OPTIMIZATION OF CONTINUOUS CASTING PROCESS IN STEEL MANUFACTURING INDUSTRY

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ABSTRACT:
Steel Industry has given a wide exposure for the researchers, academicians & professionals to deal with even minute plethora and dots to come up with new innovations and creativity. In order to increase the affordability and accessibility the continuous casting is optimized through various process and levels to overcome the drawback parameters which make this process complicated and expensive. The purpose of making this research paper is to find optimization on discovering a range of water flow rate, material properties, thermal heat transfer factors and oscillation parameters research areas which has been done till date. This continuous casting process helps in eliminating many steps like ingot teeming, stripping, primary rolling, etc.

Keywords: Optimization, Water flow rates, Quality-Material properties, Thermal heat transfer factor, Oscillation parameters, Algorithm & Numerical Simulation, ingot teeming, stripping and primary rolling.

1. INTRODUCTION

Continuous casting is also popularly called as strand casting. It is the procedure by virtue of which the liquid metal is solidified into a semi-finished billet, bloom and slabs for ensuing rolling in the mills. In early 1950s, steel was poured into molds which were held stationary in order to form ingots [1]. Continuous casting has emerged out as a fantastic and economic way to achieve improved quality, productivity, and yield and cost efficiency. This procedure is utilized most often to cast steel. Aluminum & copper are also additionally casted continuously.

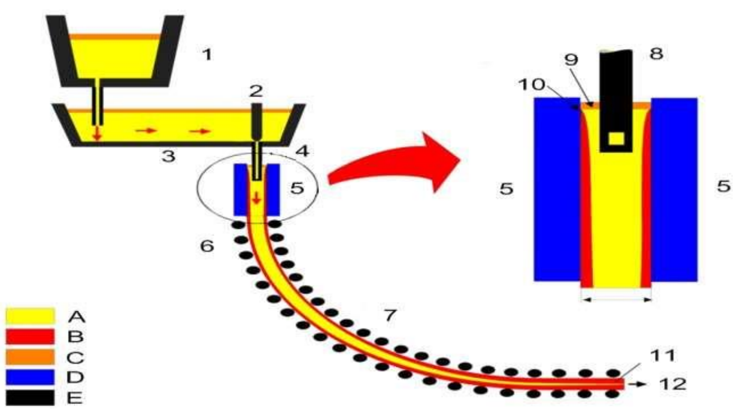

Figure 1: Elements of Continuous Casting

1: Ladle 2: Stopper 3: Tundish 4: Shroud 5: Mold 6: Roll support 7: Turning zone 8: Shroud 9: Bath level 10: Meniscus 11: Withdrawal unit 12: Slab

A: Liquid metal B: Solidified metal C: Slag D: Water cooled copper plates E: Refractory material.

1. RESEARCH METHODOLOGY

A tundish is a container that is situated over the mould, it holds the fluid metal for casting in which the liquid metal is poured. This specific casting task utilizes the power of gravity to fill the shape and to help move along the nonstop metal casting. It is found high over the ground level, more or less around eighty or ninety feet. It is the activity of the tundish to keep the mould filled to the correct level all through the assembling task. Since the metal casting is continually travelling through the mould where slag and pollutions are expelled from the melt thus, form passage might be loaded up with a latent gas for example argon. The inactive gas will push away some other gases for example oxygen that may respond with the metal [2]. The metal casting moves rapidly through the shape, in the nonstop fabricate of the metal part. A metal casting will initially cement from the mould wall or outside of the casting, at that point solidification will advance internally. The mould in the continuous casting process is water cooled, this helps to accelerate the solidification. Moreover, the constant casting does not totally solidify in the mould. A gathering of unique rollers might be utilized to twist the strand to a 90^0 point, so another set will be utilized to fix it, once it is at that edge [2-3]. The temperature field of the slab is described by Fourier-Kirchhoff equation is given by

$$\partial/\partial T\ (\rho(T)c(T)T) = \nabla(\lambda(T)\nabla T)+\partial/\partial T(V_Z\ \rho(T)c(T)T) + Q \qquad (1)$$

Where the velocity component *vz* [m/s] is considered only in the direction of casting, τ is time [s], T is the temperature [K], ρ is the density [kg/m3], c is the specific heat capacity [J/kgK], λ is thermal conductivity [W/mK] and Q represents heat generation. Usually rollers utilized as a part of the assembling business, this procedure will alter the course of the stream of the metal strand from vertical to horizontal.

