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Thermal Analysis and Comparison Between Materials of Steam Turbine Rotor

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ABSTRACT

According to common forecast the worldwide demand for power will increase significantly after next two decades and the current power plant need to double power. Steam turbine blade plays important role. The efficiency of steam turbine is dependent on material of blades, shape of blades and angle of blade. So, the material of turbine blade plays a vital role in steam turbine. The material blade should posses maximum yield strength, corrosion property, material damping etc. The main objective of this paper is to discuss different material as candidates for turbine blade. After the material selection the turbine blade analysis can be done by ANSYS. For this we take a SST-200 turbine model.

KEYWORDS: steam turbine, blade material, ANSYS

1. Introduction

Today most of electricity produce throughout the world is form steam turbine power plant. The steam turbine is simplest and most efficient engine for converting large amount of heat energy into mechanical work. Steam turbines are applied in wide verity of industries to drive pump, compressor generator and other rotating equipment, usually in a facility where steam is available for other reasons.

SST-200 steam turbines are part of a modern range of Siemens steam turbines developed to meet the most demanding customer requirements for cost-efficient power generation and mechanical drive applications in power plants and industrial environments.

This is achieved by using a highly modularized system well proven design features. Its development is based on experience accumulated during a century of steam turbine design, manufacturing and operation. The SST range of our turbines covers the complete spectrum from 2 to 180 MW and are available in back pressure, condensing and extraction design.

Turbine rotors used in power plants are subjected to high temperature especially during start up cycle. The rotor of steam turbine is subjected to temperature variations in short periods of time due to the start and stop cycles of the turbine. This causes sudden changes in the temperature with transient thermal stresses being induced into the turbine rotor. The transient effect is due to the changes in the material properties like Density, Specific heat and Young's Modulus.

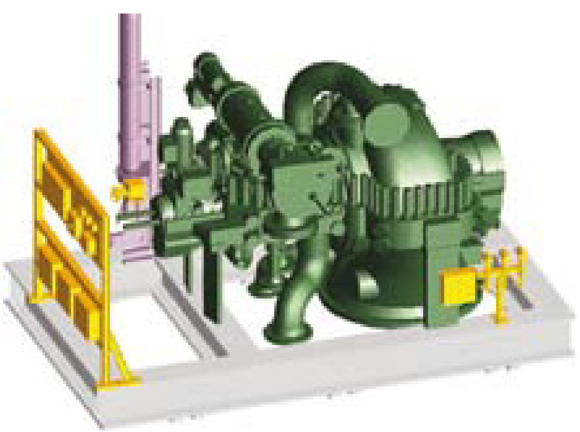

Fig-1 SST-200

1.1 Selection of material

A material is that out of which anything is or may be made. Many number of factors are affecting for the material selection. They are properties of materials, , material's reliability, safety, performance requirements environmental conditions, availability, recyclability disposability and, and finally economic factors. In these properties:-

1) One of the most important factors affecting selection of materials for engineering design is the properties of the materials. The important properties of the materials are mechanical, thermal, chemical properties etc.
2) The material of which a part is composed must be capable of performing a part's function without failure.
3) Physical attributes such as configuration, size, weight, and appearance sometimes also serve functional requirements can be used.
4) A material is must be reliable.
5) A material must safely perform.
6) The environment in which a product operates strongly influences service performance.
7) A material must be easily available, and available in large enough quantity, for the intended application.
8) The cost of the materials and the cost of processing the materials into the product or part. The development and manufacture of satisfactory products at minimum cost is to make a sound, economic choice of materials.

The material selection process involves the following major operations:

- Analysis of the materials application problem.
- Translation of the materials application requirements to materials property values.
- Selection of candidate materials.
- Evaluation of the candidate materials.

The optimal design of the rotor blades is today a complex and multifaceted task and requires optimization of properties, performance, and economy.

1.2 Material Considerations

There are three basic properties that any Material must possess at a satisfactory level in order to perform satisfactorily in any application. These are:

- Strength
- Ductility
- Toughness.

It is generally known that rotors made of high performance still such as 12Cr steels is used a material in high temperature and high pressure region, as this type of material has an appropriate strength and creep capability for such operating condition. However, manufacturing an entire rotor from such a steel material may be expensive and impractical.

Steel is an alloy of iron and carbon. Older style steam turbines were designed with heavier steel blades or nickel alloy steels which have higher inertia, and rotated at speeds governed by the AC frequency of the power lines. The high inertia buffered the changes in rotation speed and thus made power output more stable. The purpose of nickel alloy is lowers the critical temperatures of steel and widens the range of successful heat treatment. Nickel alloy possesses good corrosion and oxidation resistance. Alloy steel was once thought to be an optimum choice for blade fabrication, but was soon abandoned because of its high weight and low fatigue level.

The cost of component and equipment properly designed in titanium is never as high as the price by weight. The strength lower density and good corrosion resistance of titanium are all factor which keep its cost down.

3. Design

3.1 Steam Turbine rotor Model

A thermal analysis calculates the temperature distribution and related thermal quantities in steam turbine casing.

Fig2 : Creo design of rotor

A thermal analysis calculates the temperature distribution and related thermal quantities in a system or component. The thermal quantities are:

- The temperature distributions.
- The amount of heat lost or gained.
- Thermal gradients.
- Thermal fluxes.

