To study heat transfer characteristics of medium carbon steel during polymer quenching

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Abstract

After heat treatment Steel elements ar typically quenched in forced gas, oil or water flow to enhance mechanical properties and improve product life. throughout the extinguishing method, heat is transferred quickly from the new metal part to the encircling medium and therefore the fast temperature drop that causes part transformation and deformation within the hot metal part. This fast heat transfer in extinguishing method offers rise distortion, cracking and high residual stresses. to reduce such issues whereas rising mechanical properties, it has to optimize {the method|the method} for each half pure mathematics and extinguishing process style. during this work is concerning getting correct thermal boundary conditions, i.e. HTC distribution. The Medium steel material model behavior throughout extinguishing is to be determined and study the warmth transfer characteristics along side changes in microstructure of steel specimen. the info obtained by experimental work are analyzed and compared with the results from CFD analysis therefore on propose the advance within the existing method to cut back the time and value with the optimized material properties.

Keywords— Heat transfer constant, distortion cracking, quenching, tensile stresses, microstructure.

I. INTRODUCTION

Heat treatment could be a methodology in the main want to alter the physical properties like microstructure and mechanical behavior, and generally chemical properties like carbon concentration, of a cloth or a vicinity. there's typically no material removal in heat treatment processes because it is there within the machining processes like grinding or edge. Typical heat treatment processes embrace those fixing physical properties like extinguishing, tempering, aging, annealing, normalizing, etc. and therefore the processes which involve property changes like carburizing, nitriding, etc. This work studies heat transfer, distortion and material property evolution of steel elements in compound extinguishing.To improve mechanical properties, steel elements ar typically subject to a heat treatment together with extinguishing. extinguishing could be a fast cooling, that prevents low-temperature processes like part transformations from occurring. during this fast cooling method, heat is transferred out from the new elements to the enclosed cool extinguishing media. a big quantity of residual stresses is conjointly developed within the part once quenched notably in water. The existence of residual stresses, specially tensile residual stresses, will have a big damaging influence on the performance of a structural part. In several cases, the high tensile residual stresses may also lead to a severe distortion of the part, and that they will even cause cracking throughout extinguishing or ulterior producing processes.

II. LITERATURE REVIEW

Li Huiping [2006]et al throughout the study of extinguishing method for determination of warmth transfer constant, had conducted the experiments and therefore the inverse heat conductivity approach is employed for determination of HTC. The authors introduces a brand new methodology to calculate the temperature dependent surface heat transfer constant throughout extinguishing method and calculated the surface heat transfer constant consistent with the temperature curve gained by experiment. They explicit that in the calculation method, the phase-transformation volume and phase-transformation heat of transformation of each part in on every occasion interval is calculated simply by FEM. [1]

Peter Fernandes [2006] et al created a trial to see the warmth flux transients throughout extinguishing of Ø28mm×56mm height and Ø44mm×88mmheight AISI 1040 steel specimens throughout lateral extinguishing in brine, water, vegetable oil and oil and therefore the heat flux transients ar calculable by inverse modeling of warmth conductivity. The variation of warmth flux transients with surface temperature for various extinguishing media was investigated in several experiments. Higher peak heat flux transients ar obtained for 28mm diameter specimen than 44mm diameter specimen throughout extinguishing in binary compound medium. The study results in the ultimate conclusion that agitation of extinguishing medium will increase the height heat flux throughout the extinguishing of steel specimen altogether the extinguishing mediums. [2]

Ashok Kumar et al [2010] studied the Sensitivity of fabric properties on distortion and residual stresses throughout metal quenching processes to analyze the impact of thermal, metallurgic and mechanical properties on the ultimate distortion and residual stresses throughout metal extinguishing processes. They use the Finite part methodology (FEM) to resolve the coupled partial differential equations whereas doing this the consequences like part transformation total heat, transformation-induced physical property and dissipation were thought-about. The curvature and the amount averaged effective stresses were thought-about for the mensuration of distortion and residual stresses ,respectively. The sensitivity of the density, heat energy capability, thermal conduction, transformation begin and finish times, martensitic transformation constant, primary solid solution begin temperature, coefficient of elasticity, shear modulus, yield strength and hardening modulus were the most concern during this work. it's found that reduced metallurgic properties, yield stress, associated coefficient of elasticity at the same time lower the distortion and residual stresses for an equal cooling.[3]

