MODELING OF TURBO CHARGER AND OPTIMIZATION OF COMPRESSOR



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Abstract- *As a demand of new efficient and eco friendly engines is increasing new technologies are developing. Due to the rich air fuel mixture combustion emission will increase hence by turbo charging the engine more power can be obtained with low emission. A turbo is most significantly boost's an engine horsepower without significantly increasing its weight, which is huge benefit that makes turbo so popular.*

Here in this project I am modeling of Tata indigo turbo charger and optimizing the compressor wheel by using creo2.0 and doing Structural and modal analysis by FEA package (ANSYS15.0). the objective of this project to increase the strength and stability of the compressor wheel for this I am changing the materials and also changing the existing design by comparing the results the best model from this data we suggest the design modification to the company to improve performance of the compressor wheel.

Keywords- *ANSYS, CFD, Creo2.0, Horsepower, Turbocharger.*

I. INTRODUCTION

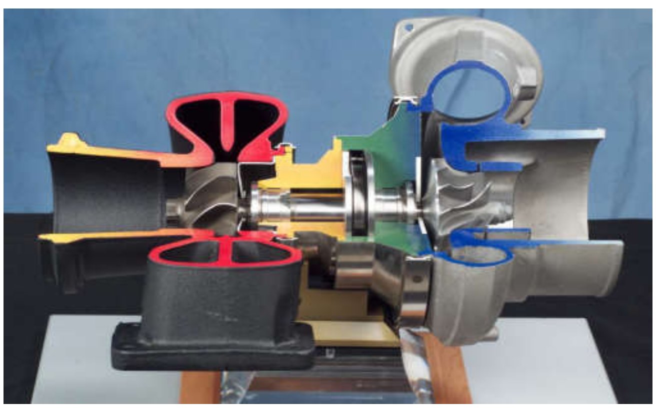
1.1PURPOSE

The purpose of this project was to analyze a turbocharger compressor wheel system in a diesel engine. The turbocharger is used to increase engine power. A Tata indigo 1.405 litre diesel engine was chosen for this project. The turbocharger is modelled by using creo 2.0 the turbo charger is modelled and examined the compressor wheel for different materials and shapes by using ansys15.0.

1.2 TURBOCHARGER SYSTEM IN A DIESEL ENGINE

The tata indigo diesel engine comes with a stock turbocharger, the GT12sz In order to obtain more power from the engine, a new and small turbocharger is being used, the. A turbocharger consists of a turbine and a compressor connected by a shaft. The turbine section is mounted to the exhaust line from the engine. The compressor is connected to the turbine by a shaft and its outlet is routed to the engine air intake. Exhaust gas from the engine enters the turbine and expands, performing work on the turbine. The turbine spins the shaft connected to the compressor.

The compressor draws in ambient air and compresses it. Figure 3 is a cross-section of a turbocharger. Turbocharger systems are measured by the amount of pressure the compressor can output above ambient. This pressure is commonly called boost pressure or boost 2 the target boost pressure for the system analyzed in this project is 17 psi.



1.3 CONSTRUCTION AND WORKING OF TURBOCHARGER

Turbo charger mainly consists of following components they are

1. Turbine housing
2. Centre hub
3. Compressor housing
4. Compressor
5. Turbine
6. bearings

The function of compressor is to compress the incoming air and is mounted on the same shaft on which turbine is mounted. The turbine is rotated by the exhaust gas coming from the engine which still hot and contains energy. As the internal energy is function of temperature, It can be further converted to rotating or mechanical energy. Thus, exhaust gas rotates the turbine and along with turbine, compressor also rotates at same speed via common shaft. Thus turbine is prime mover for compressor. Hence in turbocharger, no external power is required. It functions both turbine and compressor parts are lubricated by the forced lubricating oil from the engine. It does two works. First it provides the lubrication and second it cools the compressor and turbine parts. Housing encloses the turbine and compressor with appropriate turbo passage which enables the turbine to rotate and on the other side, it causes the incoming air to be compressed.

The compressed air has high temperature about 200 degrees centigrade and it must be cooled to room temperature before it enters the engine. Thus, a device called, 'Inter-cooler' is used to pre-cool the compressed air and lowers it temperature to specified level of temperature and now air is ready to go in to the engine with high pressure and lower temperature. Second way to reduce the air temperature is water injection before it enters the engine cylinder. Water keeps air temperature lowers.