2. LITERATURE REVIEW

Optimization Parameters**:** The following are some of the Process Parameters which have been optimized by researchers all around the globe till date:

1. Water Flow Rate [4]
2. Quality–Material Properties [5]
3. Thermal Heat Transfer [6]
4. Oscillation Parameters [7]
5. Algorithm & Numerical Simulation [8]

3.1 OPTIMIZATION OF WATER FLOW RATE

The continuous casting process is utilized for solidifying liquid steel into semi-finished steel. The innovation for Secondary Cooling Zone (SCZ) is critical for the yield of the CCM and billet quality [4]. Events of interior imperfections e.g. edge splits are generally known as diagonal cracks in the continuous cast product of steel Grade H is usually identified with the consistency of the water stream rate control in SCZ. Design of Experiment, DOE is utilized as a part of breaking down the parameters that impact the quality of the billet generation [5]. Which leads to the upgrading of yield as the research improvement throws light on discovering the reasons for diagonal cracks which usually happens amid the casting procedure in the Continuous Casting Machine (CCM). With the guide of Design-Expert Software, improvement is completed to find a scope of ideal setting for optional zone first, second and third segment water stream rate.

3.2 OPTIMIZATION OF QUALITY CAST STEEL SLABS

The quality of the steel produced by the continuous casting process is impacted by the controlled components for example, the casting rate or cooling rates. The researchers have depicted a calculation or algorithm for acquiring a black-box-type solution arrangement which keeps up a high generation rate and the high quality of the items. The mathematical model contains Fourier-Kirchhoff condition and incorporates limit conditions. Phase and structural changes are displayed by the enthalpy process. The researchers have successfully managed reasonable instruments for enhancement & optimization of the slab casting process. They have developed an algorithm for the quick and viable casting of top-notch steel. The calculation controls the cooling rates in the created numerical model and upgrades it by utilizing the supposed firefly calculation [6-7]. The entire technique is extremely adaptable and can be changed for a discretionary review of steel or quality conditions. Once the required metallurgical composition or the grade of steel is achieved at a certain temperature of 1590°C-1600°C, the molten steel is then transferred via nozzle into a ladle.

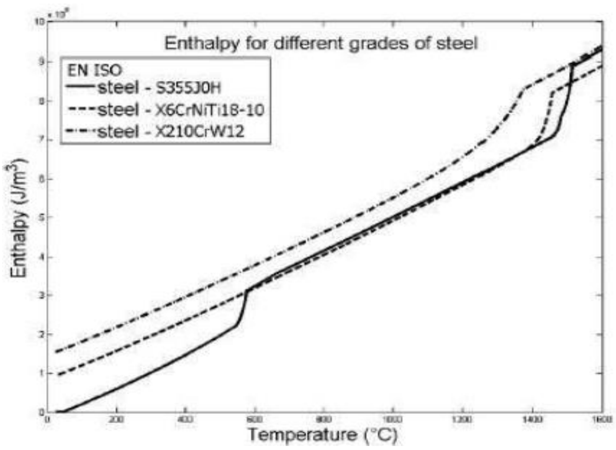

Figure 2: Relationship between the temperature and the enthalpy for three grades of steel

3.3 THERMAL OPTIMIZATION

The objective is to locate the ideal appropriation of the temperature and interfacial heat transfer coefficients relating to the essential and optional cooling frameworks, notwithstanding the pulling speed, to such an extent that the hardening along the primary pivot of strand ways to deal with the unidirectional cementing mode[8]. Dissimilar to numerous warm enhancements of stage change issues in which the attractive (target) temperature slope or interface position are thought to be a-need known, an alluring shape highlight of the solidifying interface thought to be known in the present investigation. Stage change is a vital physical marvel that occurs amid numerous issues in science and designing, e.g. the shape casting, ingot casting and crystal growth advancements. In these cases, the solidifying conditions significantly affect the nature of items. The temperature field is figured by comprehending a quasi-steady state nonlinear heat transfer condition.

