# Vibration Analysis & Weight Optimization of Impeller for Industrial Air Blower

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## ABSTRACT

*This paper deals with the field complaint from the end user namely Eco-man Industries who are manufacturers of fertilizers. The problem indicated at their end for air blower were 1) Heavy corrosion on the impeller due to corrosive environment. 2) Though it complies with I.S.-1940 vibration norms, it creates unwanted irritating sound which can be termed as noise pollution. The root cause of noise pollution is vibration, which is the result of uneven mass distribution and can be termed as manufacturing defects. Secondly improper/inadequate clamping of the mating parts can result in vibrations. Vibrations are generally observed when a system or a element which is subjected to dynamic forces which can be periodic or random, linear or rotational .Vibrations are basically dependent on mass and the elasticity of the system which is also termed as stiffness. Vibration in any system is an indicator of malfunctioning of the system, though it is unavoidable can be kept within the permissible limits. It can result in wear and tear of the moving parts and a premature failure. Finally vibrations can be transmitted to the adjacent areas, to control the vibrations it is always advisable to control it, at the excitation source by providing devices like vibration dampers. Here we have used SS-304 as a substitute material for the impeller for improving the corrosion resistance. To counter balance the increase in material cost weight optimization is done. Our goal is to minimize the weight of the impeller which will result in low starting torque and material saving without altering the vibration characteristics of the impeller. Hence the objective of this study is to present Modal Analysis to find out the natural frequency of the impeller for five modes of vibration with variation in thickness in steps of 0.2mm from 2.0mm to 1.6mm and compare it with the excitation frequency for the safety of the design and avoid resonance. Modal analysis was performed on ansys software using finite element analysis technique. Note :- Below 1.6mm thickness welding becomes a problem, hence weight optimization was restricted to 1.6mm only.*

**KEYWORDS–***Impeller, Vibration Analysis, Finite Element Analysis, Modal Analysis.*

## I. INTRODUCTION

Vibrations are observed in all structures subjected to dynamic loading. Industrial Air Blowers are used in various process equipment's like dryers, evaporators, providing draft for boilers. The moving impeller provides kinetic energy to the fluid which can generate pressure against the resistance caused by the casing and other components in the system like ducts, dampers etc. The impeller receives the energy from the rotating shaft and transmits it to the air imparting it velocity with slight increase in pressure energy. Blowers are important in providing proper draft to the boiler, which will have an impact on the efficiency of the boilers, as adequate air is supplied to the combustion chamber to ensure proper combustion of the fuel. The blower can be installed in front of the boiler which will supply air at positive pressure against boiler pressure which can be at room temperature or elevated temperature as in case of air preheater, hence they are called as forced draft (FD). Similarly flue gases can be drawn out of the combustion chamber which can be slightly below atmosphere which is called as Induced Draft (ID).The primary air blowers (PA) are used to atomization of fuel, where as Secondary Air Blowers are used for transferring the fuel through duct conveying system. Generally blowers which are subjected to positive pressure like FD are direct drive whereas ID are belt driven.

## II.LITERATURE SURVEY

AdgaleTushar, Balkrishna et al have studied the effect of vibration using alternative materials in sequence of steel ,aluminum and glass/epoxy, keeping the geometry of the impeller same. Weight reduction was achieved due to variation in density. [1].

Veeranjaneyulu et al have done static and dynamic analysis on the blower to reduce vibrations with a choice of using alternative material. The proposed design of the blower was analyzed for for strength and deformation. Modal analysis was performed for both Alumininum and Composites for five natural frequencies [2].

Dr Manal hadi Saleh. et al have studied the effect of impellor blade design on sound pressure level (SPL) on shrouded & un shrouded impellor. Following conclusions were made -SPL increases with increase in velocity, with max SPL observed in the range 200-315Hz, and the cover on the blade caused increase in pressure level[3].

O P Singh et al This paper deals with the effect of geometric parameters of the centrifugal fan with backward and forward curved blades. Parametric study was carried out to quantify Power Coefficient , Flow Coefficient & Efficiency . The parameters considered were number of blades , outlet angle and diameter ratio. Following results were concluded with increase in number of blades increases flow and power coefficient due to better guidance and reduced losses. Forward curved blades have 4.5% lower efficiency with21% higher mass flow rate and 42% higher power consumption compared with backward curved blades. Efficiency of the fan increases and then decreases with diameter ratio ,with best efficiency at 0.5 with decrease in performance at high pressure [4].