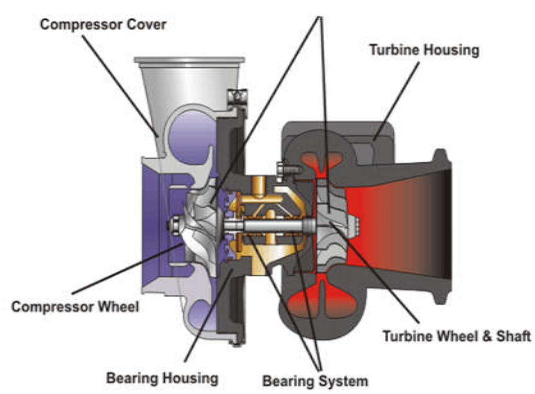


Fig1.1.construction of turbo charger

1.4 HOW IT WORKS

A turbocharger is composed of 3 basic parts, a compressor, a turbine, and center housing. The turbine is the section of the turbocharger where the exhaust gases of the engine are forced through to cause the turbine wheel to spin. This rotation energy is then transferred through the center housing and into the compressor by means of a stainless steel, or sometimes inconel, shaft. This center housing is comprised of journal or ball bearings, depending upon the application, as well as oil lubrication ports and drains. This allows the bearings to well lubricated, as well as cooled, to handle the immense rotational speeds and heat that they have to endure. Some center housings have integrated coolant passages to provide supplemental cooling. This is not always required, but it does drastically improve a turbochargers life, as well as protect it in circumstances where it is put under high or prolonged demand. The compressor does exactly what it's named for, it compresses air. The compressor is spun by the rotational force created by exhaust gases flowing through the turbine. This would feed the intake side of the motor. Air is inductedInto the compressor and then compressed into the piping, feeding the air intake ports of the motor. This creates an increased flow, as well as density, of air to be fed into the combustion chambers of the motor. The more oxygen that can be forced into the motor means that more fuel can be added to maintain a stabilized combustion. This in turn causes a larger, more powerful combustion. Thus, increasing the power output of the motor.

The diagram below depicts the process of utilizing the engines exhaust gases to force clean air

Into the motor for combustion. In the diagram above, you may notice a "charge air cooler" or more commonly known as an intercooler.

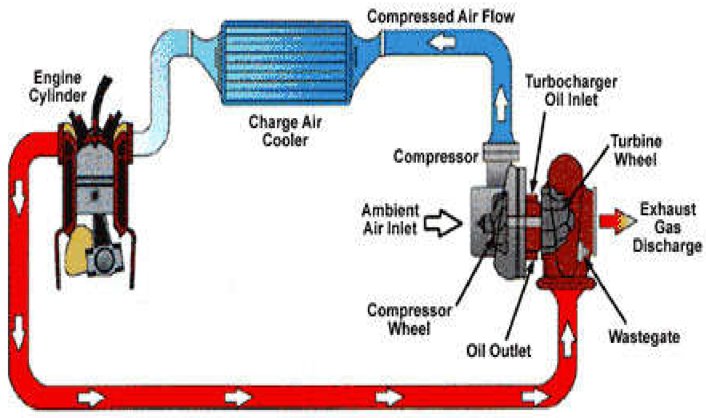


Fig 1.2.working of turbo charger

Although not utilized in all cases, most turbocharged platforms utilize an intercooler to cool the compressed air back down to the ambient air temperature. This is due to the fact that heat is transferred from the turbine of the turbocharger to the compressor by of the exhaust gases flowing through it. This causes an undesired effect of heating the compressed air that is formed by the compressor of the turbocharger. A higher temperature air becomes less dense of oxygen molecules, which intern cause less oxygen to flow into the combustion chambers and produces a smaller, less powerful combustion (less power output). So to counter this effect, an intercooler is implemented to cool the air back down.

