Generalized Data Base Model for Heat Loss in Aluminium Plant by Digital Design 4.0 industry with Research Gate, Google Scholar, & Scopus citation

Dr. M. S. Dhande[1], Pranay Mangrudkar [2], Praful Dhoble[3], Nishant Shekhar[4], Krunal Choudhary[5], Jatin Parate[6], Prajwal Vaidya[7]

[1]Asst. Professor, [2, 3, 4, 5 ,6,7] Final Year Students,
Mechanical Engineering Dept. Priyadarshini Institute of Engineering & Technology, Nagpur, M.S., India.www.piet.edu.in

ABSTRACT:- *In research paper, the potential to use waste energies from the Aluminium production at NALCO, Angul, Odisha, India investigated. NALCO is a leading producer of high strength steel, such as slab, bloom, billets, wire, ingots, other aluminium products every year. Today many of these flows are pure losses that are cooled away or burnt. Flow fluid through it and transfer liquid to vapors. Most data regarding these calculations were extracted from a local processing system and then stored in a model describing the plant. The calculations are presented in results part in the form of tables, diagram, graphs, simulation and photography. This study does not consider if an investment is economical feasible, just that it has a great potential. The results may be used in further investigation that will address the problems. The effective heat energy is radiated when the molten metal liquid pool form at the corner of continuous casting. The normal thermal conductivity converts in effective thermal conductivity, at the same 'Cp' change w.r.t. temperature at different ranges. The prandalt number also changes.*

Keywords: *Steel Plant, Heat, Energy, Continius Casting, Modelling.*

I. INTRODUCTION

1.1 Permeable: - Steel Industry is process plant, generally available nearby iron ore mine and coal mine in world. The industry utilizing large of quantity of iron ore and coke for production of steel. In this research, out target to reduce waste heat. The major to plant iron ore and coal, so coal analysis also include in the same work.

1.2 Basic Introduction: The impact of economy due to ever increasing energy prices globally and problems associated with global warming with the methods of energy utilization especially in the melting processes. There is a clear need for the heat transfer industries to focus on energy, efficient methods and implementation of new resources. 50% plant need to enhance a technology that reduces emissions for increasing thermal efficiency of furnace.

II REVIEW & LITERATURE

2.1 OUR REVIEW AND LITERATURE POINT OF VIEW Effective Heat Energy radiated in Aluminium plant research work divided in three category. Such as A) Introduction, Analysis, modeling, simulation, parametric determination for continuous casting process B) Different Process C) Other parameter

A) Regarding introduction case some research paper collect and over that basis in [1] continuous casting is used to solidify most of the millions tones of Aluminium produced in the world every year. Like most commercial processes, continuous casting involves many complex interacting phenomena. The best models for this purposes are mechanistic models based on the fundamental laws and phenomena which govern the process, because they are more reliably extended beyond the range of data used to calibrate them.

The emerging C.C. Processes, such as thin slab and strip casting, present, several special challenges, which offers opportunities for the application of modeling tools. Reducing the stand thickness from 8 inches to 2-4 inches requires higher casting speeds, if productivity is to be matched when combined with the inner mold, these processes are more prone to the fluid flows problems. Mold distortion is a greater concern, both because it is relatively larger for the thinner product, and because mold life is more critical or the expensive molds needed in these processes. For these new process to thrive, the tearing curve towards process optimization to product quality steel needs to be shorter.

III Discussion & Results

MATHEMATICAL MODELING OF CONTINUES CASTING PROCESSES

3.1 INTRODUCTION

Fig. shows the different regions of the C.C. A typical method of modeling the strand thermal condition shown in fig. the mathematical model is applied to slices of strand that start at the meniscus and travel through the machine at the casting steel. The new slices are generated periodically. A sufficient number of slices exist in each condition zone to give an accurate representation of the thermal condition in each zone.

