

# An Experimental Investigation on Heat Transfer Rate with Different Cooling Media for Heat Treatment Operations

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**Abstract**—RRR concept is plays a vital role in metallurgical (Heat treatment) operations. First R is selection of right cooling media has (Good thermal, electrical and chemical properties) and uniform cooling and diminish the vapor blanket around the heated specimen. Second R is reducing the distortion and internal stress material becomes strong. Third R is refinement of grain structure it leads sound mechanical properties. An attempt is made in this work an ideal quenching medium like base solution (CU) provides a faster cooling rate in higher temperature range and a slow cooling rate in the low temperature range thus satisfying the requirements of an ideal quenching medium.

**Index Terms**—Base solution, cooling media, grain refinement, specimen, vapor blanket.

## I. INTRODUCTION:

The success of quenching [1] procedure during industrial heat treatment mostly depends on the heat transfer characteristics of the quenching medium. The opportunity to alter the system or operational parameters in the event of quenching is quite limited, thus, the focus should instead be on creating quench media with improved heat transfer properties. Recent research on Nano fluids has demonstrated that these fluids have better heat transmission and wetting properties. Furthermore, compared to mineral oil quench media, water-based Nano fluids are more environmentally friendly. In order to [2] compete in today's market, the modern metal forming industry has fully embraced and benefited from the new processes. The modeling of solidification, a phase-change phenomenon, is extremely important in many fields of science and engineering as well as in the sphere of automotive and aerospace applications. When molten metal is poured into a mould cavity in the field of

foundry engineering, the metal solidifies, emits heat into the mold, and contracts as a result, creating an air gap between the cast and the mould. In this chapter, the [3] fundamentals of heat transfer and its applications, the classification of heat transfer technology and different heat transfer techniques, the needs for augmentation and its advantages, and various combinations of two or more inserts and integral roughness elements for heat transfer augmentation purposes have all been introduced. It has been demonstrated that for improving heat transfer, the majority of compound approaches outperformed the individual inserts. The alkali nature [4] of cow urine as a cooling medium for metallurgical operations was investigated in this study paper. Cow urine's alkaline composition makes it an excellent electrolyte drink. The vaporization of liquids during quenching is one of the most frequent processes. Due to Leiden, the frost phenomenon causes uneven residual stress, fracture distortions, and avoids homogenous quenching throughout this phase. The selection [5] of the suitable cooling medium is one of the most important factors in metallurgical processes since it affects how well metals and alloys' mechanical characteristics and grain structure are refined. choosing the best cooling medium to provide the fastest cooling rate while causing the least amount of metal and alloy distortion. The researchers noted that the Multi Criteria Decision Making (MCDM) problem has many objectives in this work. The alternative rankings are generated using the method TOPSIS, and the criteria weights are estimated using the method entropy (Technique for Order of Preference by Similarity to Ideal Solution). In this method, the ideal cooling media for metallurgy are determined from six choices. The conversion [6] of heat into energy occurs in a vast array of industrial

activities. An important industrial requirement is the addition, removal, or transfer of thermal heat throughout an industrial plant from a single cycle source. For the recovery of energy or packaging material, all systems offer heating or cooling techniques. The fluid's ability to transport heat is decreased when the particles quickly settle to create a surface layer. Review of the majority [7] of heat transfer augmentation techniques that aid fins and micro fins in improving heat transfer. Using joint-fins, fin roots, networks, convections, permeable fins, porous fins, liquid metal fins that have been encapsulated, and helical micro fins are a few of these. It is discovered that there is little consensus regarding single phase heat transfer enhanced by micro fins among the works of the many writers. Yet, in the case of two-phase heat transfer enhanced by micro fins, too many works with sufficient agreements have been completed. The fact that [8] the governing equations used to describe different flow and transport phenomena in porous media are typically based on the same type of mass and/or energy conservation rules allows for the efficient passage of heat through porous media. Local distributions of the Nusselt number along the flow direction rise as the Reynolds number and porous layer thickness increase, but they also increase as the Darcy number decreases. A new type [9] of cooling technology called intermittent spray cooling has the potential to improve spray cooling efficiency while lowering energy usage. The intermittent spray cooling three-dimensional simulation model is used in this paper for the first time to examine the intermittent spray cooling heat transfer characteristics. According to the simulation results, the spray cycle and duty ratio can be changed to maximize the intermittent spray cooling effect, and the ideal spray cycle and duty ratio are found at lower flow rates. One passive [10] method of improving heat transmission in heat exchangers is the placement of porous materials in the fluid path. The effect of using porous environments with varying porosity percentages, genders, and geometric structures in the flow path, as well as numerical simulations and laboratory investigations, on enhancing the quantity of heat transfer in heat exchangers was explored in this research. Studies have demonstrated that the inclusion of porous media in the flow channel enhances the thermal conductivity matrix and effective heat capacity of the flow, however each outcome is dependent on the specific instance and its

circumstances. The main purpose [11] of heat treatment is to change the steels' physical characteristics. To improve mechanical qualities and extend product life, steel components are often quenched in a forced gas, oil, or water flow after being heated. Rapid heat transfer from the hot metal component to the surrounding quenching medium occurs during the quenching process. Due to the heated component's surface cooling more quickly than its core during the quenching process, there is a temperature gradient. The samples [12] were heated in a variety of ways (normalizing, hardening, periodization, recrystallization, annealing), and the outcomes were compared to samples not heated. The severity of the fire is shown to be inversely correlated with the resulting considerable change in the mechanical properties of the steel bars. High temperature bars so made a significant variation in overall performance visible, and vice versa.

