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Significance of Biot and Grossman Number On Conduction and Convection Heat Transfer for Different Quenching Media

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Abstract : In heat treatment process when metal or alloy heated and quenched quenching media(cooling media). Heat transfer rate is uniform metal or alloy becomes good mechanical properties. Fluid mechanics and heat transfer study the dimensionless number and its importance each number has its own characteristics like Reynolds number indicates resistance to flow and Biot number indicates mechanism of heat transfer that is convection and conduction, number is high indicates internal resistance in the object is higher than external resistance, conductive is less indicates resistance of an object is higher than external resistance. Grossman number indicates quench severity of different quench media, the current work presents an effective heat transfer coefficient between the solid and fluid for large Biot number.

Index Terms: Biot number, Cooling media, Grossman number, Heat transfer, Quench severity

I. Introduction

So far in metallurgical operations nearly twenty five cooling media used, each media has its own properties and show its effect on mechanical properties and micro structure, whenever cooling takes place residual stress are locked in within a metal or alloy, even though the object is free of external forces. Inner portion will have a residual tensile stress and outer portion of the component will have a residual compressive stress. Therefore, the engineering challenges on producing a good parts hinge on choosing the right cooling media, designing optimal quenching process and tightly controlling the quench power of the quench media one of the index commonly referred in many literatures for quantifying quench severity is Gross man number (is the ratio of heat transfer coefficient and thermal conductivity), Biot number is the ratio of heat transfer resistance inside and at the surface of the body. Nano fluid's[1] stable two-dimensional (2D) stretched flow has been assessed. The Darcy-Forchheimer model is characterized by an incompressible Nano fluid that saturates the porous region. The surface temperature is controlled using a convection heating procedure as determined by the heat transfer coefficient. The flow was produced by applying a linear stretching surface with a homogeneous magnetic field. In a variety of applications, [2] such as nuclear reactors and fossil fuel sources, the thermal conductivity of porous materials is temperature-dependent. The thermal interactions between the solid and fluid phases inside the porous media are frequently studied using the LTNE (local thermal none equilibrium) model. The majority of earlier LTNE models made the assumption that the thermal conductivities of the fluid and solid phases were constant, while in reality, they are temperature-dependent. The Biot number $Bi > 0.1$ is [3] examined, and it is found that rising Biot number enhances the friction coefficient, along with increasing Nusselt and Sherwood number. Via tables and graphs, the impact of relevant constraints on various flow parameters is identified and examined. The effect of emerging non-dimensional [4] parameters on velocities and temperatures in the boundary layer regime is thoroughly assessed. These parameters include the third grade fluid parameter, the material fluid parameters, the magneto hydrodynamic parameter, the Biot number effect, and the Prandtl number. In order to[5] forecast the variation of the temperature field in a long slab and cylinder, a better lumped parameter model has been adopted. For both slab and tube geometry, the transient conduction equations are solved using the polynomial approximation method. Many models, including heat generation in both slab and tube as well as boundary heat flow for both slab and tube, have been examined. In order to arrive at a generic answer, several estimate temperature profiles have been made for both slab and cylindrical form. Based on the research, a modified Biot [6] number that forecasts temperature variation regardless of the problem's geometry has been developed. This article examines the flow and heat transport on a stretching, permeable sheet of magneto hydrodynamic Nano fluid under the influence of convective boundary conditions. The law of conservation of mass, momentum, heat, and concentration of nanoparticles are modeled mathematically. The purpose of this paper[7] is to examine the impacts of two-dimensional magneto hydrodynamic mixed convective Prandtl Nano fluid flow, heat and mass transfer, chemical reaction, and velocity slip boundary condition over a stretching sheet in the presence of convection. The three-dimensional [8] flow of an incompressible Nano fluid across an exponentially extending sheet in conjunction with a convective boundary condition has been studied under the effects of non-uniform permeability, thermal radiation, and changing chemical reactivity. Due to [9] their extraordinary thermal conductivity and distinctive characteristics, tiny particles are crucial in electronics, heat exchangers, nanotechnology, and materials research. The work examines the MHD flow over a stretching cylinder holding a silver-water Nano fluid in the presence of a magnetic field under a variety of convective boundary conditions over a stretching sheet and stretching cylinder. The numerical code is verified by earlier[10] research. It is thoroughly investigated how the Weissenberg number (We), power law index (n), Prandtl number (Pr), Biot number (and dimensionless tangential coordinate) influence the evolution of velocity and temperature in the boundary layer regime. Investigations are also conducted on how these characteristics affect skin friction and heat transfer rate.