P. Naveen Kumar et al. have conducted design optimization of Backward Inclined Radial Bade. The scope of this paper was to optimize the design of the backward inclined radial blade . The thickness of the blade was reduced and then the stress and deformation model of the optimized model was studied. Then the number of blades was reduced from 12 to 10 numbers with reducing the thickness from 9mm to 8mm. It was concluded that the stress and the deformation results 8mm thick ten blades is similar to 9mm thick 12 blades. Hence they are interchangeable. [5].

Manish Dadhich et al study was focused to show how fatigue and modal analysis of the centrifugal blower can be done using commercial software like catia and ansys Contours and deformation of equivalent stresses are developed to find to point of max deformation and stress. This can give us a guide line for taking preventive measures to avoid premature failure. [6].

Adam Adamkowski, et al. On the basis of analysis and studies carried out for the main cause of fracture on the shafts of pumps installed in the cooling system of two diesel generator sets in coastal power plant was investigated . It was discovered that due to torsional vibration of the shaft were observed due to accountable loss in impeller mass due to cavitations erosion during normal operation. This mass imbalance caused by cavitations can favour racks. [7].

Atre Pranav , et al this paper deals with a Detailed. Design Methodology for aerofoil high efficiency impellers which includes numerical design calculations and the results are validated using CFD analysis to improve the static pressure and efficiency [8].

KarthikMatta et al. This paper represents static and dynamic analysis for the entire centrifugal blower to find out the prone sites for max deformation stresses. Different type so impellers with varying sizes and number of blades were modeled along with different materials. Which lead to conclusion that composite material has less stress and deformation.[9].

## III.OBJECTIVES :-

1)To use a corrosion resistant material as a alternative material as the blower is subjected to a highly corrosive environment.Hence we have used SS-304 in place of MS.

2) Weight optimization of the impeller, without altering the vibration characteristics of the impeller.

3) To confirm that the design is safe for resonance.

## IV. AIR BLOWER SPECIFICATION

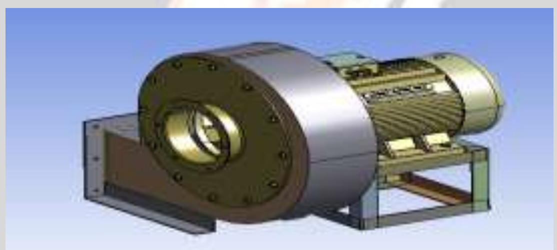

**Fig. No.1** Air Blower

| | |
|---|---|
| FAN MODEL | HN-26 |
| CAPACITY (m3/Hr) | 2000 |
| STATIC PRESSURE (MMWG) | 40 |
| FAN RPM | 2770 |
| MOTOR SPECIFICAION | 0.75KW |
| OPERATING TEMPRETURE̊C | 20 |
| TOTAL OPERATING PRESSURE (MMWG) | 42 |

## V.MODAL ANALYSIS OF IMPELLER

Modal analysis:- It is the study of the dynamic properties of systems in the frequency domain. A typical example would be testing structures under vibration excitation. Modal analysis is in the field of measuring or calculating and also analyzing the dynamic response of structures and fluids or other systems during excitation.

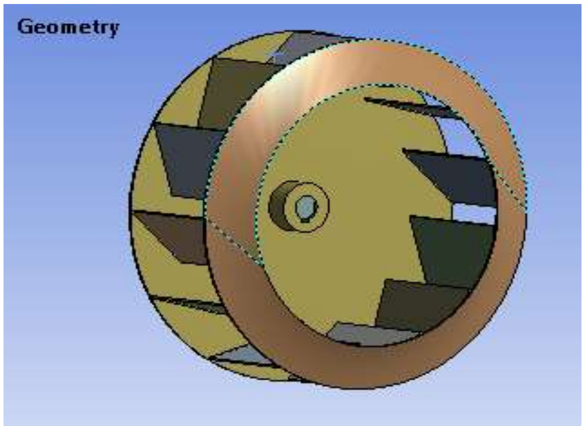


**Fig.No.2** Solid Geometry

Solid Modeling is done by using CATIA V5.

