DEPARTMENT OF Metallurgical and Materials Engineering (MME)

NATIONAL INSTITUTE OF TECHNOLOGY TIRUCHIRAPPALLI

COURSE PLAN – PART I			
Course Title	**Ladle Metallurgy and Continuous Casting of steels** (elective) (for students of BTech MME final year / 2016 – 2020 batch)		
Course Code	**MT PE 05**	**No. of Credits**	**Three (3)** LTPC: 2 1 0 3
Course Code of Prerequisite subject(s)	**MTPC 21** (Iron making and Steel making)		
Session	(2019 2020 AY: EVEN Semester)	**Section (if, applicable)**	NOT applicable
Name of Faculty	**Prof Sankara Raman Sankaranarayanan** (SRS)	**Department**	**MME (Meta)**
Email	raman@nitt.edu slagdoctor@gmail.com	**Telephone No.**	98947 02353; Adding 9385612153 with Apps MME Office: X 3450
Name of Course Coordinator(s) (if, applicable)	**(SRS)**		
E-mail		**Telephone No.**	
Course Type	☐ **Elective course (MT PE)**		
Syllabus (approved in BoS)			

Syllabus (duly approved and available in website) (Flexible system, 2015 onwards)**:**

Terminology – scrap based operation Vs refining; trends in quality of liquid steel; different approaches to refining; overview of various treatments including vacuum, inert gas, injection, electro-slag. Terminology related to injection metallurgy; Ladle furnace; advantages and approaches; injectibles – type of materials; discussion of some specific treatments; impact on overall quality; foaming of slags Ingot casting Vs continuous casting (CC); difficulties in CC of steels; increasing CC output in the steel industry; mould and machine details including different components and configurations; SEN, Ladle and Tundish

Role of mould powders (fluxes) in CC; physical and chemical interactions during CC; overview of defects in CC; production stoppages such as breakouts; indicative heat sizes and machine output; concept and implementation of sequence casting;

Overview of process modeling; applications in ladle metallurgy and CC; mathematical modeling of solidification; physical modeling of fluid flow in CC; case studies from current literature

Reference Books (listed in website)

1. Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004
2. B.Deo, R. Boom, 'Fundamentals of steel making metallurgy', Prentice Hall International, New York, 1993
3. Continuous casting – Vol.1, 'Chemical and Physical Interactions during transfer operations', Iron and Steel Society, Warrendale, PA, USA, 1983.
4. Ahindra Ghosh, 'Textbook of Materials and Metallurgical Thermodynamics', PHI Learning, 2002.

COURSE OBJECTIVES

To develop an understanding of the basic principles of ladle metallurgy and continuous casting, impart modeling skills and to apply them for industrial problems to enable them to solve the problems encountered in the steel industries

COURSE OUTCOMES (CO)

Course Outcomes	**Aligned Programme Outcomes (PO)**
1. (After the successful completion of this course, the student would be able to): Understand the terminologies used in the field of ladle metallurgy and continuous casting of steels	**[3]**
2. Classify different kinds of treatments for the steel during manufacturing	**[5], [11]**
3. Compare the capabilities of ingot casting and continuous casting	**[11]**
4. Apply the basic modeling skills in the area of ladle metallurgy and continuous casting	**[1], [4]**

COURSE PLAN – PART II
COURSE OVERVIEW
This (MT PE 05) is an advanced course related to iron making and steel making. The course presumes good grasp of iron making and steel making (core course), and presumes good comfort level in thermodynamics and metallurgical transport phenomena. The course enables the student to comprehend (and subsequently analyze) secondary treatments performed to improve the quality of liquid steel; and to get a feel for the developments in continuous casting of steels. The course involves discussion of many papers from the open literature and places significant burden on the student towards self-learning (topping up coverage in the class). Numerical problem solving forms part of this course. The course will benefit students keen on career in core technical areas. Students keen to particpate in technical competitions (such as by WorldSteel (annual online challenge) and by Tata Steel (Mind over Matter)) can ably utilize this course.

