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RAPID COOLING OF CASTING METALS BY USING BRINE SOLUTION

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Abstract :The project aim is to study method of rapid cooling of casting metals using brine solution for the mass production of pistons. The pistons are made of aluminium alloy.

The main factors described in this project is designing of the chillers , And volume flow rate of brine solution and heat removal rate of casting unit and mainly the efficiency of the system .And in this project is discussed with what are different rapid cooling methods and factors considered.

The designing of the geometry is made by taking considered from articles likes science direct, iop science and to know the different values heat and mass transfer data book psychrometric chart steam table are used.

The design of the piston is created in Creo parametric software and then imported and analysis of the piston is rendered in Ansys software for precise thermal Analysis.

The main motto of the project is not only to rapid cooling but to know the material properties when rapid cooling is done and the improvement techniques of material properties.

Keywords : Brine solution, chillers, piston (aluminium alloy),Ansys, psychrometric chat, steam table.

I.INTRODUCTION TO HVAC

A.*Brief History:*

1) HVAC is based on inventions and discoveries made by Michael Faraday, James Joule, William Rankine.First comfort air conditioning system, which was designed in 1902 by "Alfred Wolff" (Cooper, 2003) for the New York Stock Exchange, while Willis Carrier equipped the Sacketts-Willems Printing Company with the process AC unit the same year. Coyne College was the first school to offer HVAC training in 1899.

HVAC stands for heating, ventilation, and air conditioning. This system provides heating and cooling to residential and commercial working places.

Heating :Heaters are appliances whose purpose is to generate heat for in required place. This can be done by using central heating. Such system contains a boiler, furnace, or heat pump to heat water, steam.

Ventilation : Ventilation is the process of changing or replacing air in any space.To control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide.

Air Conditioning : An air conditioning system, or a standalone air conditioner, provides cooling or humidity control for all or parts of the system. Outside, fresh air is generally drawn into the

system by a vent into a mix air chamber for mixing with the space return air. Then the mixture
air enters an indoor or outdoor heat exchanger section where the air is to be cooled down.

2) *The Manufacturing Process (Casting process)*:

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.

3) *Steps Involved in Manufacturing:*

Mold cavity, Melting process,Pouring technique, Solidification process, Part removal process, Post processing.

4) *Steps Involved in Casting Process* :

While each casting method creates unique challenges and process enhancements, all techniques retain the same basic steps. These steps are:

Pattern Making,Core making, Molding, Melting and Pouring,Finishing.

B. *Heat treatment processes of casting:*

Heat treatment is the process of heating the metal, holding it at that temperature, and then cooling it back. During the process, the metal part will undergo changes in its mechanical properties. This is because the high temperature alters the microstructure of the metals.

1)Rapid cooling : Rapid cooling using a cool solution (e.g. water, oil) from the solution treatment temperature to obtain a supersaturated solid solution of alloying elements in the host metal.

Quenching :It is a type of metal heat treatment process. Quenching involves the rapid cooling of a metal to adjust the mechanical properties of its original state. To perform the quenching process, a metal is heated to a temperature greater than that of normal conditions, typically somewhere above its recrystallisation temperature but below its melting temperature. The metal held at this temperature for a set time in order for the heat to “soak” the material. Once the metal has been held at the desired temperature, it is quenched in a medium until it returns to room temperature. The metal also may be quenched for an extended period of time so that the coolness from the quenching process is distributed throughout.

Quenching Media :There are a variety of quenching media available that can perform the quenching process. Each media has its own unique quenching properties. Considerations for the type of media use include quenching speed, quenching media environmental concerns, quenching media replacement, and quenching media cost. Here are the main types of quenching media:

Air,Oil,Water,Brine.