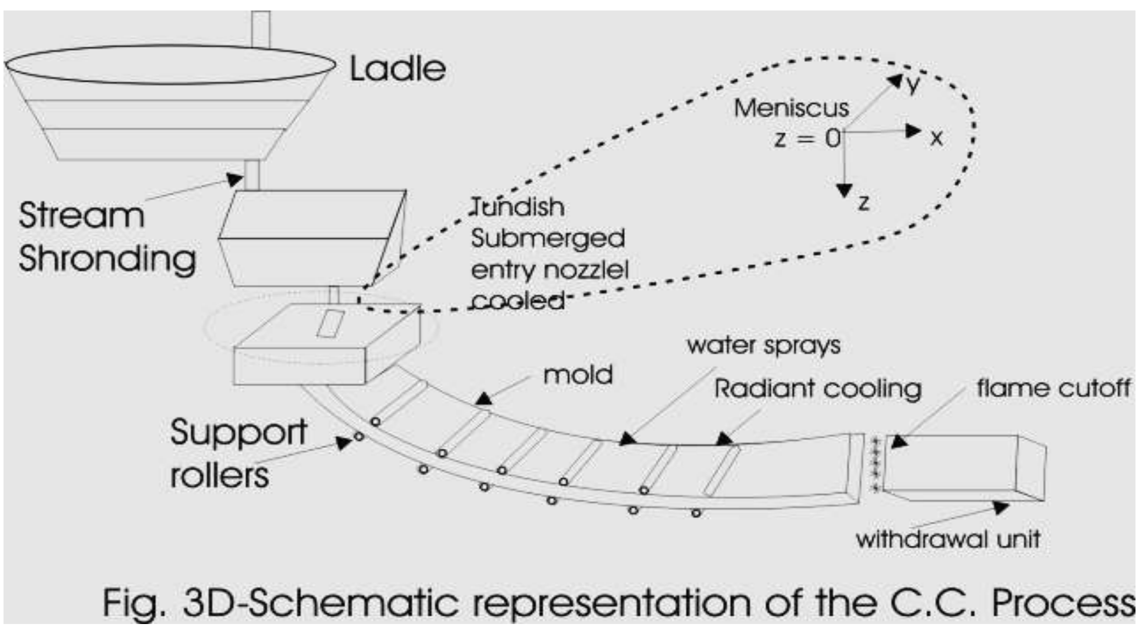


fig 3.1 Countinious Casting In Aluminium Plant

SIMULATION
Why used Ansys: To find the graphical results.
Software Selection : Creo – parametric 2.0 and Ansys 11.0
Hardware :
I 5 processor
4 GB RAM

1 GB Graphic
1 TB HDD

Photo. 3.1: Simulation on computer

Que. What the details of input raw material ?
Ans. Aluminium material
Que. What are the Products?
Ans. Slab, Bloom, Billet, Wire, Ingot.
Que. What are the properties of material while making the simulation?
Ans. Density, conductivity, thermal properties.

125Simulation
Processor for graphical modeling on simulation:-
Pro E- 2D, 3D model or Ansys direct
3D FEM – element part
Thermal load
Temperature insert
Heat loss estimate

3.2 Results for slab (Graphical result given here):-
3.2. 1) Results for Slab I: 200 x 1500 mm:-
a) Conduction
In slab size 200 x 1500 mm for conduction case the minimum flux generated i.e. at initial stage. Rest of the portion as shown in simulation (Fig). The stress generated with respect to area. In temperature gradient with respect to displacement in x direction, - 0.286872 & max 0.378015. At the bending portion or curvature portion low displacement & other portion continue. The temp case lower temp at initial & final of slab at 370C. The maximum temp generate at latter on initial & beginning of final near about 15460C . At curvature portion average of 10430C. For the thermal expansion total flux case in fig. shows vector diagram float from top to bottom. The minimum flux at curvature portion and gathers of flux vector at initial and final stage of slab.
b) Convection
In convection of temp more temp about 15460C at throughout plate,
less end 28.1840C.The total gradient case minimum through the plate but maximum at top of plate. Some average also generate shown by spot in fig. The total flux consideration of simulation minimum at 0.765 E-03 at front of the part of
126Simulationslab. Maximum at 153.932 at end stage again some expansion available on plate.
c) Radiation
The vectors in upward direction whereas in conduction in downward direction. The maximum at 0.34803J curvature portion. The minimum gradient 0.303657 at initial of plate rest of outward portion average way shown in fig. The flux in x-direction nodal solution is minimum 0.183 E-12 at curvature portion shown by dark spot fig. Maximum at 0.339 E-12 initial of plate. The radiation gradient in x-direction fig. the expansion maximum at again curvature portion & minimum at initial exactly opposite to flux in x-direction. In fig. the total flux shown by vector form more at initial 0.427 E-15 &shown by dot at end of plate & small amount of on in between of plate. The total gradient shown in fig. again dot way at end of plate & minimum at initial of plate.