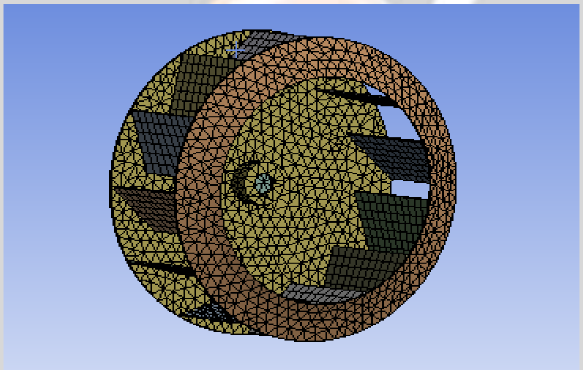

**Fig.No.3** Meshing

Meshing Details :Nodes=23341Elements=8195

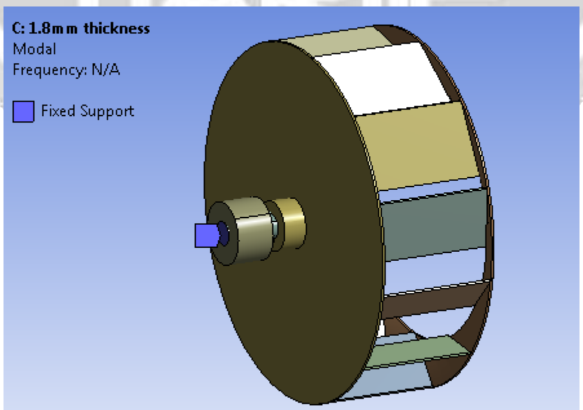


**Fig.No.4** Boundary Conditions

Boundary Conditions applied to impeller.

**MODE SHAPES:**
**This mode is obtained for the thickness of blade:**

**For 2mm thickness:**

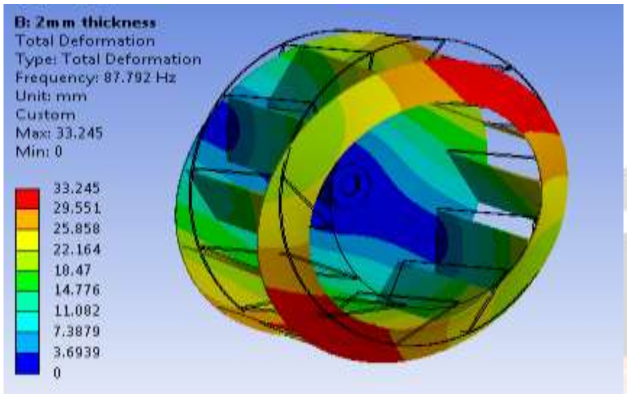


**Fig.No.5** Mode 1

This mode 1 is obtained for the 2 mm thickness of blade.

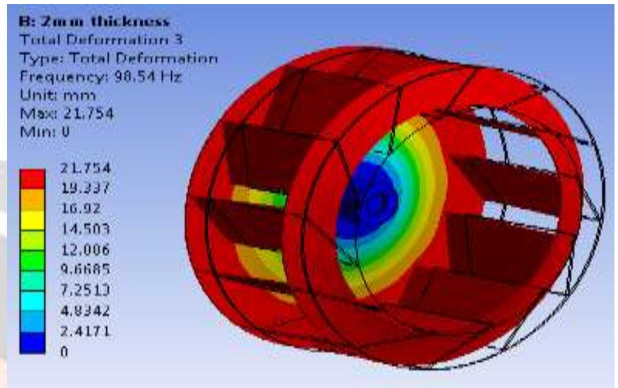


**Fig.No.6** Mode 3

This mode 3 is obtained for the 2.0 mm thickness of blade.

