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Stress Analysis of Turbine Blades of Turbocharger Using Structural Steel

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***Abstract*—**Turbocharger is a device that is driven by the turbine and increases efficiency and power output of the engine by forcing external air into the combustion chamber. This study focused on the distribution of stress on the turbine blades and total deformation that may occur during its working along with turbocharger to carry out its static structural analysis of turbine blades. Structural steel was selected as the material for turbocharger. Assembly of turbocharger and turbine blades was designed on PRO ENGINEER. Furthermore, the structural analysis is performed by using ANSYS. This research concluded that by using structural steel, the efficiency of engine is improved and by increasing number of turbine blades, more waste heat from combustion chamber is emitted.

***Keywords*—**Turbocharger, turbine blades, structural steel, ANSYS.

I. Introduction

THE Internal Combustion Engine (ICE) has been remained as the most prevalent method of global transport since the invention of the early 19th century. Extensive research and technology development by engine producers focus on two main methods: to develop combustion technique by improving cylinder performance and to resume the consume heat sparkle of the mechanism. The material of the turbocharger was chosen on the bases of its mechanical properties and is mostly used in turbine fabrication. Turbocharger was designed in PRO ENGINEER. Analysis was carried out in ANSYS to determine the amount of stress and total deformation produced for the selected material.

Trabucchi et al. [1] focused on waste heat reclamation systems of massive truck mechanisms which are based on Rankine cycle. Novel constituents are: advanced plant arrangement, and workability study that bundles entire introduction design workflow of the system. Khaled et al. [2] investigated the heat produced from exhaust gases. Heat is obtained using a concentric tube heat exchanger. Distinctive stream patterns are utilized, and effective stream design was that in which water streams in internal tube and fumes gases stream in external tube.

Hasan et al. [3] studied heat recuperation which provides superb chance to maintain value as well as energy in production and other services applications. The amount and quality of the lost heat energy mainly affect heat recuperation procedure. Heat recovered from the exhaust gas increased the flow rate and exhaust temperature. Outcome showed that as the heat rate increases, the temperature of gas also increases. Jaber et al. [4] developed heat exchanger design to recover excess heat from overtax gas and heat inlet air temperature 150 °C at full load works acceptably. Inlet air heat produces better performance of motionless diesel engines and lesser discharge levels. At full load conditions, effect of the heat exchanger is 0.615. Ram et al. [5] give the concept of waste heat recovery and use waste heat to save fuel. It saves a lot of energy by waste material. According to the paper, waste heat recovery is used in form of heat generated electrically and mechanically in the IC engine. Excess heat rehabilitation from the overtax gas is converted to mechanical operation and then converted to power through the thermoelectric generator. The efficiency of the thermoelectric generators is very low [6]. The great potential for energy savings using waste heat recovery technology has been identified. Waste heat recovery represents the recycling of excess hotness from the IC Motor to create electrical and mechanical toil to make warm. Improvements in engine performance and the emissions will be recognized by the engine. Jadhao [7] studied heat resistant austenite with high Ni Replace with Mn. It is to improve higher temperature tensile characteristics. Room temperature and higher temperature tensile characteristics analyzed thermodynamically by investigated equilibrium illustration. Seungmun et al. [8] studied the room temperature of three austenitic steels with dissimilar Cr properties and they explained the distortion and cracking appliances associated with the carbide including austenite matrices. Seungmun et al. [9] studied the experimental analysis of engine execution and overtax emissions features of biodiesel and diesel propellant for diesel engines. Results of the work showed that biodiesel has a slightly greater BSFC in both NA and TU operation compared to diesel fuel because of its greater fuel density and low calorific value. By Comparing NA operation, the BSFC dwindled for both fuels tested in TU operation. Karabektas [10] tested the properties of thermo-store solar energy can be used to operate an electric generator continual producing about 1 kW. Air is free and does not require handling considerations because it has sufficiently high thermal properties to be selectable as the working medium. Eduardo [11] investigated the casting and modeling of TiAl alloy for filling and imperfection origination in gating systems and examined the microstructure evolution during mold reaction. Si-Young [12] examined TiAl which is used for materials that

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fill gap between the heat-resistant metal and the ceramic. Next-generation light weighted and heat-resistant alloys are fabricated using the same strategy as the traditional metal materials. The properties of TiAl are well suited for rotating parts, and in the near future TiAl use will extend from the following types of equipment to the equipment. Tetsui [13] reduces CO_2, the turbocharged SI engine remains the highest priority in current trend of down-engine, but it still keeps smooth performance. Romagnoli et al. [14] focused on the heat transfer of turbocharger. This white paper provides the most complete review of the latest turbo-machinery heat transfer. This article introduces the problem of heat transfer from the engine turbocharger which is not considered in engine simulations and experiments and leads to incorrect results during engine turbocharger matching.