DESIGN OF ENERGY SAVING SYSTEM

4.1 SWOT Analysis:-

STRENHTHS End use sales Controls & Direction Right Products. Quality and reliability.

WEAKNESSES Customer list not teste Some gaps in range for certain sectors

OPPORTUNITIES Could development new products Local competitions have poor products

THREATS Legislation could impact Environmental effects would favor larger competitors

4.2 Losses of energy in practical case:-

(1) Transportation of ingot one shop to another shop by chair way.

(2) Transportation of tundish. (3) Transportation ladle. (4) Slag layer is wastage product over the molten metal. (5) Heat energy loss in continuous casting. (6) Molten metal float through land channel. (7) Heat energy radiate at pouring time.

4.3 The following methods are proposed in the design:-

4.3.1 Controlling Method

I) Air Fuel mixture: When the heated material flowt through the cavity or over the roller that time heavy amount of heat energy loss, the air passes over for collecting heat i.e. air fuel ratio should be maintained.

II) Position of each stock item in the furnace: In side furnace how position to put product.

III) Direct fuel use reductions through optimization of combustion efficiency: Good quality of coal used for furnace. So less quantity of ash form.

X) Measure to save energy:-

(1) Thermocouple. (2) Thermometer for molten solution. (3) Arrangement of water duct over C.C. to radiated energy collects there. (4) Improvements and sharpness in chemical treatment for quality of coal. (5)Electrical energy case electrical energy meter check regularly. (6) Convert heated water to vapour & strike turbine for production of electrical energy, to generate. (7) Less slag generation so insert powder there. (8) Maintenance activity effectively workout. (9) Wattmeter use. (10) Recharge battery use.(11) Storage energy. (12) Developed the energy management system. (13) Collection of energy to install water pipe in through ash dumping.

4.3. 2 Energy Saving System -1: (Attached pipe):-

In fig. 4.3.2 shows the pipe attached to the furnace. The molten metal flow through the pipe and flowt in cavity or die for casting purpose. Fg. 6.2 shows the actual thermal reading Fig. 6.3 shows wire frame model with results. Fig 6.4 shows the solid geometrical model over there shows one pipe for measuring the inlet & outlet temp flow molten metal through the pipe.

4.3.3 Energy Saving System - 2:-

(Design of heat saving system for rolling process); In fig 4.3.2 shows diagrammatical arrangement. The heated molten metal poured through ladle in die cavity. The water get warm. The temp measures at different points. Design of Energy Saving System. The experimental type arrangement fabricated for different products such as cylindered rod, square & rectangular plates or other. Through this arrangement design of heat saving system for rolling process is justified. Energy consumption For calculating heat one experimental set up discuss here as a model which is diagrammatical shown below