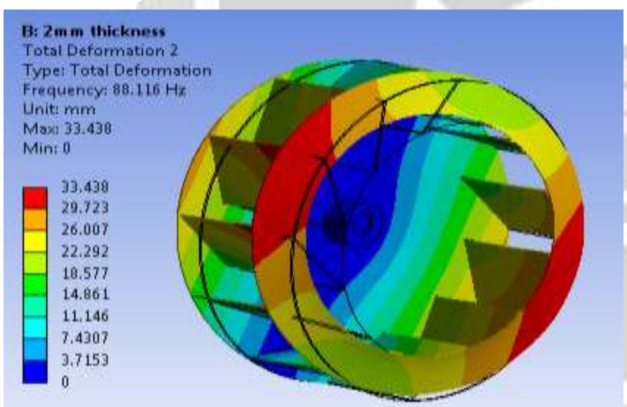


**Fig.No. 7** Mode 2

This mode 2 is obtained for the 2 mm thickness of blade.

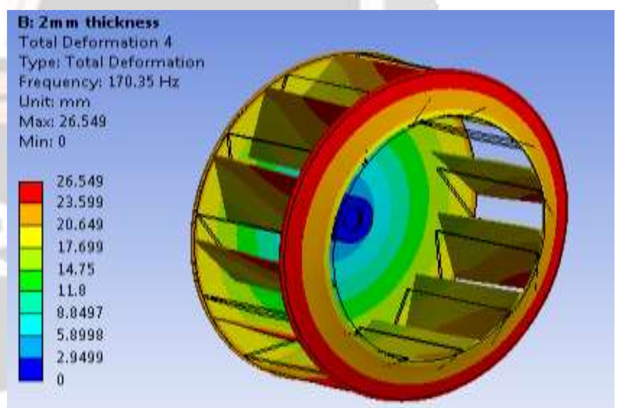


**Fig.No. 8** Mode 4

This mode 4 is obtained for the 2.0mm thickness of blade.

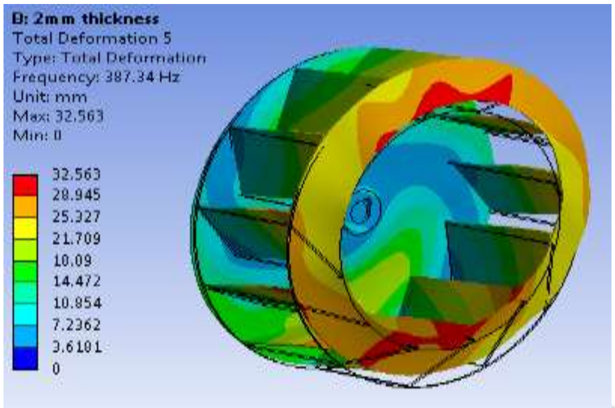


**Fig.No.9** Mode 5

This mode 5is obtained for the 2.0 mm thickness of blade.