2)*Purpose of Rapid Cooling and Quenching Processes:*

Before hardening, cast steels and iron are of a uniform and lamellar (or layered) pearlitic grain structure. This is a mixture of ferrite and cementite formed when steel or cast iron are manufactured and cooled at a slow rate. Pearlite is not an ideal material for many common applications of steel alloys as it is quite soft. By heating pearlite past its eutectoid transition temperature of 727 °C and then rapidly cooling, some of the material's crystal structure can be transformed into a much harder structure known as martensite. Steels with this martensitic structure are often used in applications when the workpiece must be highly resistant to deformation, such as the cutting edge of blades. This is very efficient.Rapid cooling is sometimes required during industrial production processes.

Liquid nitrogen (LIN) and carbon dioxide (CO2) are popular cooling agents due to the low boiling point (-196°C) and the low sublimation point of CO2 (-78,5°C).

3)*Quenching in Brine solution :*

Brine quenching, or salt bath quenching, has the fastest cooling rate. Brine is a solution of water and salt. Salts have been used in the quenching process for many of years. They have a wide operating temperature range, and can minimize problems involving iron and steel and Aluminium parts.The rate of cooling is relatively rapid during quenching in brine, somewhat less rapid in water, and slow in oil. Brine usually is made of a 5 to 10 percent solution of salt (sodium chloride) in water. In addition to its greater cooling speed, brine has the ability to "throw" the scale from metals during quenching. Quench hardenable aluminum alloys are typically quenched in cold water. When cracking or distortion is encountered.By using brine solution of -15oc to -25oc the Al alloy material is quenched and the required properties of piston is obtained. Finally the coarse grain structure is octane.

C. *Problem Statement* :

HVAC system for Rapid cooling of casting using brine solution is a essential process to acquire most suitable grain structure and god mechanical properties. The heat energy and flow rate calculations are modified by deep analyses of the process. Brine solution gives the essential characteristics to the casted product, it also removes scale formation. In this the tempeture maintenance, and heat loads and flow rate o brine solution and chillers temperature are described and by evaluation the suitable equipment and thermal condition like pouring temperature maintaining brine temperature and volume flow rate is analyzed.

D. *Results :*

Heat removal rate at Casting Unit = 9402.75 KJ/s.

Heat removal to be done by brine = 9646.84 KJ/s.

Efficiency of system = 9402.75/9646.84 *100 = 97.46 % heat flow rate to chiller and 2.53 % is wastage.

System design parameters:

1. Amount of heat in process = 9646.84 KJ/s or KW

2. Flow rate of brine required for rapid cooling sigh 30 S = 91.92 Kg/s or 0.082 m3/s.

3. Refrigerant chosen = 20% NACL based brine solution. , Heat capacity = 103.83 KJ/kg.

4. Cooling tower flow rate required = 0.082+0.082*0.3 = 0.0492 m3/s.

5. Quantity of water vapor : Heat lost in vaporization = 9646.84-9402.75 = 244.09 KJ/s Enthalpy of vaporization = 2257 KJ/kg Vapor formed due to quenching = 244.09/2257 = 0.108 Kg/s Density = 0.59 kg/m3 Volume flow rate of Water Vapor = mass flow rate/* density = 0.108 /0.59 = 0.183 m3/s.

6. Ventilation Air flow rate for 0.183 m3/s of water vapor. Exhaust air flow rate : Q = Latent Heat factor * Change in humidity Assume, 30ºC air temperature and 30 % relative humidity before quenching. Humidity ratio = 0.012 Kg/kg Added Humidity = 0.108+ 0.012 = 0.12 Kg/kg = Change in humidity Flow rate = Latent heat factor * Change in humidity = 0.0126*0.12.
Flow rate of air = 0.0012 m3 /s .

II. LITERATURE SURVEY

A. Wladyslaw : The use of water mist cooling of die can increase the efficiency of aluminium alloys Wladysiak (2013) investigated the effect of water mist cooling on the properties of hypoeutectic AlSi7Mg alloy and also indicated optimal process

parameters .Yamaga et al. (2008) reviewed the positive influence of intensive die cooling, resulting in the rapid solidification of mechanical properties and the quality of castings. Heat transfer efficiency causes a reduction in the primary Si particle size and a decrease in secondary dendrite arm spacing as reported by Shabestari and Malekan (2005). The equivalent diameter of the primary Si decreased from 89.7±17.3 to 16.5±3.8 μm and the SDAS from 22.1±5.9 to 5.1±0.8 μm, with an increase in the cooling rate from 4.9 to 82.9 K/s.