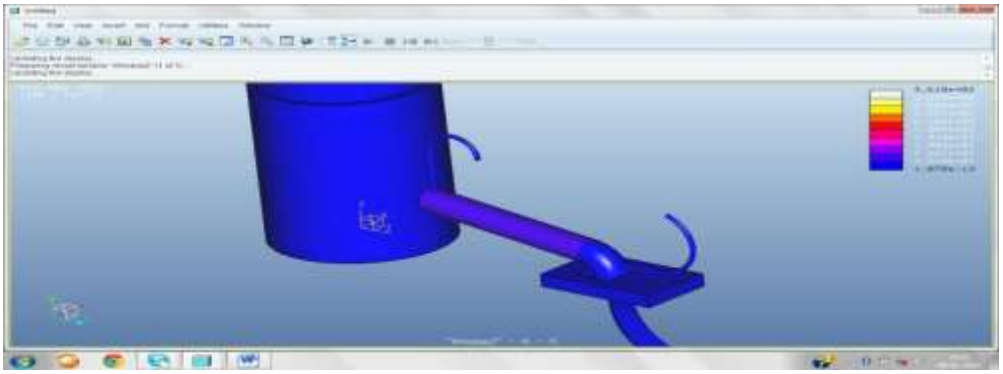


Fig. 4.3.2 (attached pipe)

EXPERIMENTAL INVESTIGATION

5.1 Introduction:- The experimental investigation for carried out by fabrication of a small prototype model using Lead-Tin material.

5.2 CAD model :- First made CAD model in Creo parametric (2.0) software before the experimental set up fabrication. In CAD modeling assembly design subpart given did the work over. Again some Top down, medium down & bottom approaches are there. Out Top down approach is the best suitable for this model.

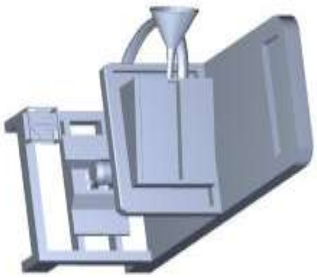


Fig. 5.2 CAD Model

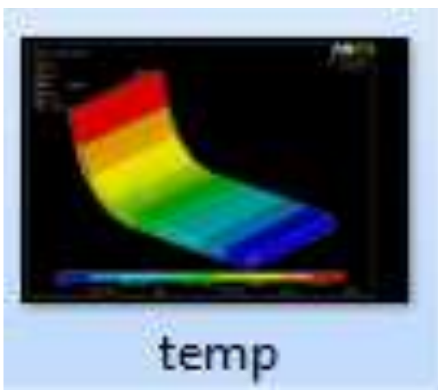
5.3 Results of CAD model:-

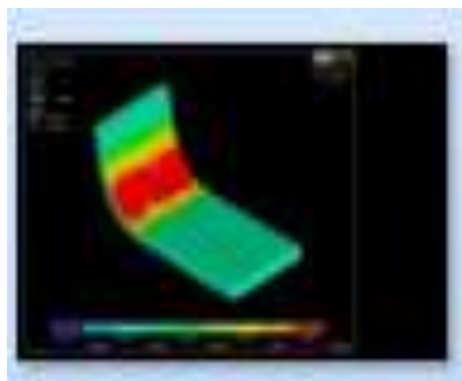
Description : After making the 3D wire frame, 3D solid geometrical model and separate every parts with front view, top view & side view of CAD model, some Ansys result are collect in Hardware system which already specification given above the CAD model in this chapter. Different results shows in colour. How to blow air over & generate the heating effect when plate is hot. Here used steel as a raw material.

Cad Modeling Ansyss, FEM Thermal Analysis, Product data. Determine Heat conduction, convention and radiation from slab, bloom, billet, wire, ingot, Furness and exhaust gas pipe

6.1 Simulation: Slab Result :-

6.1 Slab-1 Conduction Result





6.2 Tundish : Tundish meas die, when casting of slab, bloom, billets produce by continuous casting method the particular shape die used is called tundish. The die (tundish) made of special raw material, for the strong casting material powered in tundish by ladle or pipe arrangement. There is a outlet given at bottom of tundish when the molten metal powered in tundish, the raw material itself take a particular size which flowt through outlet of tundish as in the form of slab, or change the tundish size, get bloom or change the tundish size, get billet.