**For 1.8 mm thickness**:

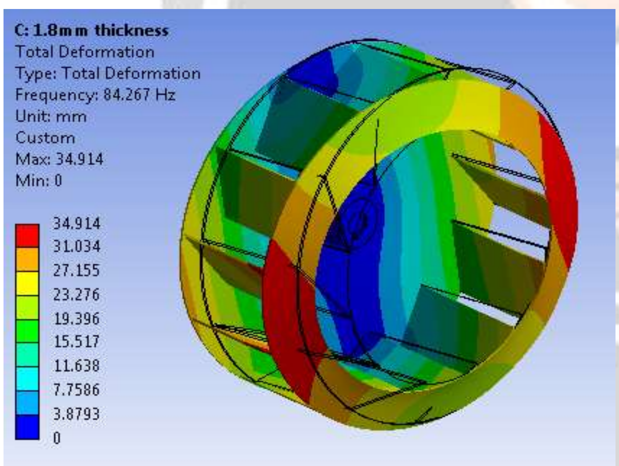


**Fig.No.10** Mode 1

This mode 1 is obtained for the 1.8 mm thickness of blade

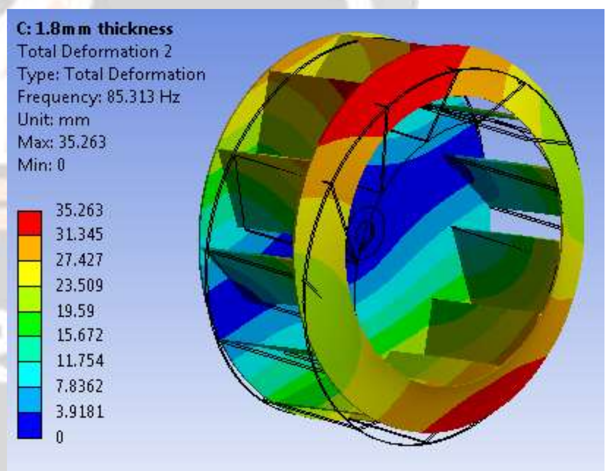


**Fig.No.11** Mode 2

This mode 2 is obtained for the 1.8 mm thickness of blade

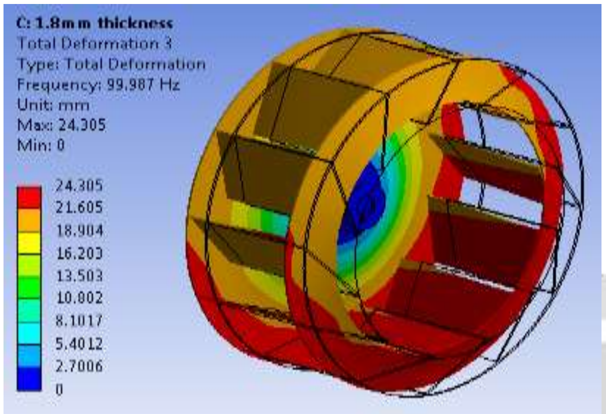


**Fig.No.12** Mode 3

This mode3 is obtained for the 1.8 mm thickness of blade

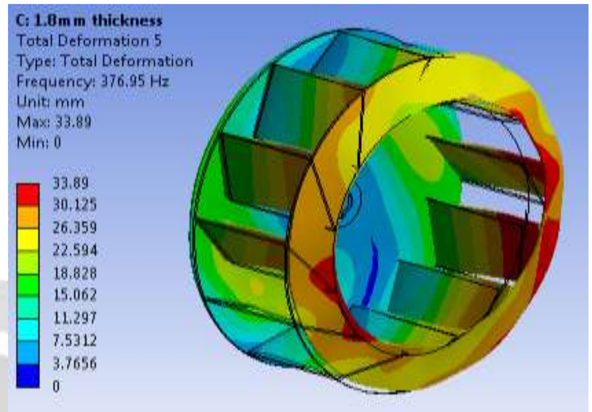


**Fig.No.13** Mode 5

This mode 5 is obtained for the 1.8 mm thickness of blade

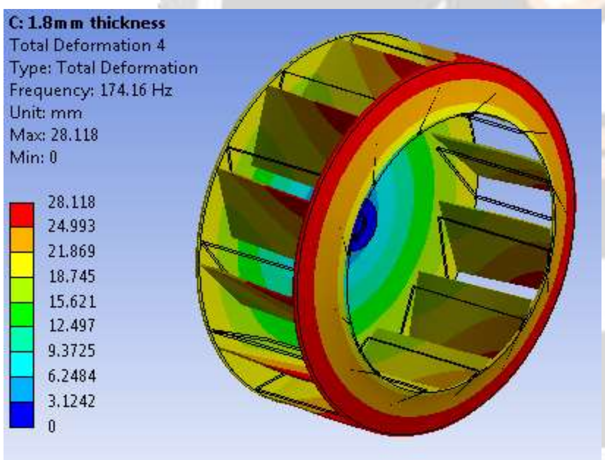


**Fig.No.14** Mode 4

This mode 4 is obtained for the 1.8 mm thickness of blade