A. Buczek et al [2014] throughout the study of warmth transfer constant throughout extinguishing in varied cooling agents authors Measured and evaluated the worth of warmth transfer coefficients (HTCs) at the surface of a metal sample throughout immersion extinguishing, victimization numerical procedures. A FEM self-developed coding system is employed to get an answer to the direct drawback.[4]

III. PROBLEM STATEMENT

To study the heat transfer characteristics of medium Carbon Steel during polymer quenching with the different concentrations of ethylene glycol in water i.e. 20%, 40% and 60% etc.

IV. OBJECTIVES

Present work targeted on simulation of extinguishing method of EN09 rollers for extinguishing medium as glycol solution for various concentration. Objective of this work is to get temperature at completely different|completely different} interval of your time at different location to plot cooling curve for various extinguishing medium. conjointly we have a tendency to ar attending to get HTC for various medium interaction and impact of concentration of glycol on HTC. Temperature distinction between core and surface of specimen may also be obtained from simulation that is helpful for prediction of residual stress formation.

V. METHODOLOGY

The steps taken within the gift experimental work are as:
1. Samples of medium carbon steel are ready for metallographic tests for the mensuration of various parameters.
2. Hardness and toughness are measured and therefore the Microstructures ar determined.
3. the warmth treatment method is then meted out within the chamber at elevated temperature followed by oil extinguishing.
4.Again the specimens ar ready for metallographic tests to watch the variation in material properties.
5.The properties Hardness and toughness were measured when heat treatment and therefore the microstructure is determined.
6.The different readings obtained throughout the experimentation ar wont to plot the graphs.

VI. INSTRUMENTS USED:

1. Laboratory Muffle chamber
2. metallurgic Specimen sprucing Machine
3. moveable Electrolytic Polisher/Etcher
4. Inverted Stage Binocular metallurgic magnifier
5. image Micrographic instrumentality
6.Charpy-Izode Impact Testing Machine
7. Hardness Tester

VII. MATERIAL COMPOSITION

No	Constituent	%
1	Carbon	55%
2	Manganese	9%
3	Phosphorous	0.04%
4	Sulphur	0.05%
5	Iron	Remaining

The model is cylindrical roller with diameter 0.05m and length 0.1m.

Solid specimen boundary conditions:
At t =0 sec, Ts = 1173 k
Quenching medium initial temperature: 298k
Fluid domain size: 4m X 4m X 4m
Fluid domain Boundary Condition: Tm= 298k, P = 1.013 bar

VIII. HEAT TREATMENT OF SPECIMENS

Additional specimens are created for measurement the toughness and hardness before and when termination. Heating is finished by mistreatment muffle chamber for all specimens by heating to900oC and so quenched within the solution of antifreeze with completely different concentrations, finally cooling in outdoors. The temperature vary and hardening/tempering soaking times for the experimental investigations were hand-picked supported the fabric composition of the specimens. when cooling method the specimen ar grinded and polished. Next section is etching by mistreatment mixture of aqua fortis and wood alcohol and so the microstructures of the specimens before and when heat treatment have additionally been determined mistreatment magnifier.

IX. CFD ANALYSIS

The specimen are often sculptural by mistreatment completely different CAD software system whichis compatible with the procedure fluid dynamics software system. For the present modeling, Pro|ENGINEERWILDFIRE five.0 has been used. The models thus shaped ar together with the fluid domain wherever within the effects of the warmth flow has got to be analyzed.