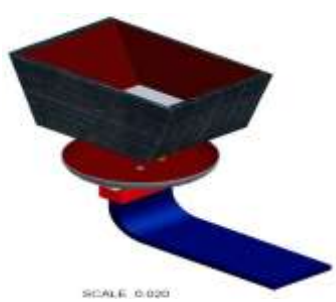


fig. 6.2 CAD Model of Tundish

7.1 CONCLUSION & RESULT

Objective

1) To finding the heat energy loss is in the search work.
2) Details takeout for research work from NALCO, Angul, Odisha, India.
3) To identify the effectiveness of thermal conductivity by simulation method.
4) Use mathematical model

CAD modeling Conclusion

After making CAD model in creo-parametric 2.0 (Assembly Design) in (top down approach), the real wire frame model and solid frame model shows, how to view is in front, Top, Side and back side.

Energy saving method conclusion

Financial loss of steel plant save. Use here strength, weakness, opportunity & Threat analysis i.e. SWOT model also success here

% energy saving and method

Energy saving method CAD model : in simulation of different products which use in BSP plant, its optimization value Flow method : When the heated material flow over the conveyor collect heat by duct method, it is succeed collect the reading

Conclusion & Result Cost worth affect : After using all above method, the research success & financially losses saving in the firm of coal, electricity which directly help to government. Research Gate citation also getting for such work.

Power Generate In parametric analysis chapter [8] there is calculation given for collection of heat a) Heat energy form collect from continuous casting method in steel melting shop. b) Heat energy collected from furnace. c) Heat energy collect from exhaust gas. d) How to generate electric power numerical value & fig given.

Hence parametric analysis result also success.

Recommendation future work :-

Heat Energy loss remain study, in lots of industries such as Textile industry, paper industry, chemical industry, workshop

Heat energy loss in cast iron plant.

Heat energy loss in copper manufactory plant.

Heat energy loss in Aluminum.

Heat energy loss in alloy industry.

Competing Interest: The authors declare that they have no Competing Interests.

Consent for Publication: Not applicable.

Ethics approval & consent to participate: Not applicable.

Funding: Self experience based data.

Availability of Data & Materials: Data collected from Government corporation. Government projects agencies.

Author Contribution : We have teaching, Research experience & field base work.

Acknowledgement: I am very much thankful to Dr. S. S. Khandare. Ex. Principal, B. D. College of Engineering, Sewagram, Dist. Wardha, Maharashtra, India. Encourage to do the research work on this theme.

Bibliography:

[1] Lautre N.K., Sharma A.K., Das S., Kumar P. "On crack control strategy in near-field microwave drilling of soda lime glass using precursors" 2015 , Journal of Thermal Science and Engineering Applications

[2] Ya Meng and Brian G. Thomas, Heat Transfer and Solidification Model of Continuous Slab Casting: Con1D, Metallurgical and Materials Transactions B. Vlo.34B, No.5. Oct.2003, pp.685-705

[3] C. Beckermann, R. Viskanta, Mathematical modeling of Transport phenomena during alloy solidification, Appl. Mech Rev. Vol 46, no., January 1993, pp. 1 to 27

[4] B.G. Thomas& I.V. Samarasekera and J. Brimacombe; Application of Mathematical hat Flow and Stress Models of Steel Ingot Casting to Investigate Panel Crack Formation; Modeling and Control of Casting and Welding Processes TMS American Institute of Mining, Metallurgical and Petroleum Enginners Conference Proceedings, Santa Barbara, CA, Jan. 12-17, S.Kou, R. Mehrabian, Eds, 1986, pp. 479 to 495

[5] Bruce Kozak SMS & Joseph Dzierzawsk S., Continuous Casting of Steel : Basic Principles, The Steel Network |Media|, 2011, pp. 1 to 9

[6] Johan Isaksson[1,*], Simon Harvey[1], Carl-Erik Grip[2], Jonny Karlsson[3], Possibilities to implement pinch analysis in the steel industry –a case study at SSAB EMEA in Lulea, World Renewable Energy Congress 2011, Sweden, Industrial Energy Efficiency (IEE), 2011, pp. 1660 to 1667

[7] Ryosuke Tasaki, Yoshiyuki Noda, Kazuhiro Terashima, Kunihiro Hashimoto, "Modelling and Control of Pressurized Molten Metal in Press Casting"; Preprints of the 18th IFAC World Congress Milano (Italy) August 28-Sept. 2, 2011, pp. 11726-11731.