2. MODELING PROCEDURE FOR TATA INDIGO TURBO CHARGER COMPONENTS:

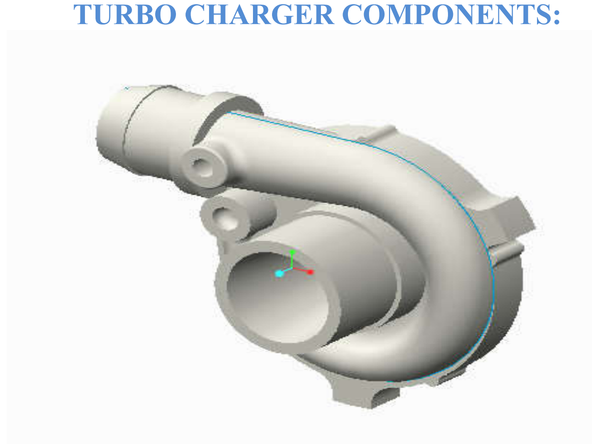


Fig 2.1 compressor **housing**

2.1COMPRESSOR

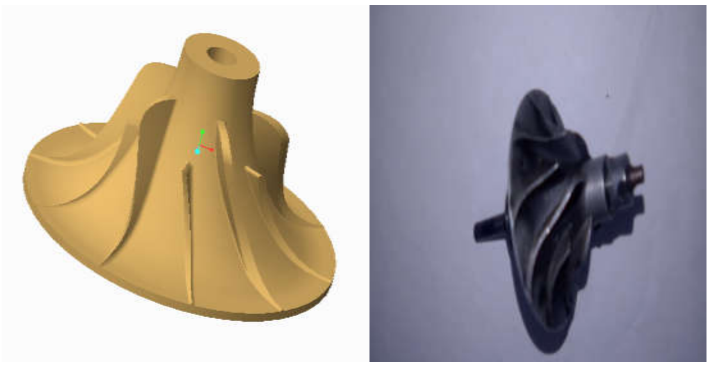


Fig 2.2 compressor wheel

2.2CENTER HOUSING

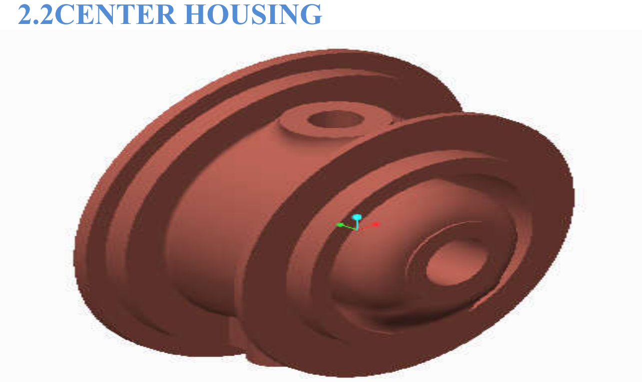
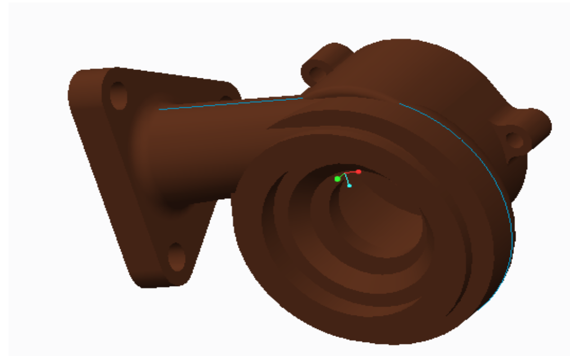