2. Experimental work

Present work six cooling media used for metallurgical operations like (Cow urine, Tap water, Distilled water, Engine oil, Soap nut and Shikakai Nut solution). Maruthi rao etal, (JPNR), specimen heated at 500^0C (Al 2585) alloy quenched above media temperature of specimen reached 100^0C. As per LHCA Biot number and Grossman number found that is mode of heat transfer and quench severity which media is higher.

3. Formulae used

LHCA (Lumped Heat Capacity Analysis) (1)

$$-hA_s(T - T_\infty) = \rho V c \frac{dT}{dt}$$

Biot Number (2)
hl/k

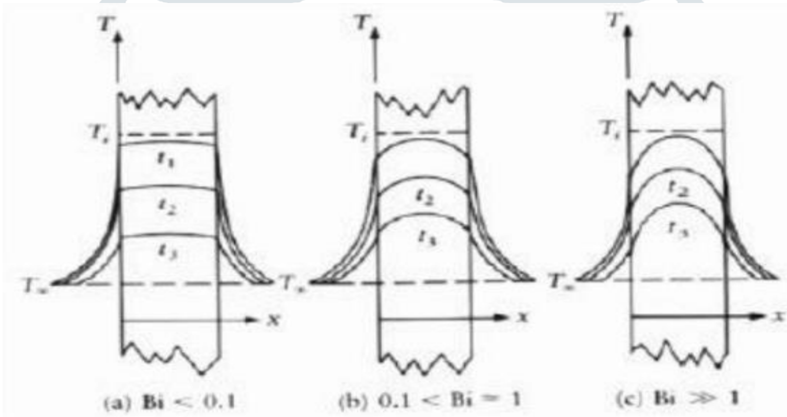

Fig 1.Relationship between Biot number and the temperature profile

Grossman Number (3)
h/2k

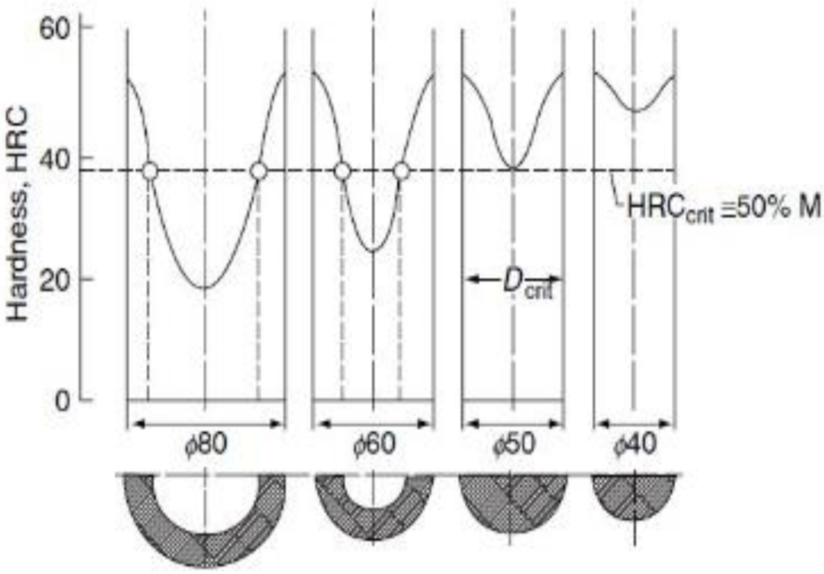

Fig 2. Grossmann's Hardenability test

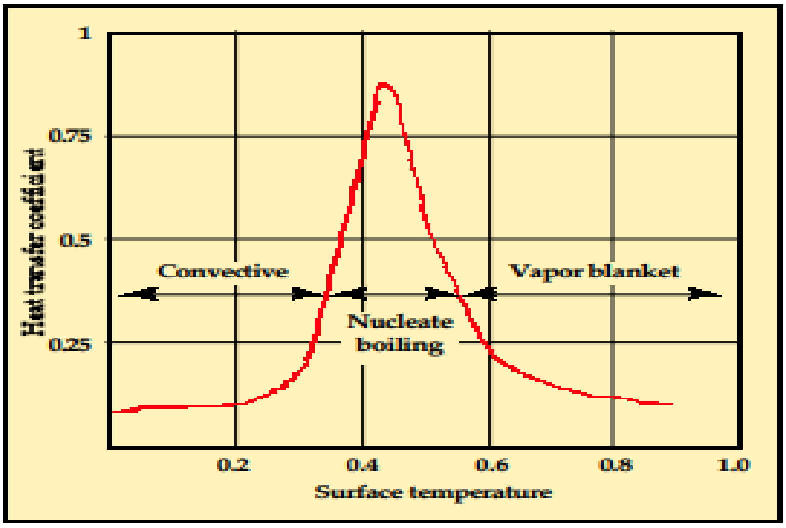

Fig 3. Heat transfer coefficient and the three regimes of heat transfer.

