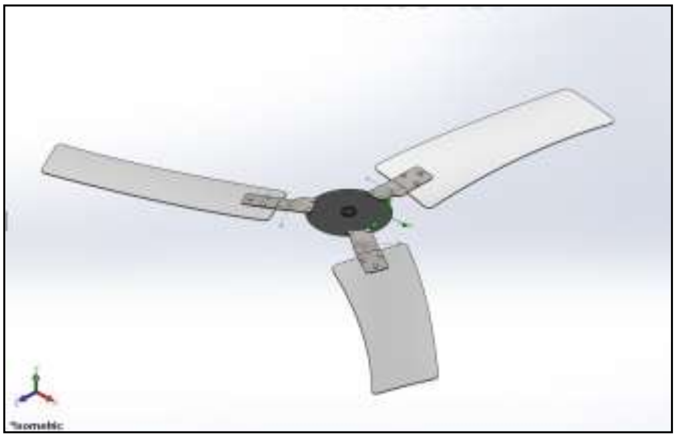

**Fig.3 Backward, Twisted Fan**

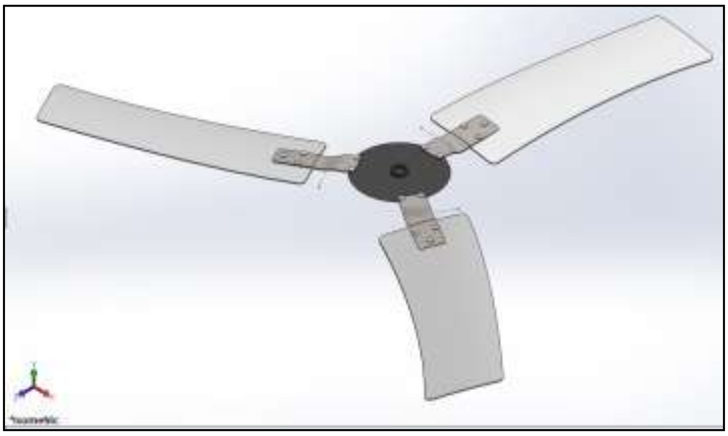

**Fig.4 Backward, Untwisted Fan**

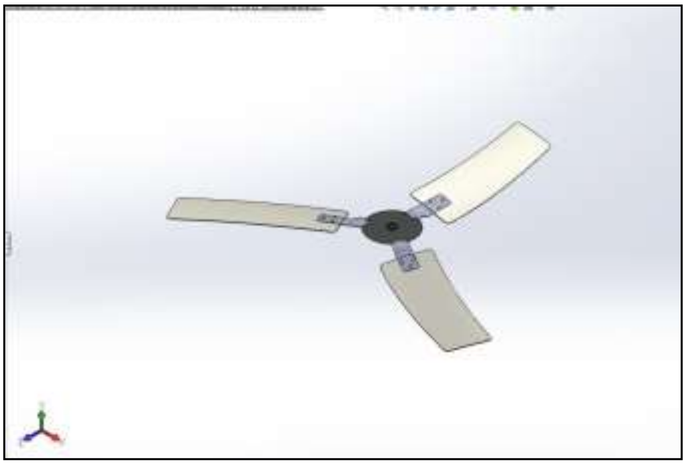

**Fig.5 Forward, Twisted Fan**

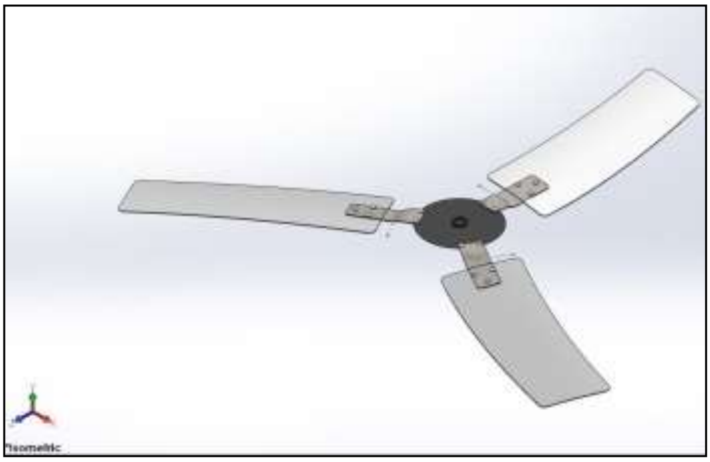

**Fig.6 Forward, Untwisted Fan**

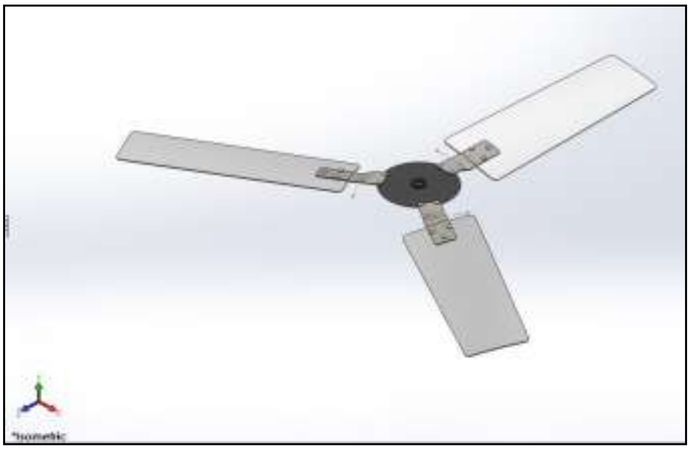

**Fig.7 Straight, Untwisted Fan**

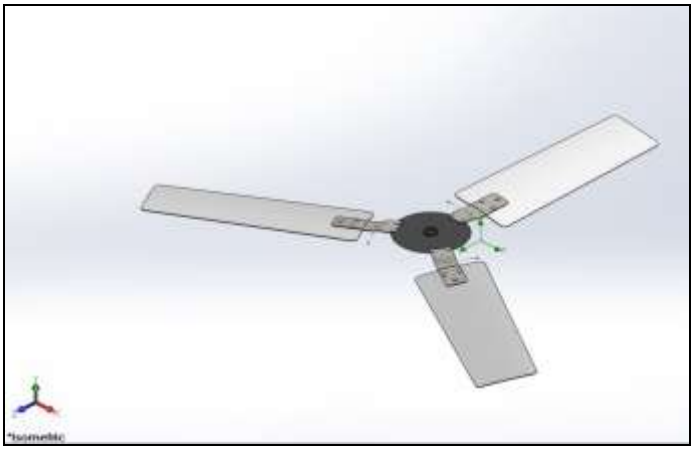

**Fig.8 Straight, Twisted Fan**

## III. RESULTS OF FLOW ANALYSIS

This analysis gives the ability to simulate the flow of specified fluid over the specimen under controlled conditions and estimates the variation in flow parameters. Here, The Flow analysis is performed within the SolidWorks software. The materials used for different components in the assembly are:

Table.2 Component Material Properties

| **Material** | **Density(r) kg/m³** | **Youngs Modulus(E)N/m²** | **Poisson Ratio(m)** |
|---|---|---|---|
| Plain Carbon Steel | 7800 | 21000 | 0.28 |
| Aluminium | 2700 | 70000 | 0.33 |
| Carbon Steel Sheet | 7858 | 205000 | 0.29 |
| Grey Cast Iron | 7200 | 66178.1 | 0.27 |

From the flow analysis, the following values are obtained at different rotational speeds of fan assemblies and the required graphs have also been drawn.

