

# Material Science & Metallurgical Engineering Education in India-Past, Present & Future

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## **Abstract.**

Metallurgy as a science discipline has been established from the beginning of stone-age. It is imperative to note as we have progressed we have added facets of material science to it and the field has evolved into a discipline of engineering. From science fiction to reality the inherent inter-disciplinary nature of this branch sets up the need of its education and training. There have been several instances in when the pivot of development has completely changed due to advancement in material science and metallurgy whether it is semiconductor industry or space industry. In this paper, we have reviewed the scope and development of this discipline in India detailing through the course of history to the present status.

**Keywords:** Material Science, Metallurgical Engineering, Technical Education, India.

## **1. Introduction:**

Material science, also known as material science and engineering is the science of metals and metallurgy is the study of extraction of metals. Its study is important as we deal with metals every day. To sustain life and energy, we are surrounded with metals and materials in various forms. The use of metals was started 5th and 6th millennium BC, even the periods and ages are being named after the major advancement in use of material. First came the Stone Age as during that era equipment and



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utensils were made of stones, then came the Bronze Age and Iron Age. Earlier, metals found in native state were being used then metals which can be extracted, reformed in simple way by heating were used by masses. These all evidence shows that the metallurgy engineering or material science was needed and used from much earlier period. In India, we can get concepts related to metallurgy in various Vedas as Yajurveda & Atharvaveda. Metals were exchanged in trades between India and nearby regions. Earlier people used metals which can be obtained easily and materials like gold, silver and so on were being extensively used by people. In ancient India, metals were used majority for making weapons for wars and for making utensils. The Iron pillar made in New Delhi, India, is a perfect example of showing that metallurgy or material science was being practiced in earlier India too. To let the pillar stand for generation it was made corrosion resistance and the concept of alloy was used in making of the marvel [1].

In medieval India, with arrival of foreigners, there was more improvement to the use of material in different product making activities. Material science or Metallurgy is the science of material in which every aspect which affects the physical and chemical process of material like nature, structure, bonding, environmental factors are studied. Material science is an interdisciplinary field included in almost every branches of engineering as every field is incomplete without use of materials, so it is important to have proper knowledge to have better understanding of the field. Material science or metallurgy is included as a subject or optional subject in curriculum of mechanical engineering, electrical engineering, chemical engineering, electrical and electronics engineering, aeronautics engineering, and various other branches of technology. Due to rapid development after the world war, the manufacturing field has grown rapidly. These manufacturing units of any country provide a great boon to economy of that country, and developing countries such as India which has biggest population of youth [2].

This paper is divided three parts, first we have discussed about the metallurgy and material science education in India at undergraduate, postgraduate, doctoral and post-doctoral level, then future scope of metallurgy in different industry with the employment of material science engineer and at last conclusion of material science education in India.

## **2. Basic Structure of Engineering Education in India:**

First technical institute in India had been established in year 1847 (Thomson college of civil engineering) after that till now there are around ten thousand technical institutes in India. Technical education in India has been divided into five stages (diploma, under graduate, post graduate, doctoral research, and post doctoral research). There are 60 major polytechnic courses, 45 major under graduate courses, more than 200 post graduate courses, doctoral research in almost all major sub fields

of engineering and post doctoral research in emerging areas of engineering are offered by the different technical engineering institute in India. Indian Institute of Sciences (IISc), Indian Institute of Technology (IIT), National Institute of Technology (NIT) and Indian Institute of Information Technology (IIIT) are top technical institutions of India [3, 5].

The duration of diploma polytechnic degree is three years or six semesters, undergraduate technical course is of four year or eight semesters, dual degree program course that is (B.Tech + M.Tech) or (B.Tech + MBA) is of five years or ten semesters. For further course like Doctoral research, the duration is between three years to six years according to the research topic. Post Doctoral program is generally of two years but, can be extended to one more year as per the requirement of research.

First dedicated independent department for Metallurgical Engineering in India was founded at Banaras Hindu University, Varanasi at 1923, awarded first undergraduate degree in 1927 & doctoral degree in 1955 [8]. Next department was open in Bengal Engineering College in 1939 as 3 year degree course in Metallurgy affiliated to Calcutta University. Department of Materials Engineering at Indian Institute of Science was open in year 1945 to offer undergraduate degree in material science. Oldest department related to the field is mentioned in the Table 1.