II. METHODOLOGY

The turbocharger model was designed using PRO ENGINEER. 3D model of the turbocharger was exported onto the ANSYS for processing. Pre-processing of model consists of meshing, selection of material properties, creation of load collectors, and boundary conditions. Then, solution was performed using ANSYS components. Results of solution were plotted in post-processor of ANSYS software.

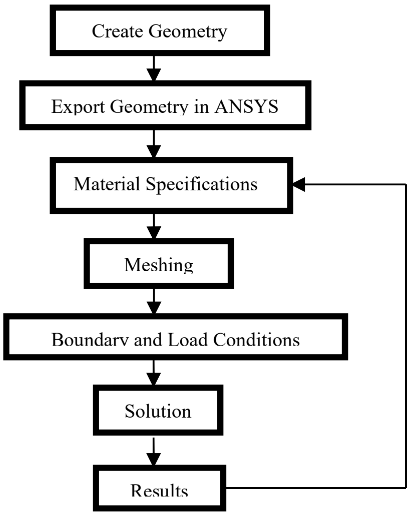

Fig. 1 Methodology

TABLE I
DESIGN SPECIFICATIONS OF TURBOCHARGER

Sr. No.	Parameters	Dimension
1.	Volume	$1.6292 \times 10^7 m^3$
2.	Mass	127.89 kg
3.	Centroid X	-1.7819×10^{-2} mm
4.	Centroid Y	18.75 mm
5.	Centroid Z	2.9125×10^{-3} mm

The 3D model is built by using PRO ENGINEER as in Fig. 2. The materials specifications of the structural steel are described in Table II.

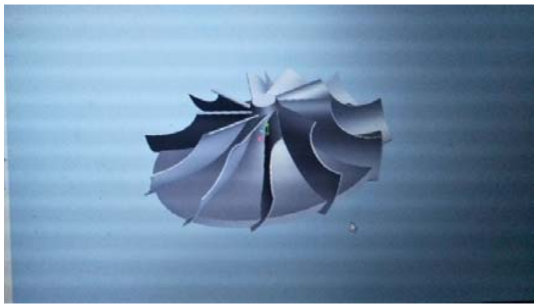

Fig. 2 3D model of turbine blade

TABLE II
MATERIAL SPECIFICATIONS OF STRUCTURAL STEEL

Property	Value	Units
Structural Steel Constraints		
Density	7.85×10^{-6}	kg/mm^3
Co-efficient of thermal expansion	1.2×10^{-5}	C^-1
Specific Heat	4.34×10^5	mJkg^-1C^-1
Thermal Conductivity	6.05×10^{-2}	Wmm^-1C^-1
Ultimate tensile strength	460	MPa
Ultimate Strength	0	MPa
Yield Strength	250	MPa
Property	**Value**	**Units**
Structural Steel Parameters		
Strength Coefficient	920	MPa
Ductility Exponent	-0.47	
Cyclic strain Hardening Coefficient	0.2	
Strength Exponent	-0.106	
Poisson's ratio	0.3	
Bulk Modulus	1.67×10^5	MPa
Shear Modulus	76923	MPa
Young's Modulus	2×10^5	MPa
Cyclic Strength Coefficient	1000	MPa

The CAD model developed in PRO ENGINEER is imported onto ANSYS, and the model is divided into number of small finite elements by mesh generation.

Pressure is exerted on the whole piston head surface. It is the peak in turbine blades of turbocharger. The meshed turbine blade of turbocharger is also used to conduct steady state thermal analysis to calculate temperature distribution and total heat flux across the geometry.