Table: Indicates Biot number (shows heat transfer mechanism and Gr N indicates quench severity)

S. No	Cooling Media	Biot Number	Grossmann number
1	Cow urine	0.000307	0.0153
2	Tap water	0.000215	0.0107
3	Distilled water	0.000195	0.00977
4	Soap nut solution	0.000170	0.0085
5	Shikakai nut solution	0.000154	0.00768
6	Engine oil	0.000107	0.00474

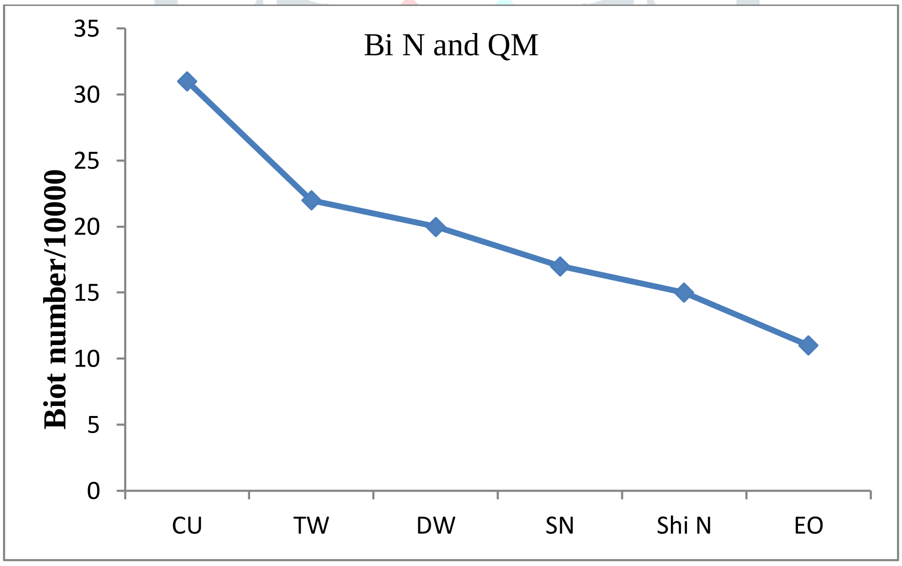

Fig 4. Biot Number and Cooling media

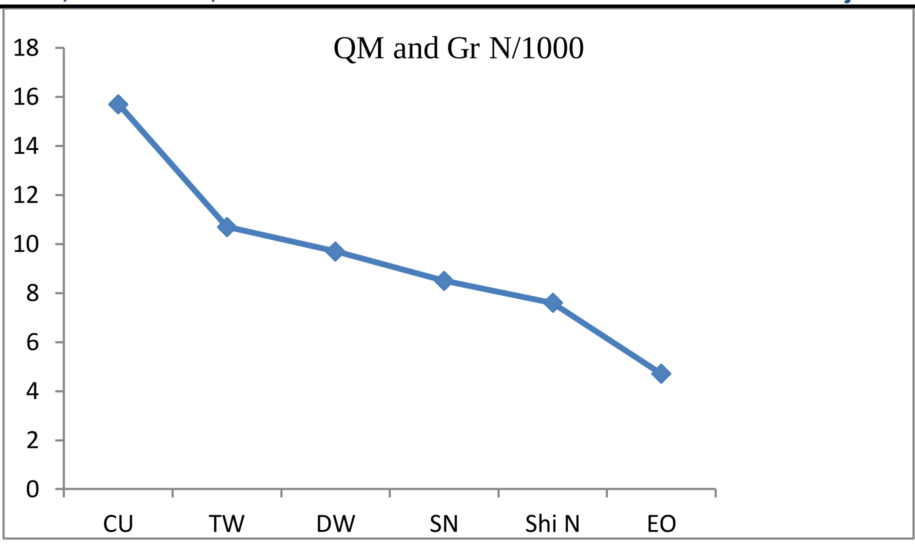

Fig 5. Cooling media and Grossmann Number

Nomenclature:

h - heat transfer coefficient W/m^2K
K - Thermal conductivity W/mK
A_s - Cross sectional area m^2
T - Initial temperature ^0K
C - Specific heat Kj/KgK
T_∞ - Final temperature ^0K
ρ – Density m/v^3
dT - change of temperature - ^0K
dt – time sec
l – length meters

Conclusion:

Biot number shows how convection and conduction heat transfer phenomena are related. Smaller values of this number shows that the conduction is the main heat transfer method. Higher values of this number indicates that the convection is the main heat transfer mechanism. Grossmann number showed that generally alkaline nature of cow urine high quench severity among the cooling medium means fast and uniform quench.

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