## II. COOLING MEDIA PROPERTIES:

Before the selecting the cooling, media is properties very crucial to decide micro structure and mechanical properties of metals and alloy.

- (a) Temperature of the coolant: Coolant temperature decides the how effectively heat transfer to specimen to coolant.
- (b) Boiling Point: Lesser boiling point of coolant, more easily the vapors from to increase the stage of cooling, which provide slower rate of cooling. Higher boiling point should provide better cooling rate.
- (c) Specific heat of coolant: Amount of heat required to raise the temperature of one gram of a substance by one Celsius degree. Coolant which low specific heat will get heated up at a faster rate than the one with higher specific heat.
- (d) Latent Heat of Vaporization: A coolant with Latent heat of vaporization changes into vapor easily that is provides slower cooling rate.
- (e) Thermal conductivity: A coolant with high thermal conductivity transfers the heat rapidly from the component to its entire mass increasing thereby cooling rate of component.
- (f) Viscosity: High viscosity conducts the heat slowly. Low viscosity not only provide faster cooling rate, but decreases the vapor blanket stage.

III. EXPERIMENTAL WORK:

Lumped Heat Capacity Analysis (LHCA): When there is no temperature gradient, the lumped-heat-capacity technique of analysis is applied. This indicates that in compared to the exterior resistance (convection), the body's internal resistance (conduction) is insignificant. that is, tiny heat transfer coefficient (h) and high thermal conductivity (k).

Biot Number: It measures the ratio between the resistance to heat transfer inside a body and at its surface. Number demonstrates the relationship between the convection and conduction heat transfer phenomena. This number's low values indicate that conduction is the primary means of heat transmission. High values of this number suggest that convection is the primary means of heat transport.

$$\frac{T - T_{\infty}}{T_0 - T_{\infty}} = e^{-\frac{hA}{\rho CV}t} \quad \text{----(1)}$$

K = conductivity of Al 2585W/m<sup>0</sup>C  
 C= 0.8 Kj/kg<sup>0</sup>C  
 Density = 3000kg/m<sup>3</sup>  
 T= Intermediate temperature

T<sub>0</sub> = Initial Temp  
 T<sub>∞</sub> = Liquid temperature  
 A<sub>s</sub> = π d l = 0.012566 m<sup>2</sup>  
 d = 20 mm = 0.02 m  
 l= 200 mm =0.2m

Lc = 0.02m =  $\frac{R}{2}$  = 0.01  
 Volume of the cylinder = πR<sup>2</sup>L = 0.000062831 m<sup>3</sup>  
 In Reverse Engineering Specimen Temperature is 530 to reach 100<sup>0</sup>C (Time taken is 3.5 milli sec)

Quenching Media: COW URINE  
 $\frac{100-26}{530-26} = 0.146825 = \ln(6.8108)$   
 = 1.91851  
 $h = \frac{1.91851 \times 0.1507944}{0.043981} = 6.577 \text{ W/m}^2\text{K}$   
 $Bi = \frac{hl}{k} = \frac{6.597 \times 0.01}{214}$   
 $\frac{Q}{A} = h \Delta T = 6.577 \times 504 = 3314.8 \text{ W/m}^2$

Quenching Media: Water 5 sec  
 $h = \frac{1.91851 \times 0.1507944}{0.06283} = 4.604 \text{ W/m}^2\text{K}$   
 $Bi = \frac{4.604 \times 0.01}{214} = .000215$   
 $\frac{Q}{A} = h \Delta T = 4.604 \times 504 = 2320.416 \text{ W/m}^2$

Quenching Media: Distilled Water 5.5 sec  
 $h = \frac{1.91851 \times 0.1507944}{0.069113} = 4.1859 \text{ W/m}^2\text{K}$   
 $Bi = 0.0001956$   
 $\frac{Q}{A} = h \Delta T = 2109.69 \text{ W/m}^2$

Quenching Media: Soap Nut solution 6.3sec

$$h = \frac{1.91851 \times 0.1507944}{0.07916} = 3.6546 \text{ W/m}^2\text{K}$$

$$Bi = \frac{hl}{k} = \frac{3.6546 \times 0.01}{214} = 0.00017$$

$$\frac{Q}{A} = h \Delta T = 3.6546 \times 504 = 1841.91 \text{ W/m}^2$$

Quenching Media: Shikakai Nnt Solution 7 sec

$$h = \frac{1.91851 \times 0.1507944}{0.087962} = 3.288 \text{ W/m}^2\text{K}$$

$$Bi = \frac{hl}{k} = \frac{3.288 \times 0.01}{214} = 0.000153$$

$$\frac{Q}{A} = h \Delta T = 3.288 \times 504 = 1657.15 \text{ W/m}^2$$

Quenching Media: EO 10 sec

$$h = \frac{1.91851 \times 0.1507944}{0.12566} = 2.3022 \text{ W/m}^2\text{K}$$

$$Bi = \frac{hl}{k} = \frac{2.3022 \times 0.01}{214} = 0.000107$$

$$\frac{Q}{A} = h \Delta T = 2.3022 \times 504 = 1160.30 \text{ W/m}^2$$

V. CONCLUSION

Cooling media properties plays vital role to decide sound micro structure and mechanical properties. Above cooling media cow urine better cooling properties it is generally alkaline nature (base). It is one more option (quenching media) for metallurgical operations.

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