**For1.6mm thickness:**

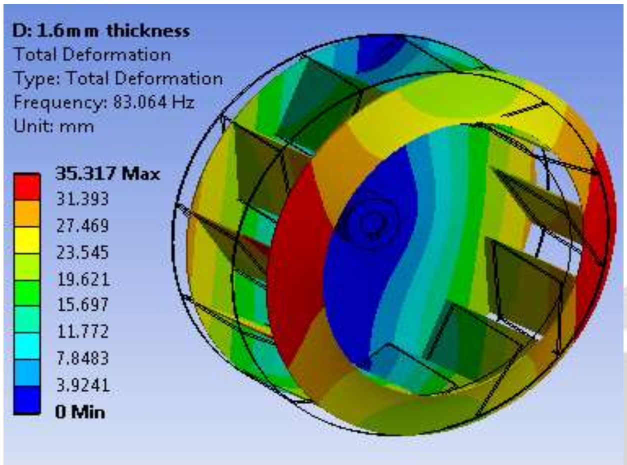


**Fig.No.15** Mode 1

This mode 1 is obtained for the 1.6 mm thickness of blade

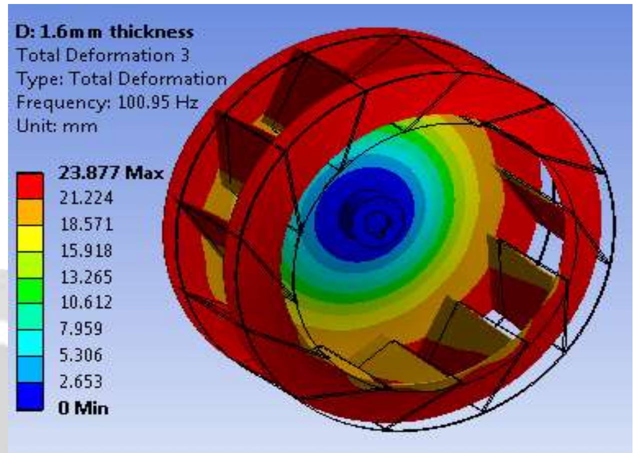


**Fig.No.16** Mode 3

This mode 3 is obtained for the 1.6mm thickness of blade

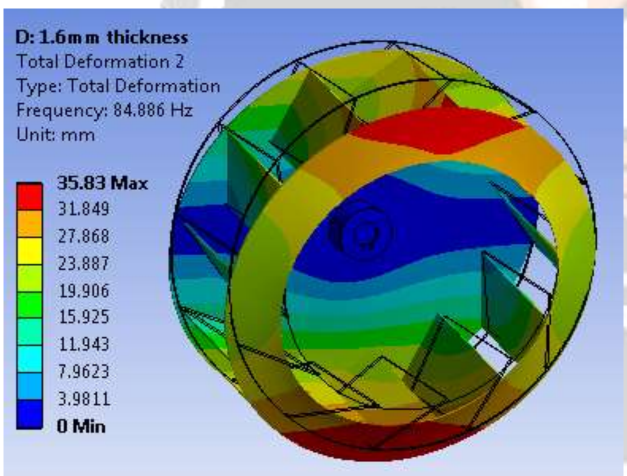


**Fig.No.17** Mode 2

This mode 2 is obtained for the 1.6 mm thickness of blade

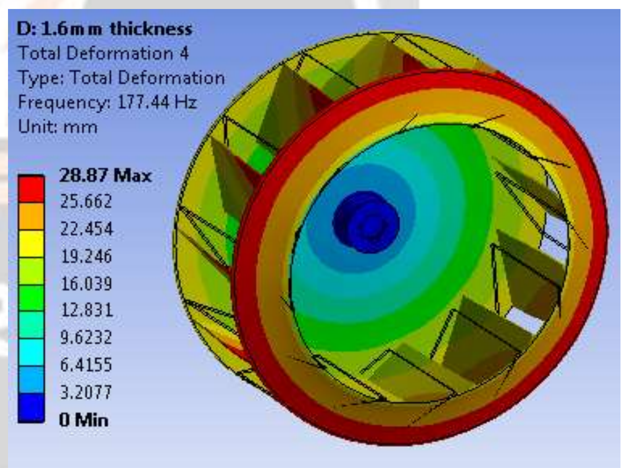


**Fig.No.18** Mode 4

This mode 4 is obtained for the 1.6mm thickness of blade

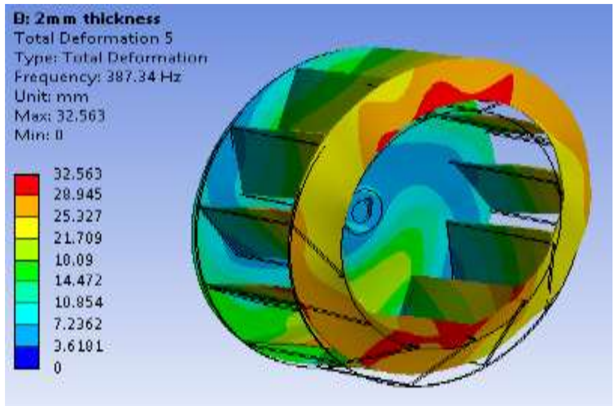


**Fig.No.19** Mode 5

This mode 5 is obtained for the 2.0 mm thickness of blade.