Fig 2.3 center housing

2.2 TURBINE HOUSING



2.3 TURBINE

2.4 ASSEMBLY OF TURBO CHARGER

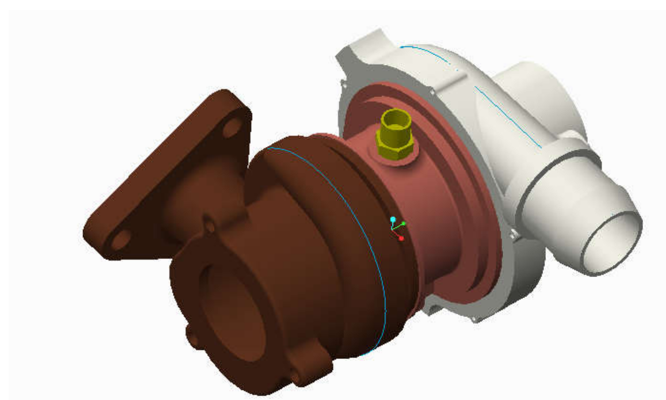


Fig 2.4 turbo charger assembly

2.4 MODEL CHANGES IN COMPRESSOR:

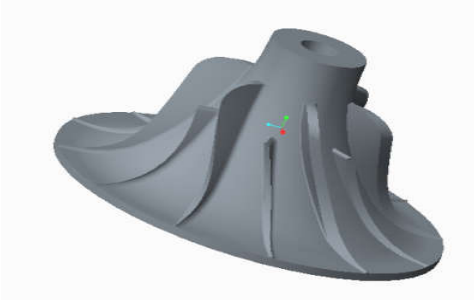


Fig 2.5 Six blade compressor

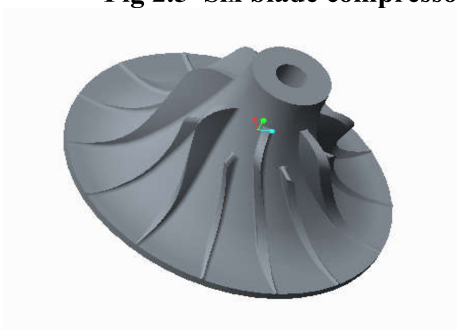


Fig 2.6seven blade compressor

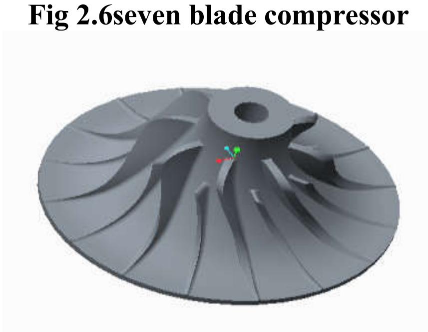


Fig 2.7eight blade compressor

3.ANALYSIS OF COMPRESSOR WHEEL

3.1 Analysis of 5-blade compressor wheel and different materials:

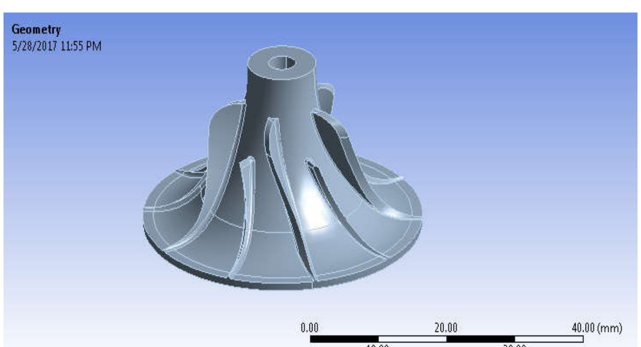


Fig. 3.1 Geometry of the 5-blade compressor

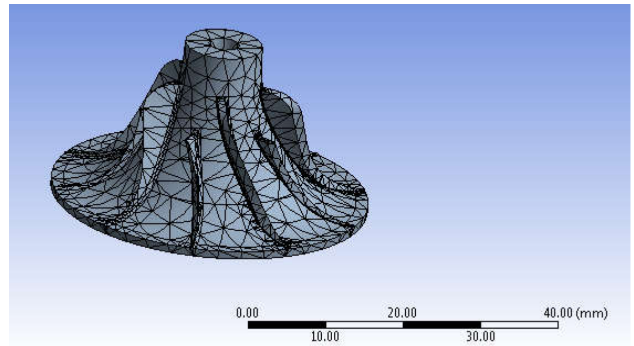


Fig. 4. 2Meshed model

3.2Boundary Conditions:

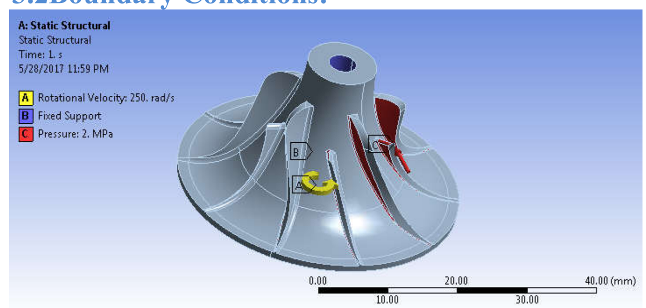


Fig. 3.3 structural analysis Boundary Conditions

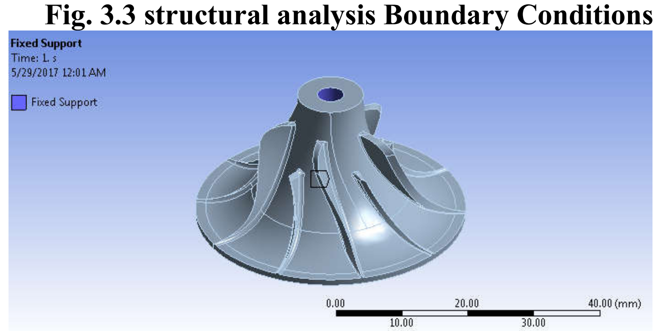


Fig.3.4 modal analysis Boundary

3.3Structural Analysis of Aluminum compressor wheel:

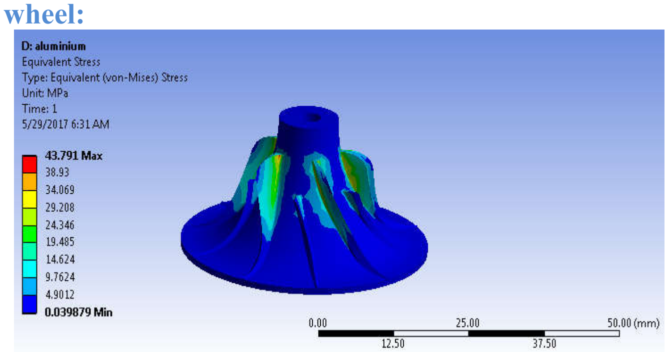


Fig 3.5 equivalent stress

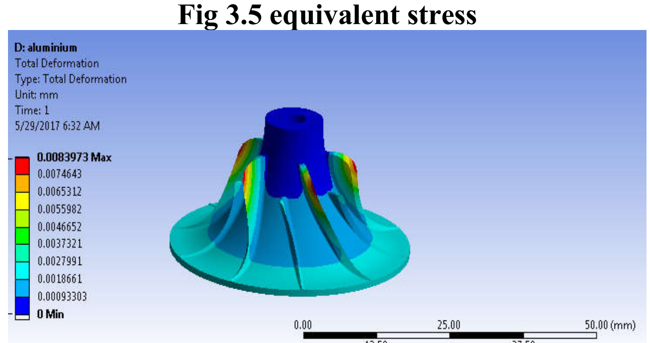


Fig. 3.6 total deformation

3.4 Modal analysis of Aluminum alloy compressor wheel:

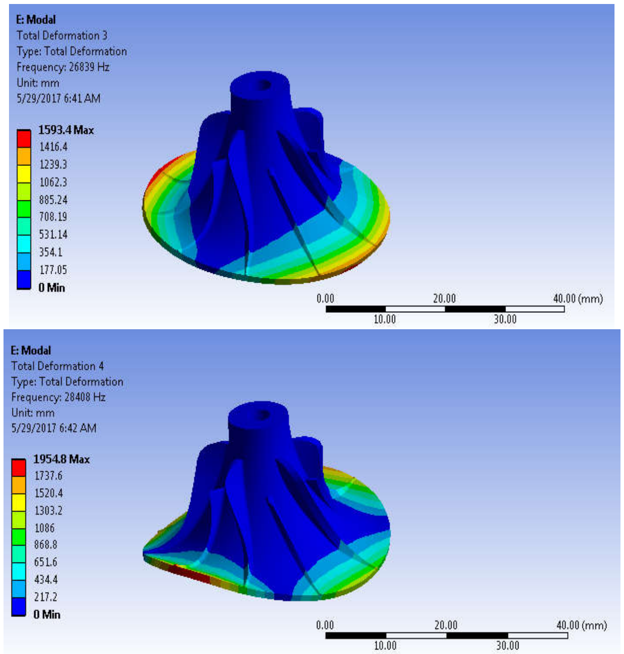


FIG.3.7.MODE SHAPES

4. RESULTS AND DISCUSSION

4.1Structural and modal analysis:

4.2.physical properties of the materials

Materials	Density(Kg/m3)	Poisson's Ratio	Young's modulus(MPa)
Aluminum alloy	**2770**	**0.33**	**7100**
stainless steel	**7750**	**0.31**	**$1.93x10^5$**
Structural Steel	**7850**	**0.3**	**$2x10^5$**
inconel718 alloy	**8192**	**0.29**	**1035**

4.3. Five blade compressor wheel analysis:

		5-BLADE COMPRESSOR WHEEL		NATURAL FREQUENCIES (HZ)			
S.NO	**MATERIAL**	**STRESSES (MPA)**	**DEFOR-MATION (MM)**	**MODE-1**	**MODE-2**	**MODE-3**	**MODE-4**
1	STRUCTURAL STEEL	45.26	0.003015	18098	26447	26483	28222
2	ALUMINUM ALLOY	43.791	0.008397	17974	26784	26839	28408
3	INCONEL 718 ALLOY	44.857	0.58676	1278.4	1858	1861.7	1983.5
4	STAINLESS STEEL	44.409	0.003104	17833	26236	26291	27943