Table.3 Data At 400 RPM

| | (V)Abs. Velocity, m/s | ($V_f$)Flow Velocity, m/s | (T)Torque, N-m | (Q)Discharge, m³/min | (P)Power, W | (h)Energy Efficiency, m²/N-min |
|---|---|---|---|---|---|---|
| Backward, Twist | 20.48 | 3.06 | 2.54 | 576.79 | 106.39 | 227.08 |
| Backward, Untwist | 11.92 | 1.901 | 2.093 | 358.33 | 87.67 | 171.20 |
| Forward, Twist | 20.92 | 2.154 | 1.985 | 406.01 | 83.14 | 204.53 |
| Forward, Untwist | 16.99 | 2.021 | 1.69 | 380.94 | 70.79 | 225.40 |
| Straight, Twist | 17.09 | 2.73 | 3.012 | 514.54 | 126.16 | 170.84 |
| Straight, Untwist | 13.41 | 3.21 | 3.37 | 605.07 | 141.16 | 179.54 |

Table.4 Data At 350 RPM

| | (V)Abs. Velocity, m/s | ($V_f$)Flow Velocity, m/s | (T)Torque, N-m | (Q)Discharge, $m^3$/min | (P)Power, W | (h)Energy Efficiency, $m^2$/N-min |
|---|---|---|---|---|---|---|
| Backward, Twist | 14.375 | 2.31 | 1.619 | 435.42 | 59.33 | 268.9 |
| Backward, Untwist | 10.427 | 1.701 | 1.646 | 320 | 60.32 | 188.23 |
| Forward, Twist | 17.02 | 1.804 | 1.701 | 340.04 | 62.30 | 200.02 |
| Forward, Untwist | 16.5 | 1.5 | 1.303 | 282.74 | 47.75 | 216.99 |
| Straight, Twist | 15.172 | 2.528 | 2.457 | 476.516 | 90.05 | 188.49 |
| Straight, Untwist | 12.276 | 3.062 | 3.155 | 577.17 | 115.363 | 182.93 |

Table.5 Data At 300 RPM

| | (V)Abs. Velocity, m/s | ($V_f$)Flow Velocity, m/s | (T)Torque, N-m | (Q)Discharge, $m^3$/min | (P)Power, W | (h)Energy Efficiency, $m^2$/N-min |
|---|---|---|---|---|---|---|
| Backward, Twist | 12.469 | 1.471 | 1.336 | 277.08 | 41.97 | 207.39 |
| Backward, Untwist | 8.93 | 1.403 | 0.996 | 263 | 31.29 | 187.45 |
| Forward, Twist | 13.95 | 1.431 | 1.292 | 269.737 | 44.45 | 209.77 |
| Forward, Untwist | 13.86 | 1.154 | 0.751 | 217.52 | 23.59 | 289.64 |
| Straight, Twist | 12.879 | 2.656 | 2.013 | 481.794 | 73.78 | 239.34 |
| Straight, Untwist | 9.086 | 2.958 | 2.766 | 557.56 | 86.84 | 201.57 |

Table.6 Data At 250 RPM

| | (V)Abs. Velocity, m/s | ($V_f$)Flow Velocity, m/s | (T)Torque, N-m | (Q)Discharge, $m^3$/min | (P)Power, W | (h)Energy Efficiency, $m^2$/N-min |
|---|---|---|---|---|---|---|
| Backward, Twist | 11.351 | 1.798 | 0.832 | 337.40 | 21.78 | 405.5 |
| Backward, Untwist | 7.430 | 1.20 | 0.736 | 226 | 19.26 | 188.25 |
| Forward, Twist | 10.883 | 0.974 | 0.984 | 183.59 | 25.76 | 186.57 |
| Forward, Untwist | 11.75 | 0.660 | 0.503 | 124.50 | 15.802 | 247.51 |
| Straight, Twist | 13.335 | 2.101 | 1.903 | 396.02 | 69.82 | 208.107 |
| Straight, Untwist | 10.535 | 2.697 | 1.784 | 508.37 | 46.705 | 284.96 |