III. RESULTS AND CONCLUSIONS

From the above analysis of turbocharger of turbine blades, the maximum stress generated as well as the maximum deformation which is produced in the turbocharger turbine blades are 1.2582×10^5 Max and 35660 Min vale, respectively.
It also helps to recognize the improvement of engine performance and emissions. From this research, we concluded that increasing the number of blades helps waste heat to pass slowly in the turbine which is more useful.

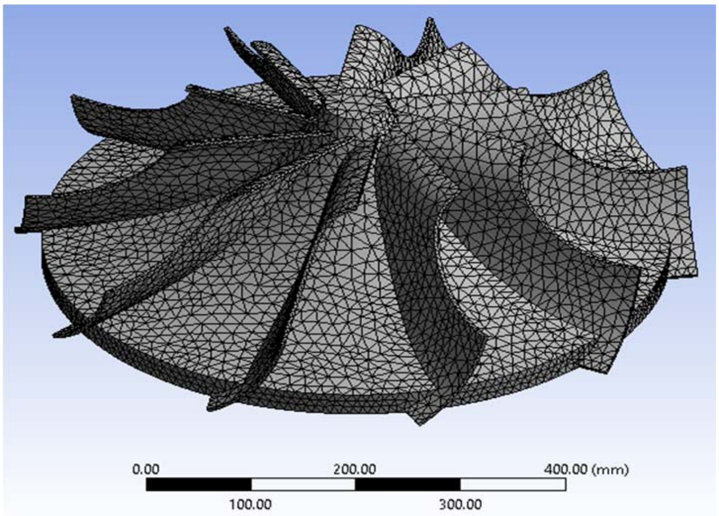

Fig. 3 Mesh analysis of turbine blade

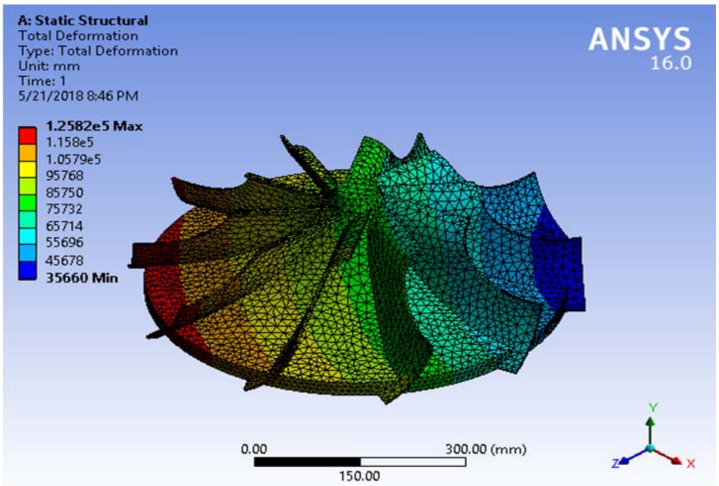

Fig. 4 Static structural deflection

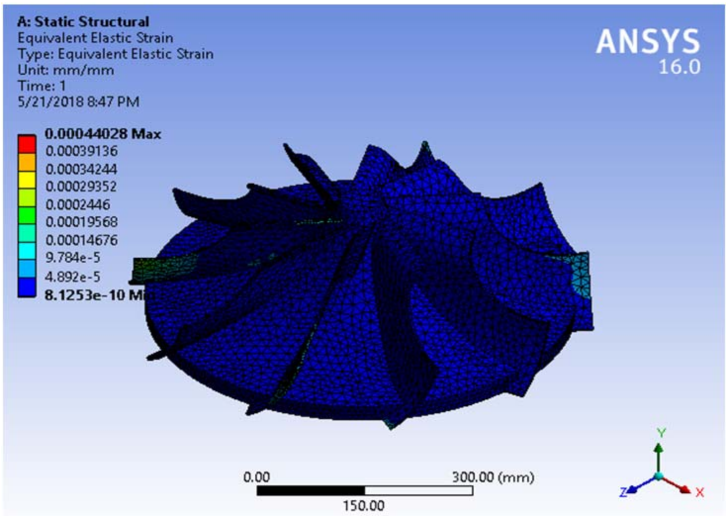

Fig. 5 Static structural elastic strain

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