Material science as a subject is included in various branches of engineering at different period at undergraduate and post graduate level. It was first included with physics, and then was taught with chemistry but later due to its inevitability in various fields it was taken separately as a subject [4]. It also keeps in track the research development and projects related to this field. Then its branches were

| Serial | Technical Institute                                                                                                 | Institute Establishment Year | Department Establishment Year |
|--------|---------------------------------------------------------------------------------------------------------------------|------------------------------|-------------------------------|
| 1      | Indian Institute of Technology (BHU) Varanasi<br>(Old Name : Banaras Engineering College, Varanasi)                 | 1919                         | 1923                          |
| 2      | Indian Institute of Engineering Science and Technology, Shibpur<br>(Old Name : Bengal Engineering College, Shibpur) | 1856                         | 1939                          |
| 3      | Indian Institute of Science, Bangalore<br>(Old Name : Tata Institute , Bangalore)                                   | 1911                         | 1945                          |
| 4      | College of Engineering, Pune                                                                                        | 1856                         | 1948                          |
| 5      | Jadavpur University, Kolkata<br>(Old Name : College of Engineering and Technology, Jadavpur)                        | 1912                         | 1956                          |

Table 1: Oldest departments of material science & metallurgy engineering in India with their establishment year.

Being set up in different IITs and NITs, many private institutions also included it as a separate degree course.

Both UG and PG degree courses were being offered and doctoral or PhD was done on the specific field one want to pursue. Although it is being taught as a separate degree course but still many branches have one or more of material science course as subject in UG level.

### ***2.1 At Diploma Level:***

Diploma courses associated to material science or metallurgy engineering has been offered by only few polytechnic. In first year subjects are common with other linked branches. In second year, specific subjects (Metal Forming, Fuel Furnaces, Metallurgical Analysis etc.) related to the discipline has been offered. Subjects like testing of metals, physical metallurgy etc. are offered as a compulsory subjects in mechanical, civil, industrial, production and manufacturing diploma students. In final semester specific subjects (Steel Making, Corrosion of Metals, Alloy Steel etc.) related to the specialization are offered.

### ***2.2 At Under Graduate Level:***

There are about 6-10 core courses which is associated to the Material Science & Metallurgical Engineering and rest of the subjects are related to the mechanical engineering discipline. Couple of courses are inter disciplinary courses (open elective) which are normally offered in final year. First year is common to all branches. In second year there are common subjects with mechanical engineering discipline. From fifth semester specialization in material sciences has been offered. There is one major project in the final year of the course in which student have to choose a specific topic related to material science or metallurgy engineering. Student need to choose the departmental elective associated to the project. Department of Metallurgical Engineering, Indian Institute of Technology Banaras Hindu University (IIT-BHU), Varanasi is the oldest department which laid out a proper format of curriculum for undergraduate studies. Core courses associated to the metallurgical engineering are thermodynamics, structure of material, extractive metallurgy, heat treatment, steel making, foundry metallurgy, mechanical behaviour of materials, iron making etc. Above courses give the in-depth knowledge of physical and chemical behaviour of metallic element, their associated alloys, heat treatment of different elements, plating, shot peen. Production of ores and manufacturing of metal associated with different items.