B. N. Vellu Vakkandi : In permanent mold casting, die design for cast aluminium alloy and magnesium alloy products includes a number of high conductivity material cooling blocks (also called channels or cooling circuits) that are aimed to extract heat away from molten metal through direct conduction heat transfer and freeze the casting as quickly as possible in a directional manner.One of the biggest problems during this solidification process occurs when the molten metal naturally shrinks away from the mold as it solidifies. This makes it increasingly difficult to efficiently and effectively cool targeted areas in the casting through conduction, since the direct contact between the solidifying casting and the cooling block is significantly reduced or even lost.

C. A.Stotter: This paper presents the results of an experimental investigation in the effectiveness of various cooling methods of pistons in internal combustion engines. The advantages and disadvantages of different methods are stressed and quantitative data are obtained for calculation and prediction of piston temperatures. The methods discussed are: no oil cooling, cooling from a pressure lubricated small end, jet cooling, and "cocktail shaker." The maximum piston temperature must be controlled to prevent premature piston wear and engine damage. The piston can be cooled by an oil spray jet directed at the bottom of the piston, or by oil flowing through a cooling channel or gallery that is incorporated into the piston.

D. Design of Piston by using CREO Parametric :Creo Parametric provides the broadest range of powerful yet flexible CAD 3D modeling software capabilities to accelerate the design of parts and assemblies. With Creo and its extensions, you'll have access to technologies such as: Generative design. Real-time simulation. Additive manufacturing.

PTC began developing Creo in 2009, and announced it using the code name Project Lightning at PlanetPTC Live, in Las Vegas, in June 2010.[2] In October 2010, PTC unveiled the product name for Project Lightning to be Creo.[3] PTC released Creo 1.0 in June 2011.[4]

Creo apps are available in English, German, Russian, French, Italian, Spanish, Japanese, Korean, Chinese Simplified, and Chinese Traditional. The extent of localization varies from full translation of the product (including Help) to user interface only.

Creo is part of a broader product development system developed by PTC. It connects to PTC's other solutions that aid product development, including Windchill for Product Lifecycle Management (PLM), Mathcad for engineering calculations and Arbortext for enterprise publishing.

E. Thermal Analysis By Using Ansys Software :Ansys software :ANSYS Workbench is a new-generation solution from ANSYS that provides powerful methods for interacting with the ANSYS solver functionality. This environment provides a unique integration with CAD systems, and your design process, enabling the best CAE results.

The ANSYS Workbench platform is the backbone for delivering a comprehensive and integrated simulation system. Using Workbench for your product development simulations will result in higher productivity from integrated applications and access to multiphysics and systems level capabilities.

Thermal Analysis of Piston :The design of piston is created and it is imported into Ansys software.In Ansys software by giving different inputs like convective heat transfer coefficient, temperature, material[h = 60 w/m2c, T=727ºC, Aluminium alloy] the thermal stresses, heat distribution within the piston and factor of safety deformation is rendered.

REFERENCE

[1]Wlady saw: Effect of Water Mist Cooling on Microstructure of Hypereutectic Al-Si Alloy. DOI: 10.2478/afe-2014-0074 Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences ISSN (2299-2944) Volume 14Issue 3/2014 117 – 122.

[2]Velluvakkandi:Developing an Effective Die Cooling Technique For Casting Solidification.A thesis submitted in fulfilment of the Master of Engineering School of Engineering Auckland University of Technology July 2009.

[3]A.Stotter: Heat Transfer in Piston Cooling at the time of water bath,and solidifying. SAE Transactions Vol. 75, SECTION 3: Papers 660463–660786 (1967), pp. 705-710 (6 pages) Published By: SAE International.