3.4 OPTIMIZATION OF OSCILLATING PARAMETERS

The continuous casting manner itself is facilitated by means of interlinked sub-strategies specifically, mould oscillation and lubricant addition. The mould is made to sway along its longitudinal hub with an amplitude of under 10 mm & frequency somewhere in range of 50 and 250 cycles for each moment (CPM) [9]. Oil is poured from the best onto the meniscus where it dissolves in contact with the hot material. The fluid 'grease' at that point infiltrates into the hole amongst strand and shape since the strand inside the shape is continually moving downwards with a specific speed, in relative terms the form moves to descend just when its descending velocity is more noteworthy than strand speed. This piece of the wavering cycle is alluded to as "negative strip" while its supplement is "positive strip".

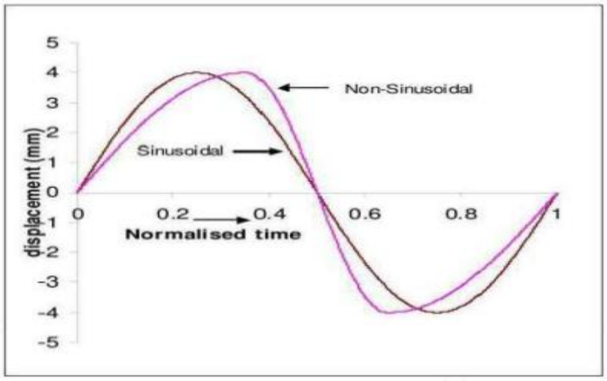

Figure 3: Variation of mold displacement in an oscillation cycle – sinusoidal versus non-sinusoidal wave pattern

Figure shows the variation of mold displacement in an oscillation cycle – sinusoidal versus non – sinusoidal wave pattern [10]. The connections between oscillation execution measurements like lubrication, oscillation mark depth and peak friction and the outline parameter set comprising of stroke s, recurrence f and deviation from sinusoidal waveform t, are communicated in a scientific structure which can be found out from it.

3.5 OPTIMIZATION OF ALGORITH & NUMERICAL SIMULATION

Two numerical models were exhibited. The principal demonstrates is the numerical model of temperature field where the stage and auxiliary changes are displayed by an enthalpy strategy, while the second one speaks to a heuristic streamlining calculation [11-12]. The entire strategy has exceptionally broad nature and along these lines, it can be effectively altered for the subjective level of steel, quality conditions or particular caster geometry including rollers and spouts positions [13-15].Many researchers have done commendable works in the field of Optimization as described above. The Optimization of Continuous Casting Process or machine sees its future in Artificial Intelligence and some more hybrid strategies are being worked upon. Moreover, apart from optimizing the optimum available some new Optimization parameters is the objective.

4. ANALYSIS PART

So from the above discussion we can analyze the thermal optimization was done for the heat transfer rate during the process, also for the Oscillation Parameters, Algorithm, Numerical Simulation, Mold and Strand. Artificial Intelligence and Hybrid strategies are the hot topics of research. Keeping the constant rate the long metal strand is moved by the rollers it will help to manage the strand and aid the smooth stream of the metal cast out of the shape and along its given way. Indeed, the objective is identical to achieve an almost at the strong fluid interface that is included by its zero mean ebb and flow.

1. CONCLUSION

The researchers have done really a commendable work by studying the optimization of process parameters in continuous casting process. Optimization was done to discover a possible range of optimum setting for secondary zone water flow rate. Firefly Algorithm was used for optimization of the quality and production rate.

Overall the research work was great having seen its wide applications and demand this research work added much contribution to both academicians as well as industries. The detailed review was done to find out solutions to little flaws and limitations in the above mentioned research works. The idea is to take this Optimization sequence a little further ahead in the research world.

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