'Visiting' (casual) students are discouraged from opting for this course. Attendance will be monitored.

COURSE TEACHING AND LEARNING ACTIVITIES – indicative listing:

1. Lecture on review of liquid metal processing and continuous casting
2. Couple of lectures on review of secondary treatments
3. Series of lectures related to inclusions and dissolved gases – background, causes, problems, remedial measures, calculations, strategies for control
4. Role of slags in refining and casting – background, some input using related phase diagrams, indicative calculations, slag steel interaction at different stages, predicting properties and performance of slags, critical role while producing specialty steels
5. Continuous casting – conventional, advanced, thin slab, strip casting, complexities in the process, strategies for problem solving in the shop floor
6. Demonstrated and potential use of modeling in related areas
7. **Significant part of learning based on literature**; for example (not in specific order)

a. S K Choudhary and A Ghosh, Prediction of Composition of Inclusions Formed during Solidification of Liquid Steel, ISIJ, 2009
b. B H Reis et al, Absorption of inclusions by steel making slags – a review, JMR&T, 2014
c. D Satish Kumar et al, Forced floatation of inclusions in tundish, Iron making and steel making, 2009
d. A Chatterjee and S Chandra, Thin slab casting – new possibilities, Sadhana, 2001
e. J W Cho et al, Assessment of $CaO–Al_2O_3$ Based Mold Flux System for High Aluminum TRIP Casting, ISIJ, 2013
f. A Dey, Development of viscosity calculation method for mould powders, Iron making and steel making, 2014
g. B Khurana et al, In situ Observation of Calcium Oxide Treatment of Inclusions in Molten Steel by Confocal Microscopy, Met Trans B, 2017
h. D Apelian et al, Melt purification via filtration, AMMRC interim report, 1981
i. A Arefpour et al, Investigation of Viscosity Effects on Continuous Casting of Steel Mold Powders, SciRes, 2012
j. A Badri et al, Mold Simulator for the Continuous Casting of Steel, Met Trans B, 2005
k. Seshadri Seetharaman et al, Understanding the Properties of Slags, ISIJ, 2013
l. J A Kromhout and R C Schimmel, Understanding mould powders for high-speed casting, Iron making and steel making, 2016

COURSE ASSESSMENT METHODS (shall range from 4 to 6)

S.No.	Mode of Assessment	Week/Date	Duration	% Weightage
1	Mid Term Test	Vide common schedule suggested by class committee; or by the second half of March	One hour	20%
2	Assignment	By mid - March	(5 hours prep.)	20%
3	Viva	To be scheduled in the first half of April	Individual basis	20%
CPA	Compensation Assessment* (other than final assessment)	To be arranged in consultation with the class committee; context of prevailing regulations		
4	Final Assessment *	Vide common schedule, towards the end of the semester	Three hours	40%

***mandatory; refer to guidelines on page 4**

COURSE EXIT SURVEY (mention the ways in which the feedback about the course shall be assessed)

Suitably designed feedback form

COURSE POLICY (preferred mode of correspondence with students, policy on attendance, compensation assessment, academic honesty and plagiarism etc.)

MODE OF CORRESPONDENCE (email/ phone etc)
Typically communication through the class representative/s; by phone, by WhatsApp (if feasible) and by email

ATTENDANCE
Students expected to attend and participate in all classes; minimum requirement of 75% attendance will be enforced; ie., **students with less than 75% attendance** (as recorded by the teacher) **will not be permitted to appear in the final exam**;

COMPENSATION ASSESSMENT
To be arranged in consultation with the class committee; context of prevailing regulations

ACADEMIC HONESTY & PLAGIARISM
All stakeholders expected to commit for academic honesty; and to avoid any kind of plagiarism

ADDITIONAL INFORMATION

Discussion encouraged in the context of this course.

FOR APPROVAL

Course Faculty _____ **CC-Chairperson** _____ **HOD (MME)** _____