[8] Pedro Gutemberg Q. Netto, Roderick I.L. Guthrie; "The importance of turbulence modeling in the design of a novel delivery system for a single-belt steel casting process"; International Journal of Heat and Mass Transfer 43(2000); pp.21 to 37.

[9] R.Grzymkowski, E. Hetmaniok, D. Slota; "Application of the homotopy perturbation method for calculation of the temperature distribution in the cast-mould heterogeneous domain"; Journal of Achievement in Material and Manufacturing Engineering, Vol.43, Issue 1, Nov.2010; pp. 299 to 309.

[10] R. Forestier, Frederic Costes, Olivier Jaouen, Michel Bellet; "Finite element thermomechanical simulation of steel casting"; Author manuscript published in "Proceedings MCWASP XII, 12th International Conference on Modelling of casting Welding are advanced Solidification Process, Vancouver, Canada (2009); pp.1 to 12.

[11] 11] Chakravorty, S.S., 2009. 'Six Sigma programs: an implementation model', International Journal of Production Economics,Volume 119, pp1–16.

[12] B. Naveen, Dr. T. Ramesh Babu, 'Productivity Improvement in Manufacturing Industry Using Industrial Engineering Tools', IOSR Journal of Mechanical and Civil Engineering (IOSR- JMCE), PP 11-18.

[13] Awad S. Hanna, M.ASCE1; Cindy L. Menches, M.ASCE2; Kenneth T. Sullivan3; and Joseph R. Sargent4 (2005), 'Factors Affecting Absenteeism in Electrical Construction', journal of construction engineering and management © asce, pp121.

[14] Lahutre N. K., Sharma A.K., Kumar P. Distortions in hole and tool during microwave drilling of perspex in a customized applicator, 2014 IEEE MTT-S International Microwave Symposium Digest .

[15] Solvent Extraction Plant, Panchgaon, Umred Road, Dist. Nagpur, Maharashtra, India.

[16] Murli Agro. Solvent Plant M.I.D.C., Hingna, Nagpur, M. S., India.

[17] G. S. Oil, Rampur Road, Light Industrial Area, Adilabad, Telangana (Andhrapardesh), India.

[18] Juang, R. and Huang, R., "Kinetic studies on lacticacid extraction with amine using a microporousmembrane-based stirred cell. Journal of Mem-brane Science", 129 (2), 185- 196 (1997).

[19] Kahya, E., Bayraktar, E. and Mehmetoglu, U., "Opti-mization of Process parameters for reactive lacticacid extraction". Turkish Journal of Chemistry, 25,223-230 (2001).

[20] Kertes, A. S. and King, C. J., "Extraction chemistry offermentation product carboxylic acids". Biotech-nology and Bioengineering, 28(2), 269-282 (1986).

[21] King, C. J., "Amine-based systems for carboxylic acidrecovery". Chemtech, 22(5), 285-291 (1992).

[22] Kumar, S., Wasewar, K. L. and Babu, B. V., "Intensi- fication of nicotinic acid separation using or-ganophosphorous solvating extractants by reac-tive extraction". Chemical Engineering and Tech-nology, 31(11), 1584- 1590 (2008).

[23] Lee, H. J., Koo, Y. M. and Wang, N. H. L., "Separa- tion of lactic acid from acetic acid using a four-zone SMB. Biotechnology Progress", 20, 179-192(2004).

[24] M. S. Dhande, R. L. Himte, V. M. Nanoti, J. P. Modak, "The Practical Approach to Field Base Data Model of Industrial Layout to Improvement in Productivity", IJIRSET, VOL.6, Issue 9, Sept.2017, Page No. 17906- 17909, ISSN(online):2319- 8753ISSN (Print): 2347-6710, DOI:10.15680/IJIRSET.2017.0609009.