Table 4.1 analysis of eight blade compressor

4.4Six blade compressor wheel analysis:

The structural and modal analysis of the six blade compressor is shown in table 6.3

		6-BLADE COMPRESSOR WHEEL		NATURAL FREQUENCIES (HZ)			
S.NO	**MATERIAL**	**STRESSES (MPA)**	**DEFORMATION (MM)**	**MODE-1**	**MODE-2**	**MODE-3**	**MODE-4**
1	STRUCTURAL STEEL	45.572	0.0031153	18047	26558	26612	28354
2	ALUMINUM ALLOY	46.923	0.0087335	17924	1539.8	26933	28524
3	INCONEL 718 ALLOY	47.804	0.60266	11.841	29.253	37.59	43.46
4	STAINLESS STEEL	47.33	0.0032239	17783	26333	26386	28064

Table 4.2 analysis of six blade compressor wheel

4.5 Seven blade compressor analysis

		7-BLADE COMPRESSOR WHEEL		NATURAL FREQUENCIES(HZ)			
S.NO	**MATERIAL**	**STRESSES (MPA)**	**DEFORMATION (MM)**	**MODE-1**	**MODE-2**	**MODE-3**	**MODE-4**
1	STRUCTURAL STEEL	45.537	0.0032	17985	26690	26721	28517
2	ALUMINUM ALLOY	44.736	0.009	17862	27008	27039	28687
3	INCONEL 718 ALLOY	45.791	0.6183	1270	1874	1877	2003
4	STAINLESS STEEL	45.271	0.0033	17721	26463	26493	28225

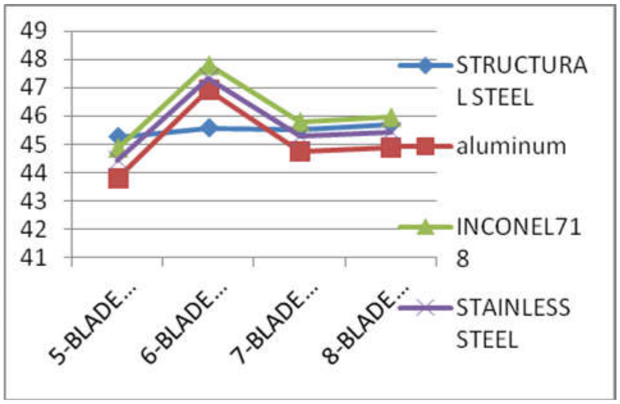
4.6 Eight blade compressor analysis:

		8-BLADE COMPRESSOR WHEEL		NATURAL FREQUENCIES (HZ)			
S.NO	**MATERIAL**	**STRESSES (MPA)**	**DEFORMATION (MM)**	**MODE-1**	**MODE-2**	**MODE-3**	**MODE-4**
1	STRUCTURAL STEEL	45.698	0.0033192	17924	26804	26854	28653
2	ALUMINUM ALLOY	44.888	0.009315	17801	27117	27167	28831
3	INCONEL 718 ALLOY	45.952	0.6419	1265.7	1881.8	1885.3	2012
4	STAINLESS STEEL	45.434	0.003436	17661	26573	26623	28366

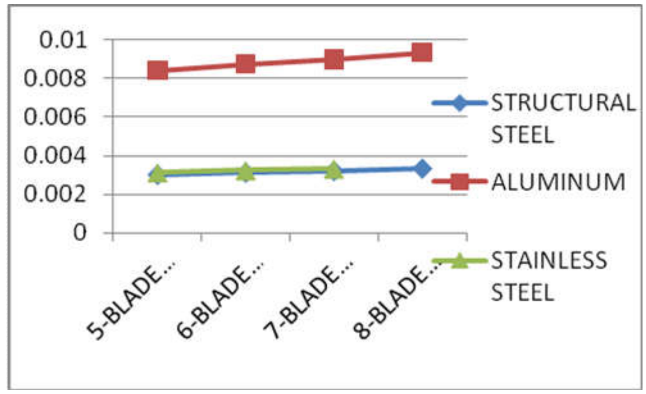
Table 4.3 analysis of eight blade compressor

5.GRAPHS:

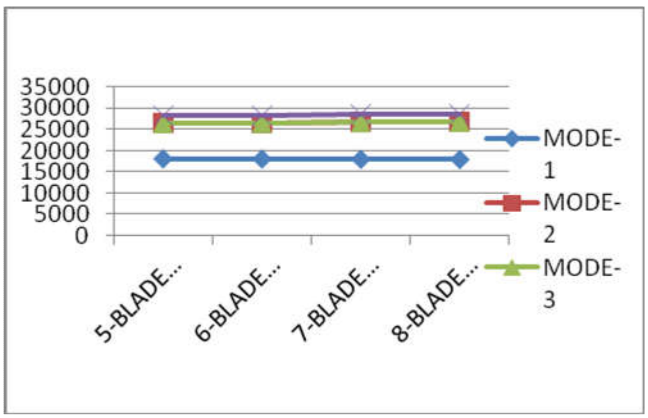
5.1 STRESS VS NO OF BLADE



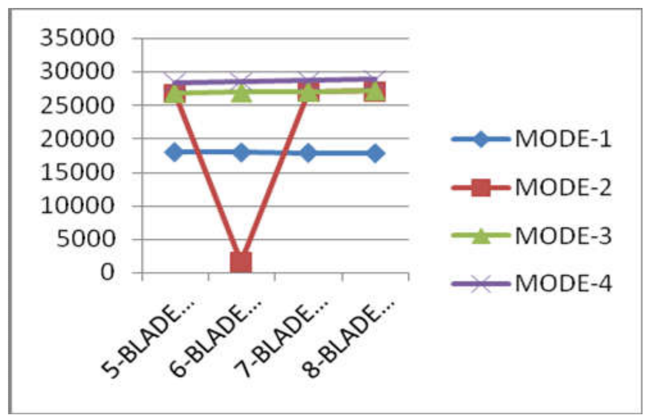
5.2 DEFORMATION VS NO OF BLADES



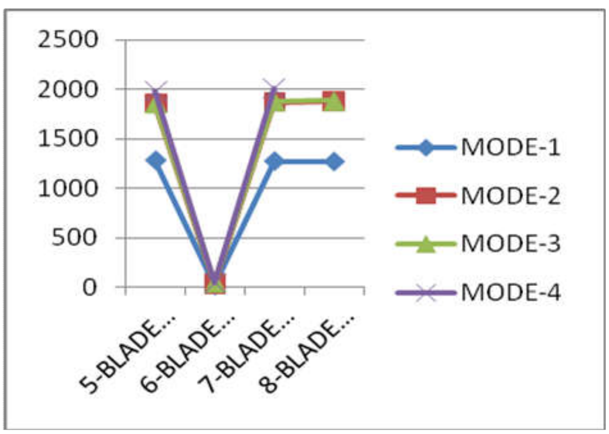
5.3 STRUCTURAL STEEL FREQUENCIES



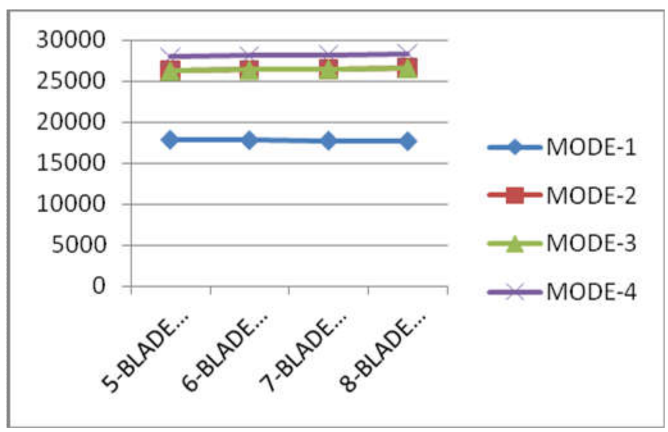
5.4 ALUMINUM FREQUENCIES



5.5 INCONEL 718 ALLOYS



5.6 STAIN LESS STEEL



CONCLUSION

In this project the turbo charger compressor wheel is designed in CREO 2.0 software. The analysis is done on ANSYS workbench. In this analysis was done by changing the geometry of the compressor blades and changing the materials of the compressor wheel. The present used material for the compressor wheel is aluminum. In this project other materials are considered which have more strength and stability.

- From the above observations I conclude that out of all four designs five blade stainless steel gives best stresses and deformation results compare with six, seven and eight blade compressor wheel.
- From the above observations weight taken in to the considerations five blade aluminium materials gives the best results.

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