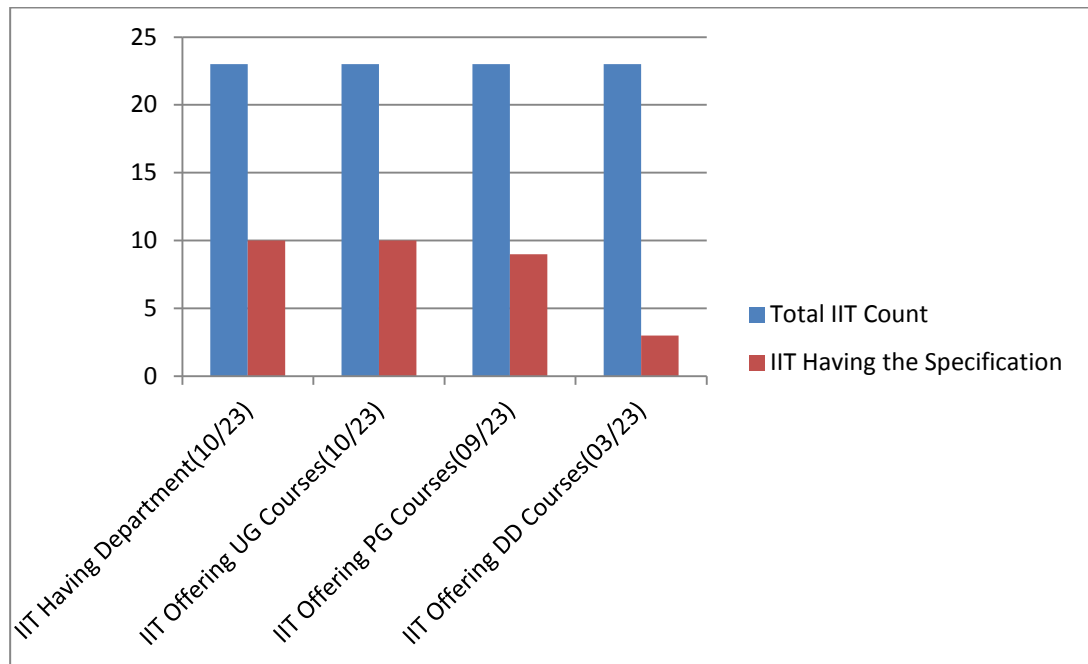


Fig 1: Current scenario of Material Science & Metallurgical Engineering in different Indian Institute of Technology in India.

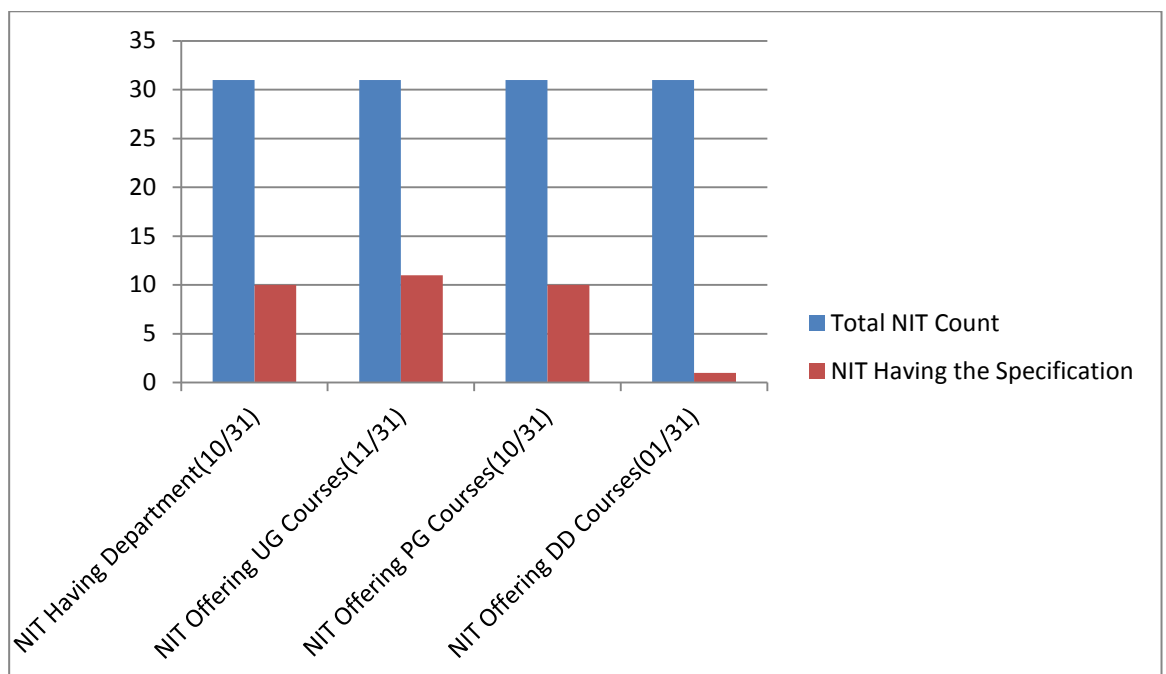


Fig 2: Current scenario of Material Science & Metallurgical Engineering in different National Institute of Technology in India.

