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Structure Analysis of a Turbocharger Compressor Wheel Using FEA

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ABSTRACT
When people talk about race cars or high-performance sports cars, the topic of turbochargers usually comes up. Turbochargers also appear on large diesel engines. A turbo can significantly boost an engine's horsepower without significantly increasing its weight, which is the huge benefit that makes turbos so popular.
Turbochargers are a type of forced induction system. They compress the air flowing into the engine. The advantage of compressing the air is that it lets the engine squeeze more air into a cylinder, and more air means that more fuel can be added. Therefore, you get more power from each explosion in each cylinder.
Here in this project we are designing the compressor wheel by using Pro-E and doing analysis by using FEA package. The main aim of the project is to increase the performance of the compressor wheel for this we are changing the material and also we are changing the existing design. By comparing the results we will get the best model from this data we suggests the design modifications to the company to improve the performance of the compressor wheel.
Keywords – Ansys, Diesel engines, FEA, horsepower, Pro-E, Turbocharger.

I. INTRODUCTION

An aluminum alloy cast compressor wheel, also known as a compressor impeller, is the main component of a turbocharger. Since 1965 we have manufactured compressor wheels at our casting plant at Oyama, Tochigi Prefecture, delivering high-quality products that meet the needs of our customers. Figure 1 shows a cross section of a typical turbocharger, comprising a compressor wheel, a turbine and housing, with the compressor wheel and the turbine coupled to a single shaft. Exhaust gas from the engine turns the turbine, causing the compressor wheel mounted at the engine intake also to turn and supply compressed air to the engine. Because their exhaust is black, diesel vehicles have tended in Japan to be saddled with the image of having an adverse effect on the environment, but in Europe and other countries the many advantages in terms of economy, including the cost of fuel, and low levels of CO_2 emission have led to steady growth in the demand for diesel vehicles. In addition, with stricter environmental regulations, it has become necessary for diesel vehicles to be fitted with turbochargers, leading to a strong increase in demand for them. On the other hand, as turbocharger performance has improved, customer expectations in terms of levels of quality have risen enormously. Because they turn at speeds in excess of 150,000 rpm, there is a need not only for high durability, but also for high dimensional accuracy, and particularly for product coaxiality, also known as initial balance. To address these user needs, Furukawa Sky-Aluminum has developed new manufacturing technology that achieves dramatic improvements in initial balance.

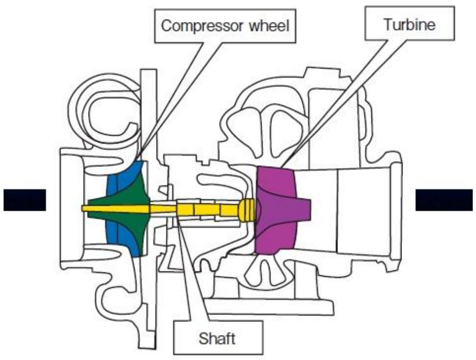

Fig.1 Cross section of typical turbocharger

II. TURBOCHARGER WORKING

A turbocharger consists of a compressor and turbine operating on a single common shaft. These are often designed for use on automobile internal combustion engines. When installed, the hot exhaust gases exiting the cylinders pass through the turbine side of the turbocharger, spinning the turbine blades, and thus the shaft. The shaft then transmits power to drive the compressor. The exhaust gases then continue out to the exhaust manifold and continue as usual.

As the compressor spins, it raises the pressure of the incoming air from the air intake. The high pressure air is often directed through a charged air cooler (also known as an intercooler) to further raise the density of the air. The high density air is then ducted into the cylinder and combustion occurs as normal. The larger mass of air, however, allows for more fuel to be burned in the same volume, and thus more power to be extracted by the piston during the power stroke, transmitting more power to the crankshaft and eventually the wheels. The cycle of an automotive Turbocharger follows closely to that of an aircraft turbine engine and thus allows for the correlation between an aircraft engine and that of the automotive based turbine engine to be created and thus implemented in the Propulsion course at Cal Poly San Luis Obispo.

A depiction of the operation of a turbocharger is shown in Figure

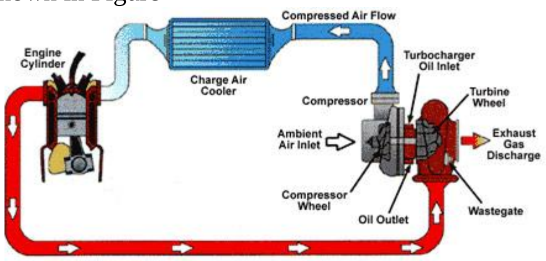

Fig.2 Diagram of the function of a turbocharger on a piston-driven internal combustion engine.