## VI.RESULT

| Sr No | Material Thickness (mm) | Mode Number | Frequency (Hz) | Deformation (mm) |
|---|---|---|---|---|
| 1 | **2** | 1 | 87.792 | 33.245 |
| 2 | **2** | 2 | 88.116 | 33.438 |
| 3 | 2 | 3 | 98.54 | 21.754 |
| 4 | 2 | 4 | 170.35 | 26.549 |
| 5 | 2 | 5 | 387.34 | 32.563 |
| 6 | 1.8 | 1 | 84.267 | 34.914 |
| 7 | 1.8 | 2 | 85.313 | 35.263 |
| 8 | 1.8 | 3 | 99.987 | 24.305 |
| 9 | 1.8 | 4 | 174.16 | 28.118 |
| 10 | 1.8 | 5 | 376.95 | 33.890 |
| 11 | 1.6 | 1 | 83.064 | 35.317 |
| 12 | 1.6 | 2 | 84.886 | 35.830 |
| 13 | 1.6 | 3 | 100.95 | 23.877 |
| 14 | 1.6 | 4 | 177.44 | 28.870 |
| 15 | 1.6 | 5 | 376.67 | 35.792 |

| MATERIAL THICKNESS (MM) | WEIGHT (KG) | % REDUCTION (In weight) |
|---|---|---|
| 2mm | 3.5118 | Nil |
| 1.8mm | 3.3622 | 4.26 |
| 1.6mm | 3.2824 | 6.53 |

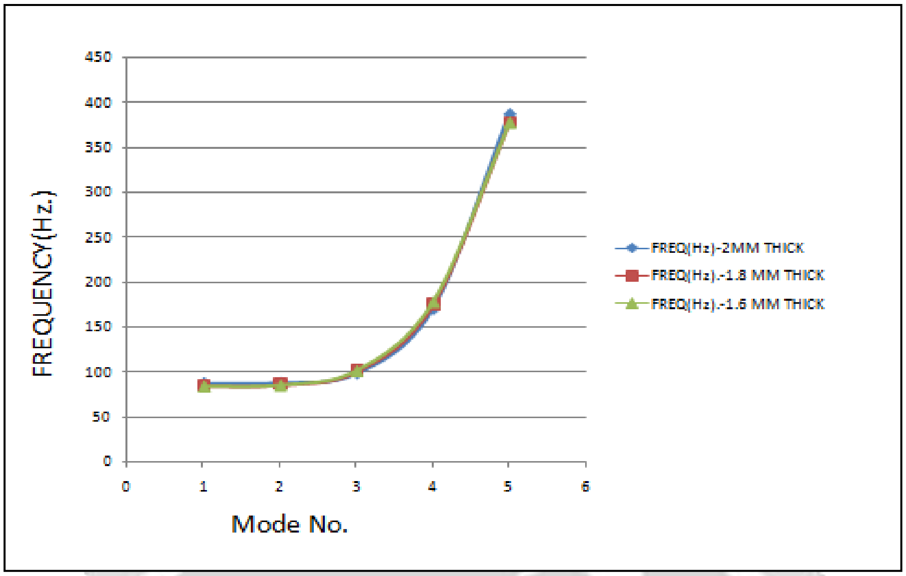


**Fig.No. 20** Result Plot

Result for the Frequency Vs.Mode for the Impeller Blade.

## VII CONCLUSION

- Thickness of impeller blade was reduced from 2 mm to 1.8 mm and 1.6 mm without altering vibration characteristics. (Natural Frequencies of the structure)
- Reduced Mass:

  For 2mm thickness,Mass=3.5118 kg.

  For 1.8 mm thickness, Mass=3.3622 kg.

  For 1.6 mm thickness,Mass=3.2824 kg.

- Design is safe as working frequency due to motor accelerations (46Hz.) isn't encountered as Impeller Assembly as natural frequency above 80 Hz.

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