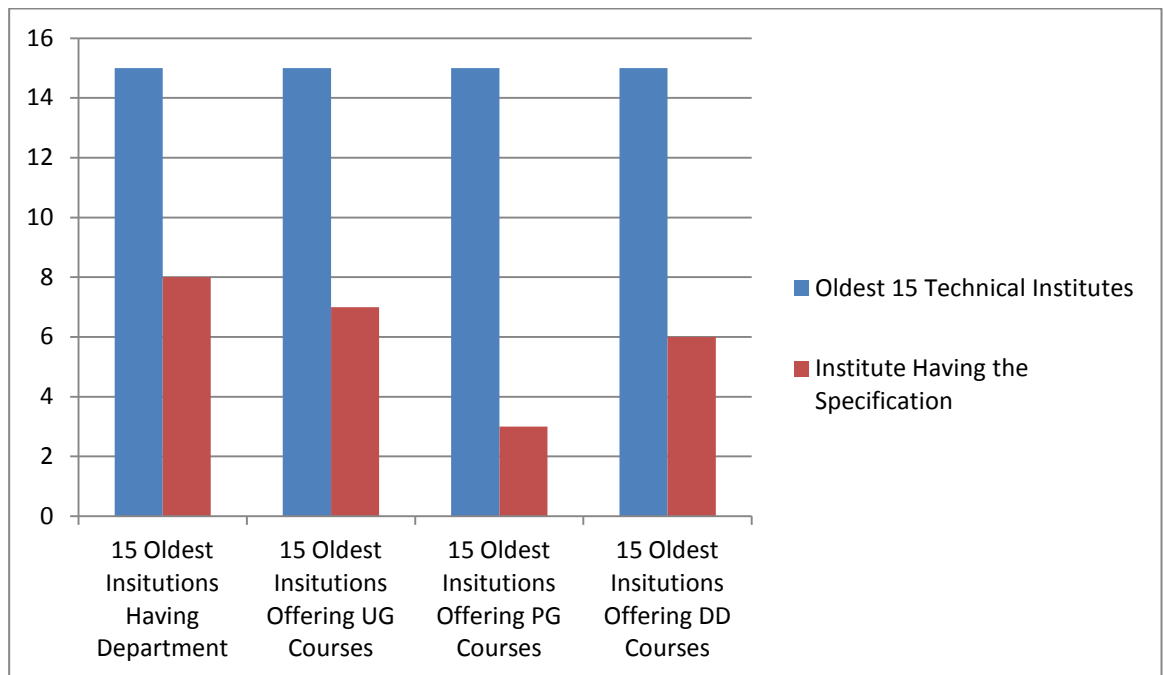


Fig 3: Current scenario of Material Science & Metallurgical Engineering in different Fifteen Oldest Institute in India.

### 2.3 At Post Graduate, Doctoral & Postdoctoral Level:

Material Science & Metallurgical Engineering is divided into two main domains ferrous metallurgy and non-ferrous metallurgy at post graduate level material science and metallurgical engineering is offered under the specialization in Material Science, steel technology, corrosion science, industrial metallurgy, process metallurgy, foundry technology etc. [6, 8]. Major topic covered under postgraduate course includes advance material characterization techniques, ceramics, steel technology, corrosion science, process energy, industrial metallurgy, material engineering, nano material, biomaterials in the end of last semester student have to justify his/her dissertation before the audience, which are the examiner.

Doctoral Research is done in the field of metal forming and mechanical behavior, material joining, iron and steel technology, integrated computational material engineering, material characterization, surface engineering, composite metal (bio-metal, ceramics, nano-metal) are the major fields in which major Indian researcher works.

Post doctoral research has been performed only in few technical premium institutes in the emerging areas of Metallurgical Engineering. At present level post doctoral research has been done in the areas of physical metallurgy and multi component metallic alloys.

#### ***2.4 About the Professional Bodies:***

The Indian Institute of Metals (IIM) which is started just after independence in 1947 (December 29), is the oldest professional society of Metallurgical & Material Engineers in India. Associate Membership of Indian Institute of Metals (AMIIM) examination is conducted by the IIM which is equivalent to the diploma offered by the Indian polytechnics. Indian Stainless Steel Development Association (ISSDA) is another professional body for the engineers & professional, working with the metal companies which are specific to the steel sector. Aluminium Association of India (AIA) is a professional body of the engineers working towards the aluminium sector. All India Non Ferrous Metal Exim Association (ANMA) is another professional body associated with the working professional in the non-ferrous metal industry of India.

#### ***2.5 About Simulation Tools:***

There are multiple simulation tools which are used in academics & research associated with the material science. Materials Studio (license software package) is used to create the modelling & simulation environment of different material. Materials Studio Visualizer is associated with the Materials Studio gives a graphical user environment. Avizo is also a license software package for scientific data visualization and analysis of different metals. Ansys, Abaqus and Matlab are the other commercial license software package, which is used in solving the complex mathematical problems as coated with the field. Prism Uncertainty Quantification (PUQ), Atom Touch, Material Simulation Toolkit (MAST) open source software used for uncertainty propagation, statistical model calibration and data analysis and validation of simulations that will eventually enable predictions with quantified confidence.

#### ***2.6 About Literature:***

There are many fields of engineering (aerospace engineering, ceramic engineering, chemical engineering, civil engineering, electrical engineering, electronics engineering, industrial engineering, manufacturing engineering, mechatronics engineering, mechanical engineering, production engineering, renewable engineering and so on) in which Material Science & Metallurgical engineering subjects are offered as core subjects as well as elective subjects in India.