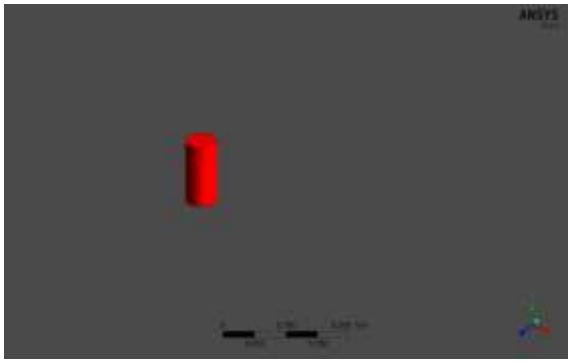

Fig 1 3D model of solid specimen

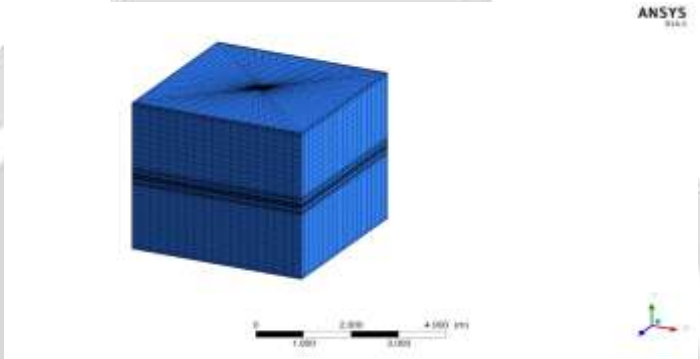

Fig. 2 Meshing Of outer domain

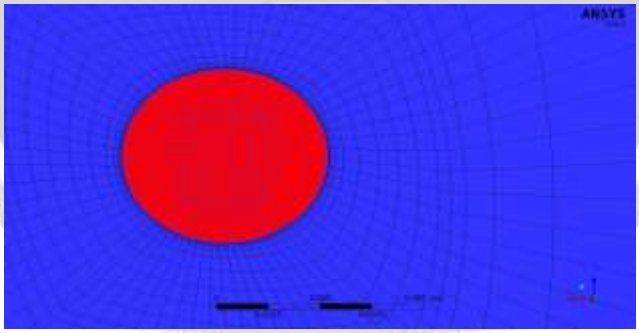

Fig. 3 Top view of solid domain

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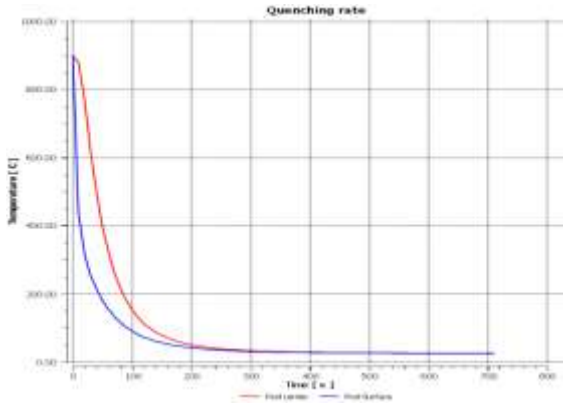
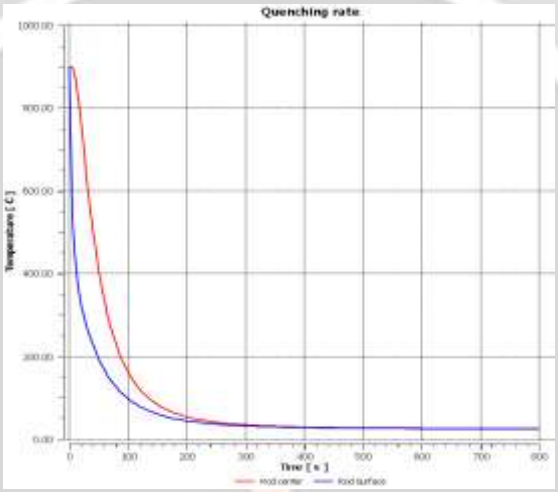
X. RESULT AND DISCUSSION

The thermal performance is analyzed for work to be quenched. completely different trials ar taken by varied termination medium with increasing concentration of antifreeze by mass. The results obtained ar mentioned during this chapter.