[25] M. S. Dhande, R. L. Himte, V. M. Nanoti, "The Survey Practice in Ash Brick Plant" 7 th ICRTESM-2017,International Conference, Sept 2017, Pune, M. S., India, ISBN;978-81- 934288- 2-5, Page No. 65-68.

[26] M. S. Dhande, R. L. Himte, V. M. Nanoti, J. P. Modak, "Survey with Design & Development of Mathematical Modelling for Ash Brick Production Hydrualic Machine", IJIRSET, VOL.7, I ssue 9, Sept.2018, ISSN(online):2319-8753, ISSN (Print): 2347- 6710, Page No.9604-9610, DOI:10.15680/IJIRSET.2018.0709.

[27] Vikhar A D, Modak J.P, " Formulation of Field Databased Model : A Case Study at PVC Pipe ManufacturingIndustries". International J ournalof MechanicaI Engineering and Technology (IJMET), ISSN0976– 6340(Print), ISSN 0976 – 6359(Online) Volume 4, Issue 3, May - June (2013) © IAEME, IJMET., Page No.94-99.

[28] M.S.Dhande, S. S. Khandare,"Mathematical Modeling on effective heat energy radiated in steel plant", International Journal on Computer Application, ISSN-0975-8887, Page No.21-25.

[29] M.S.Dhande, S. S. Khandare, "Energy consumption in steel plant by SWOT Analysis",IJMRAE, Vol. 3, No.1, (January 2011),ISSN NO. 0975-7074, Page No.165- 177.

[30] M.S.Dhande, "Removal of ladle & saving the effective heat energy radiated in steel industry" Elixir Mech. Engg. (2014), ISSN-2229-712X, Page No.22971-22973.

[31] Jagdamba Rice Mill, Kuhi, Dist. Nagpur, M. S., India.

[32] M.S.Dhande, S. S. Khandare,"Mathematical Modeling on effective heat energy radiated in steel plant", International Journal on Computer Application, ISSN-0975-8887, Page No.21-25.

[33] Dr. M.S.Dhande, Generalized Data base Model for Solvent Extraction Plant toImprove Productivity: 2019 International Journal of Latest Engineering Science (IJLES)E-ISSN: 2581-6659Volume: 02 Issue: 03Mayto June2019www.ijlesjournal.org

[34] Dr. M. S.Dhande, Generalized Data base Model for Improve the Human Heart Productivity International Journal of Latest Engineering Science (IJLES)E-ISSN: 2581-6659Volume: 02 Issue: 03Mayto June2019www.ijlesjournal.org

[35] Dr. M.S.Dhande, "Generalized Data base Model for Improve the Productivity of Smart World Flexible Manufacturing System : 2020 "International Journal of Latest Engineering Science (IJLES)E-ISSN: 2581-6659Volume: 02 Issue: 04 July to August 2019www.ijlesjournal.org

[36] Dr. M.S.Dhande, "Generalized Field Base Data Model for Improve Productivity of Education Envelope " International Journal of Latest Engineering Science (IJLES)E-ISSN: 2581-6659Volume: 02 Issue: 04 July to August 2019www.ijlesjournal.org

[37] Dr. M.S.Dhande, "Generlized Data Base Model of Modernization for Smart City-2020" International Journal of Latest Engineering Science (IJLES)E-ISSN: 2581-6659Volume: 02 Issue: 04 July to August 2019www.ijlesjournal.org

[38] Dr. M.S.Dhande, "Generalized Field Base Data Model for Improve Productivity of Education Envelope " International Journal of Latest Engineering Science (IJLES)E-ISSN: 2581-6659Volume: 02 Issue: 04 July to August 2019www.ijlesjournal.org

[39] Dr. M. S. Dhande, Dr. R. L. HImte, Dr. V. M. Nanoti, "The Generalized Data Base Model for Survey Practice in Ash Brick Plant Smart City : 2019 ", PP 67-67, International Conference on " Redefining Environmental Governance for Smart City, 2nd March 2019, Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur, M. S. India. In Association with Vidyapeeth Shikshan Manch.