III. MODELING BY USING PRO-E

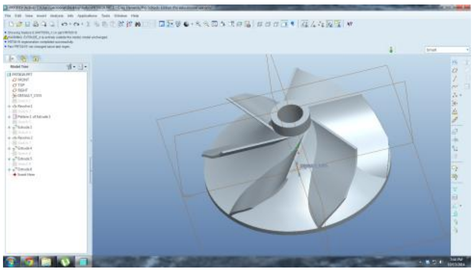

Fig.18 Actual model of turbocharger compressor wheel

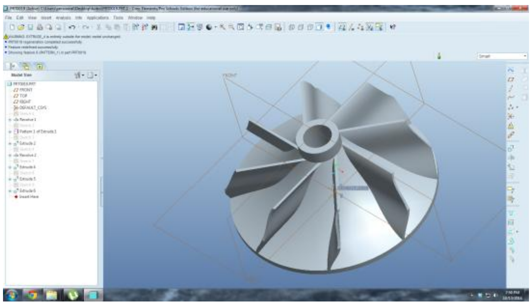

Fig.19 Modified model of turbocharger compressor wheel

IV. RESULTS & DISCUSSION

- **Actual turbocharger compressor wheel model results**
  - **Steel**

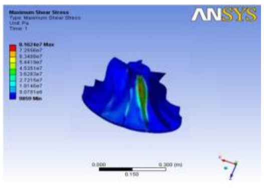
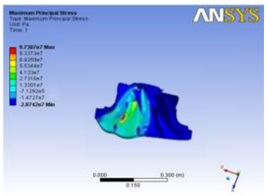

Fig.20 Maximum shear stress Fig.21 Maximum principal stress

  - **Alloy 718**

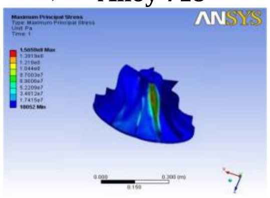
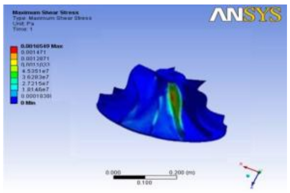

Fig.22 Maximum principal stress Fig.23 Maximum shear stress

  - **Alloy 706**

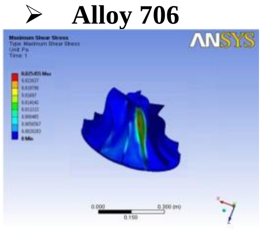
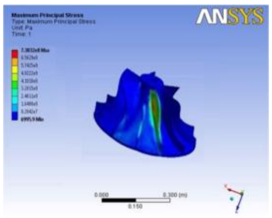

Fig.24 Maximum shear stress Fig.25 Maximum principal stress

- **Modified turbocharger compressor wheel model results**
  - **Steel**

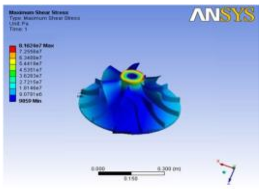
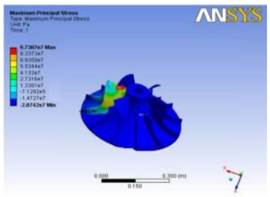

Fig.26 Maximum shear stress Fig.27 Maximum principal stress

  - **Alloy 718**

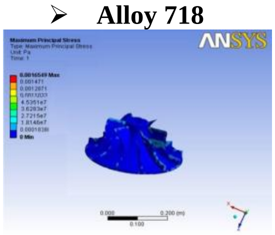
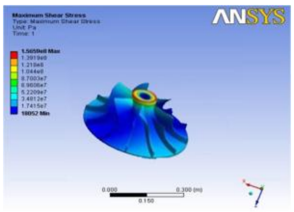

Fig.28 Maximum principal stress Fig.29 Maximum shear stress

- **Alloy 706**

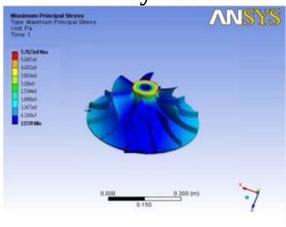
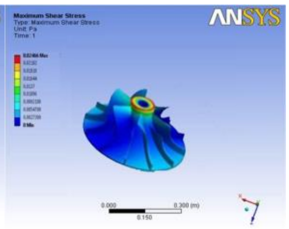

Fig.30 Maximum principal stress Fig.31 Maximum shear stress

V. RESULTS SUMMARY

	Actual model		Modified model	
Material	Maximum principle stress N/mm2	Maximum shear stress N/mm2	Maximum principle stress N/mm2	Maximum shear stress N/mm2
Steel	233.68	233.68	219.81	219.813
Alloy706	207.19	190.273	183.18	170.354
Alloy 718	221.46	203.50	199.82	186.35

Table.1 results data

VI. CONCLUSION

The analysis was carried out for Turbocharger compressor wheel which was done using ANSYS. In the analysis part the model was created in Pro-E and saved file in the format of IGES after it was imported into Ansys. The analysis is carried out on the two models with the different materials and the results were compared. From the above results summary table we concluded that Inconel 706 alloy was found better results than other two alloys, 718 alloy and Timken steel.

And the changed model also safe to use because the results of the modified are nearly equal to the actual turbocharger wheel. So that we propose the new model to the company with new alloy material. From the above data we observed that stresses are minimized for new model with the alloy material therefore if stresses are minimized then the performance maximized therefore finally we achieved the objective of the project.

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