4. Analysis result

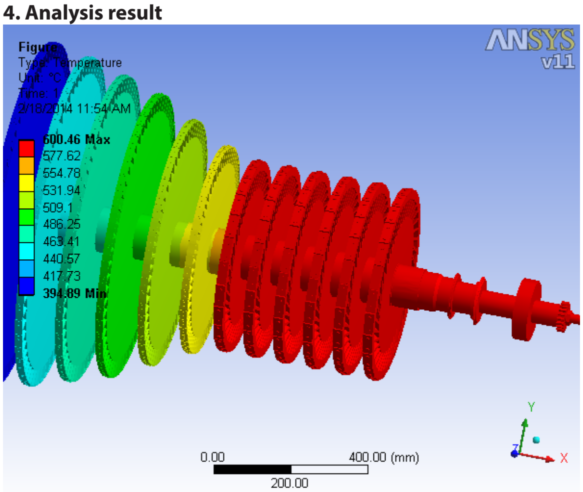

Fig3.1: Temperature Distribution in cast iron rotor

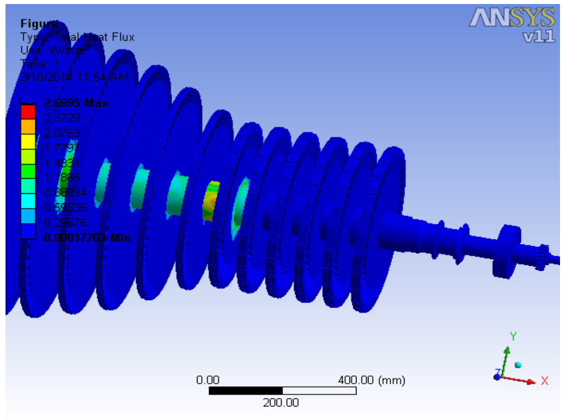

Fig3.2: Heat flux Distribution in cast iron rotor

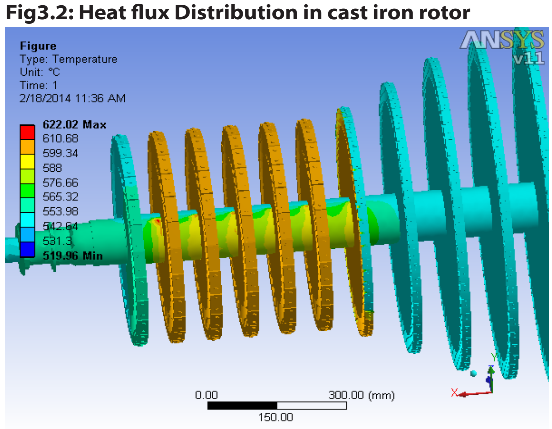

Fig3.3: Temperature Distribution in Cu-Ni alloy rotor

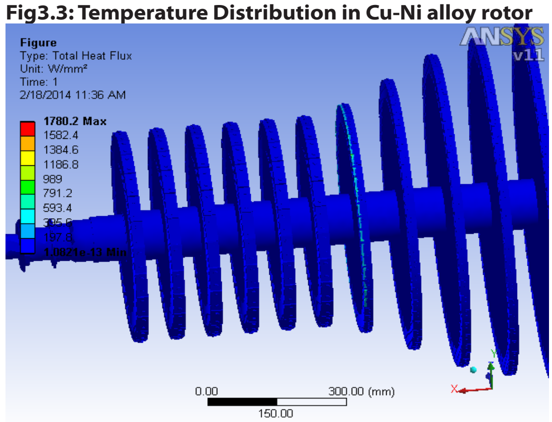

Fig3.2: Heat flux Distribution in Cu-Ni alloy rotor

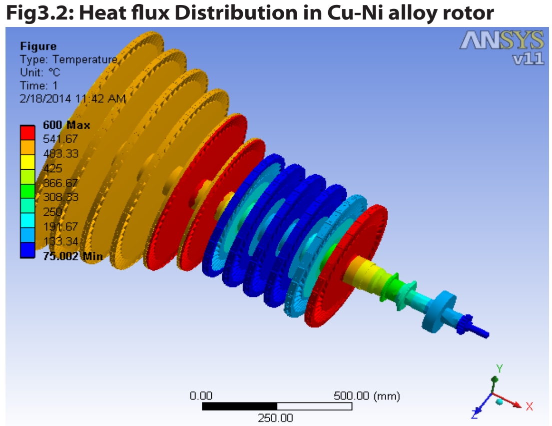

Fig3.3: Temperature Distribution in Titanium alloy rotor

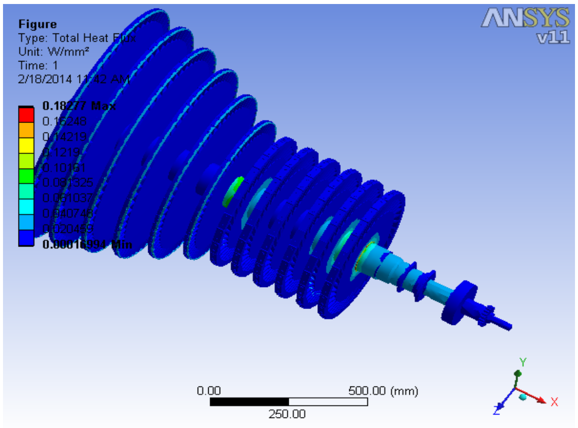

Fig3.2: Heat flux Distribution in Titanium alloy rotor

4. Conclusions

In this paper, we discussed the material selection for steam turbine blades using ANSYS. From analysis project we can approve the titanium alloy as a good material for rotor of Steam turbine because it have good thermal properties, light in weight so work cycle can be improved and cost effectively. The titanium alloy can provide constantly high performance, reliability and operating flexibility at moderate prices for competitive life cycle costs.

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