Table.7 Data At 200 RPM

| | (V)Abs. Velocity, m/s | ($V_f$)Flow Velocity, m/s | (T)Torque, N-m | (Q)Discharge, $m^3$/min | (P)Power, W | (h)Energy Efficiency, $m^2$/N-min |
|---|---|---|---|---|---|---|
| Backward, Twist | 9.206 | 1.680 | 0.658 | 316.67 | 13.78 | 481.26 |
| Backward, Untwist | 5.95 | 0.933 | 0.481 | 175.866 | 10.07 | 365.62 |
| Forward, Twist | 8.12 | 0.63 | 0.783 | 118.75 | 16.39 | 151.66 |
| Forward, Untwist | 9.617 | 0.492 | 0.390 | 92.73 | 8.166 | 237.76 |
| Straight, Twist | 11.74 | 1.98 | 1.62 | 373.22 | 33.92 | 230.38 |
| Straight, Untwist | 9.87 | 1.74 | 1.59 | 327.98 | 33.29 | 206.27 |

Graphical Representation of Results:

1)Velocity v/s Speed graphs:

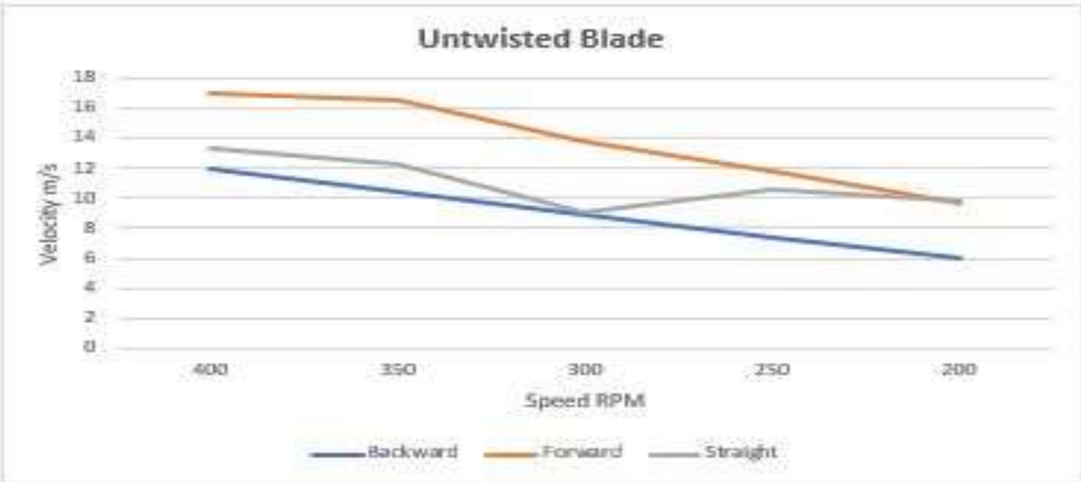


Fig.9 Velocity graph of Untwisted Blades

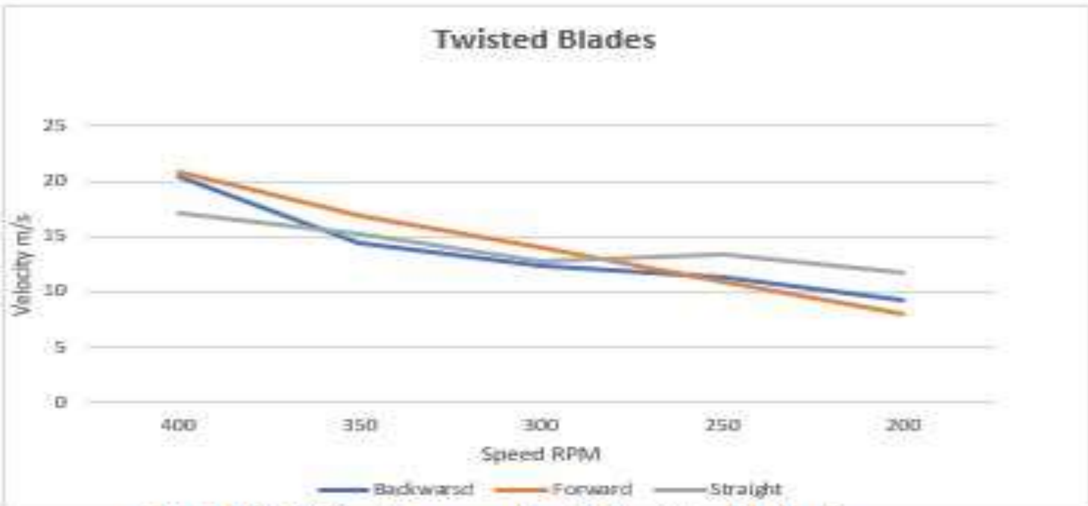


Fig.10 Velocity graph of Twisted Blades

2) Torque v/s Speed graphs:

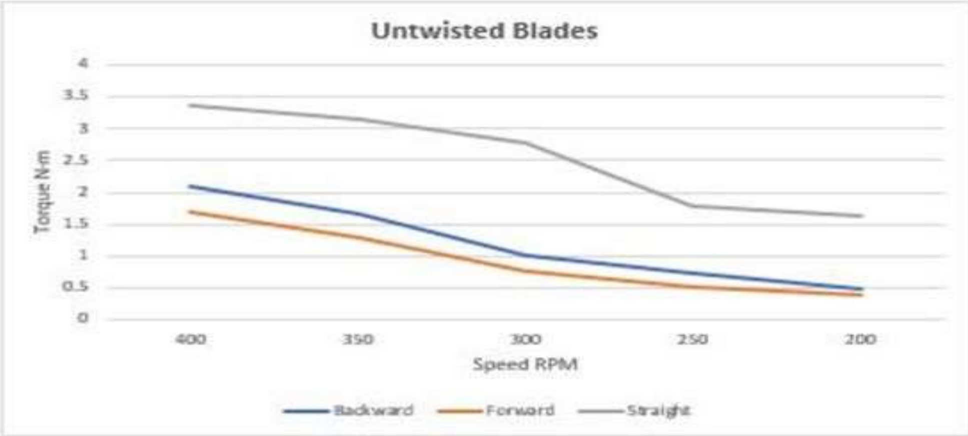


Fig.11 Torque graph of Untwisted Blades

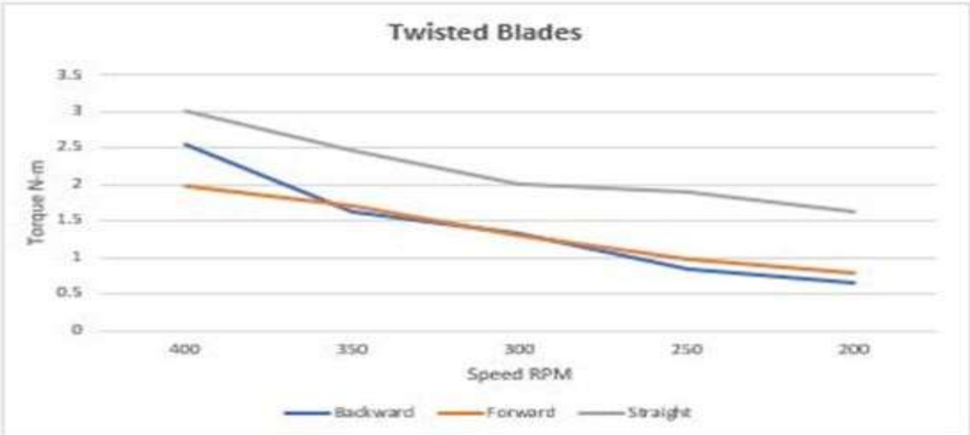


Fig.12 Torque graph of Twisted Blades

## IV. CONCLUSIONS

In this work, Flow analysis is conducted on different blade profiles and comparison is done between the results obtained, in the previous chapter and the following conclusions are obtained:

- The Energy efficiency of Blades were better at lower speeds than at higher ones.
- The Torque requirement of straight profile with and without twist feature was high, thus the power consumption will also be high, with almost constant air velocity.
- The Backward swept blade's performance is in between the other two profiles.
- Of all 3 profiles, the Forward swept blade with twist is giving better air velocities with low torque requirements

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