[40] Dr. M. S. Dhande, Dr. R. L. HImte, Dr. V. M. Nanoti, "A Field Base Data Model on Filteration of waste water from Urban Area & Collection of waste water from Mine for utilization in Thermal Power Plant: Smart world -2019" IOSR Journal of International Conference on Innovations in Engineering, Technology, Science & Management – 72-79 2019 (ICI-ETSM-2019) Jhulelal Institute of Technology (JIT) is governed by Samridhi Sarwajanik Charitable Trust (SSCT), Koradi Road, Village Lonara, Nagpur-441111.Engineering (IOSRJEN) ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 09, Issue 5 (May. 2019), ||S (XV) || PP 72-79. www.iosrjen.org

[41] Dr. A. P. Kedar, A comparative review of TQM, TPM and related organisational performance improvement programs, First International Conference on Emerging Trends in Engineering and Technology, PP725-730. 2008

[42] C. Beckermann, R. Viskanta, Mathematical modeling of Transport phenomena during alloy solidification, Appl. Mech Rev. Vol 46, no., January 1993, pp. 1 to 27

[43] B.G. Thomas& I.V. Samarasekera and J. Brimacombe; Application of Mathematical hat Flow and Stress Models of Steel Ingot Casting to Investigate Panel Crack Formation; Modeling and Control of Casting and Welding Processes TMS American Institute of Mining, Metallurgical and Petroleum Enginners Conference Proceedings, Santa Barbara, CA, Jan. 12-17, S.Kou, R. Mehrabian, Eds, 1986, pp. 479 to 495

[44] Bruce Kozak SMS & Joseph Dzierzawsk S., Continuous Casting of Steel : Basic Principles, The Steel Network |Media|, 2011, pp. 1 to 9

[45] Johan Isaksson[1,*], Simon Harvey[1], Carl-Erik Grip[2], Jonny Karlsson[3], Possibilities to implement pinch analysis in the steel industry –a case study at SSAB EMEA in Lulea, World Renewable Energy Congress 2011, Sweden, Industrial Energy Efficiency (IEE), 2011, pp. 1660 to 1667

[46] Ryosuke Tasaki, Yoshiyuki Noda, Kazuhiro Terashima, Kunihiro Hashimoto, "Modelling and Control of Pressurized Molten Metal in Press Casting"; Preprints of the 18th IFAC World Congress Milano (Italy) August 28-Sept. 2, 2011, pp. 11726-11731.

[47] Pedro Gutemberg Q. Netto, Roderick I.L. Guthrie; "The importance of turbulence modeling in the design of a novel delivery system for a single-belt steel casting process"; International Journal of Heat and Mass Transfer 43(2000); pp.21 to 37.

[48] R.Grzymkowski, E. Hetmaniok, D. Slota; "Application of the homotopy perturbation method for calculation of the temperature distribution in the cast-mould heterogeneous domain"; Journal of Achievement in Material and Manufacturing Engineering, Vol.43, Issue 1, Nov.2010; pp. 299 to 309.

[49] R. Forestier, Frederic Costes, Olivier Jaouen, Michel Bellet; "Finite element thermomechanical simulation of steel casting"; Author manuscript published in "Proceedings MCWASP XII, 12th International Conference on Modelling of casting Welding are advanced Solidification Process, Vancouver, Canada (2009); pp.1 to 12.

[50] Monika Erika POPA, Gabriela Mihut, Vasile Alexa; "Simulation Tendencies in the Continuously Cast half-Products Area"; Fascicule (Jan.-Mar-2010), Tome III; pp.95 to 102.

[51] Ya Meng and Brian G. Thomas, Heat Transfer and Solidification Model of Continuous Slab Casting: Con1D, Metallurgical and Materials Transactions B. Vlo.34B, No.5. Oct.2003, pp.685-705