R. Balasubramaniam, O.P. Khanna, R.K. Rajput, R.S. Khurmi, U.C. Jindal are the famous authors whose books are adopted as the textbook in the different courses associated with the material science and metallurgy engineering. R.H. Tupkary (Iron and Steel Making), R.S. Parmer (Material Joining Technologies), A.V.K. Suryanarayan (Mechanical Behaviour of Materials), R. Shridhar (Non-Ferrous Metal), Raj Narayan (Corrosion Engineering), V.K. Sikka (Physical Metallurgy), P.L. Jain (Foundry Technology), D.F. Sudarshan (Surface Engineering), T. Pradeep (Nanomaterials), R. Raj (High-Temperature Material), S.D. Sehgal (Emerging material) etc. are the famous Indian authors who contributed in the field of material science and metallurgy engineering.

### **2.7 Online Web Resources by Indian Government:**

There are twenty-six different courses in NPTEL database and it is offered by different IIT's. Major courses are Defects in Materials, Material Characterization, Iron Making, Material Science and Engineering, Physics of Materials, Principles of Polymer Synthesis, Surface Engineering of Nanomaterials, Theory and Practice of Non Destructive Testing, Electroceramics, Analysis and Modelling of Welding, Introduction to Crystal Elasticity and Crystal Plasticity, and so on which are offered as four weeks, eight weeks & twelve weeks. Weekly, five to ten videos of duration about forty

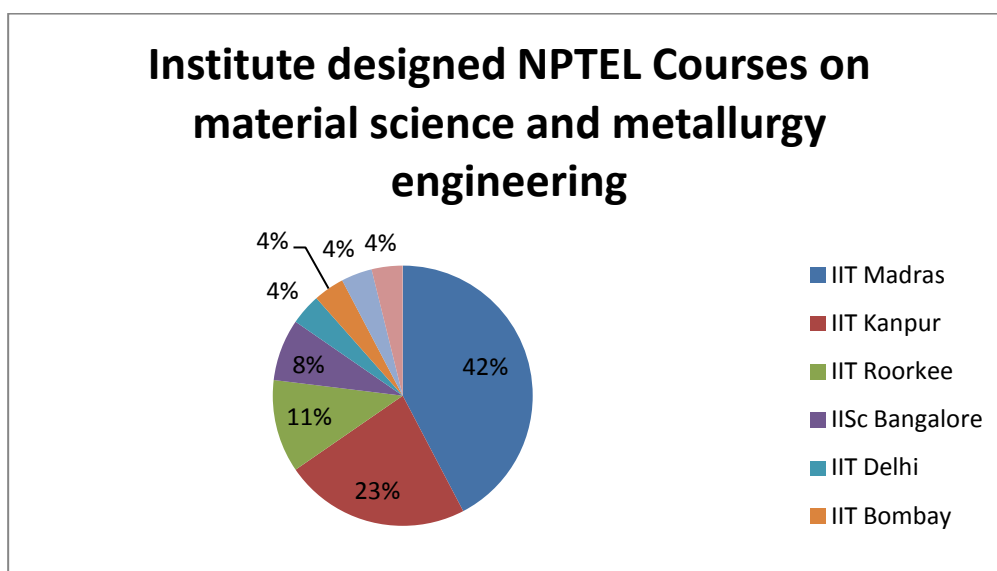


Fig 4: NPTEL lecture designed by the different institution in India.

Minutes uploaded on the course registered candidate profile which he can able to see & download it. Weekly quiz (objective) or assignment related to that week has to be submitted by the candidates. Marks are allocated for each quiz and a final examination is also conducted which covers the whole course. After completing any course successfully, a certificate is issued by the NPTEL with the logo of concerned institute and MHRD [7].

### **2.8 Job Prospect:**

The metallurgical profession is a wide field which offers a variety of job prospects for the students who took its associated courses in technology and engineering. Metallurgical engineers in India take the employment with the companies involved in ore production and metal extraction companies. They can take the profile of plant engineer, metallurgist, welding engineer, quality check engineer, and Metallurgical R&D lab technician and so on. They are also eligible in railways, armed force and government sectors [10].

### **3. Conclusion**

With push coming through programs such as 'Make in India' and other initiatives from government focused on marking India on world as a manufacturing hub, it is quintessential to start from the primal need of machines that is raw material [9]. Through our research we have found that Indian institutes have a good platform through years of educational background. The inherent need is to allocate more budget to research activities in the department to allow them evolve. Industry-academia partnerships are also important as initial set up cost is a big factor in this area. To realize the ambitious goals set up my government agencies material science engineering could be the missing link.

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