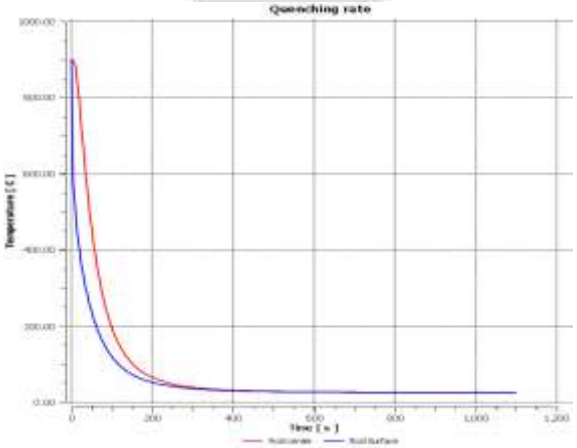
1 .Temperature vs. Time for 0% concentration by mass of ethylene glycol

The higher than graph shows variation of temperature with reference to time for surface and core. we are able to observe giant temperature distinction between surface and core of the specimen. thanks to variation in cooling of surface and core there'll be uneven contraction of fabric of specimen that is accountable for residual stresses.

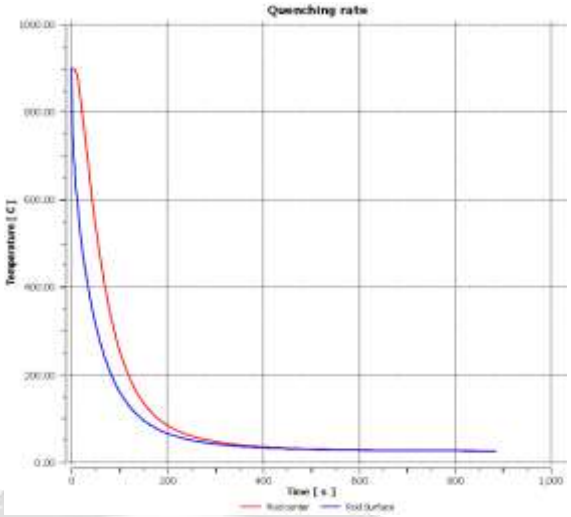


2. Temperature vs. Time for 20% concentration by mass of ethylene glycol

The higher than graph shows variation of temperature with reference to time for surface and core once termination medium is 20% antifreeze resolution by mass. The temperature variation between surface and specimen at explicit instant is a smaller amount compare to previous termination medium that ends up in less residual stress formation compare to previous trial.



3. Temperaturevs. Time for 40% concentration by mass of ethylene glycol



4.Temperature vs. Time for 60% concentration by mass of ethylene glycol

The higher than graph shows variation of temperature with reference to time for surface and core once termination medium is hr antifreeze resolution by mass. The cooling rate is slowest for this trial. As share of ethylene glycol will increase in solution rate of warmth transfer from surface to termination medium decreases. Heat transfer by convection approaches the warmth transfer by physical phenomenon at intervals specimen and therefore gradient between surface and core of specimen is least for this trial. we are able to predict that residual stress formation is least for this trial. As share of antifreeze will increase in termination medium the gradient goes on decreases and it'll end in less residual stress formation. we are able to additionally make sure the formation of solid solution throughout the work piece by scrutiny slowest cooling curve with crucial cooling curve.

XI. CONCLUSION

Based on the outcomes of the warmth treatment and termination method investigations performed on medium steel, the conclusions are:

1) variation in cooling of surface and core there's uneven contraction of specimen which can ends up in residual stress.
2) because the concentration of antifreeze is increased , Temperature variation between surface and core is bated ends up in less stress.
3) As share of antifreeze is increased the warmth transfer rate from the surface is bated.
4) HTC is additional for the recurvate surface of specimen as compared to high and bottom.
5) by ddition of antifreeze HTC decreases.

XII. REFERENCES

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