

INDIAN EDUCATION IN MATERIALS SCIENCE-PROBLEMS AND PERSPECTIVES**D.ANANTHAPADMANABAN ^{1*},T.R.VIJAYARAM ²****1*-Associate Proessor,Department of Mechanical Engineering,Sri Subramanya Nadar College of Engineering, College of Engineering,Kalavakkam-603110.****Professor-Bharath Institute of Higher Education and Research, Selayur-****KEYWORDS-Teaching, Materials Science, Modern concepts****1.0.INTRODUCTION**

Metallurgy has been an ancient art in India. While many pioneering advances were made in India in ancient times as evidenced by the archaeological findings, teaching learning processes have not seen the kind of innovations that are being practiced in western countries. Nowadays, throughout the world ,Metallurgy has become Materials Science A proper blend of traditional ways of teaching and modern concepts is therefore necessary to teach Materials Science.

Having taught Metallurgy for the last 23 years,an article on how to inspire students is definitely not out of place. The author was also inspired by an article written by Asit Kalra in the year 2017 in The Journal of Materials Education.This article deals with innovative ways to teach Metallurgy and Materials Science. [1]The article presented here is an extension of this work ,with many more new ideas.The basics of Physics and Chemistry are very essential for the study of Materials Science. In India, there were Metallurgical Engineering Departments in I.I.Ts and NITs(National Institutes of Technologies)starting from the 1960s.Slowly ,they have evolved into Materials Science and Engineering. The number of Institutes offering Materials Science and Engineering as a course of study at the undergraduate level is quite less, the reason being students are not very aware of the possibilities that a study in Materials Science offers.So.it would be good and useful if teachers in school teach them something outside of Extraction Metallurgy(which is commonly taught in schools).

2.0.HISTORY OF METALLURGY IN INDIA

Metallurgy and Materials have been rediscovered over the last century by stalwarts like M.F.Ashby and H.W.Cahn at Oxford and Cambridge. However, in India,the subject became known when researchers started returning with Ph.Ds in the U.K during the late 1960s and early 1970s.

Any subject should be introduced with its history .Great people and researchers in that particular area should be identified and their contributions to research and development should be highlighted. Professor T.R.Anantharaman from B.H.U(Banaras Hindu University,now known as IIT,Varansi) was the first Indian in modern times to systematically study Metals. He established a Metallurgical Engineering Department at B.H.U(Now I.I.T-Varanasi).In fact, I was inspired by him when I was a student. Later on many of his students like Dr.K.A.Padmanaban from I.I.T,Madras who later went on to become Director, I.I.T,Kanpur and who also taught me Metal forming ,Dr.Ramachandra Rao from National Metallurgical Laboratory ,Jamshedpur, Dr.P.Rama Rao, Director,DMRL(Defence Metallurgical Research Laboratory) and many others established Metallurgy Departments in many places in India. The founding fathers of Industries like TISCO(Tata Iron and Steel Company) and

SAIL(Steel Authority of India) were all students of the above mentioned Professors.This is pertaining to the current age after the Industrail revolution.

But even before the Industrial revolution, in ancient times, metallurgy was a well known field of application in ancient India as evidenced by the various archaeological findings .The Damascus sword is said to be an Indian discovery ,which later became famous in Syria. Unfortunately many of the ancient findings were lost due to various reasons ,primary among them being that knowledge was erlier passed on within the family only and trade secrets were not let out of the family.

Historically all knowledge in India were passed down through gurukulams where a single teacher taught various aspects of life for a long time, imparting knowledge according to the temperament of the student.Critical knowledge was not made available to all due to the fear of misus of knowledge as we are seeing in the current world in the field of nuclear science.

3.0.CURRENT SCENARIO AND PROBLEMS

As already mentioned above, Metallurgy and Materials Science is available in only a few I.I.Ts(Indian Institute of Technology) and N.I.Ts(National Institutes of Technology).Mostly, Materials Science is just one subject attached to the Mechanical Engineering stream and most students don't know the value of Materials Science. Moreover, research and development in Applied Sciences is just picking up in India now and below the average compared to advanced countries like U.S.A,U.K and China. The author was lucky to study at I.I.T(Madras) and is aware of the inspirational teachers and Professors at I.I.T s.. This may not be the case in other Universities. Without in any way casting any aspersions on other Universities, suffice to say that in India, basic facilities to teach Materials Science is just picking up in many Universities.In western Universities, interdisciplinary research has been the norm for many decades now, but India has only recently been concentrating on interdisciplinary research A combined interdisciplinary approach is also lacking, except in very good Universities.Usually Materaials Science takes ideas from physics,chemistry ,mathematics,Mechanical and Electronics Engineering and ther is no area where materials are not used.Hence it is imperative to study Materials Science in depath and detail and also have a separate department of materials science as found in good universities.

3.0.NOVEL WAYS TO CREATE INTEREST IN MATERIALS SCIENCE

3.1PRACTICAL MODELS

Crystal structures can actually be made with plastic balls and metal rods. This is possible even in school physics classes. As shown in Figure, the practical f.c.c in the middle diagram could be made by anyone easily and then close packing could be explained using simple mathematics.

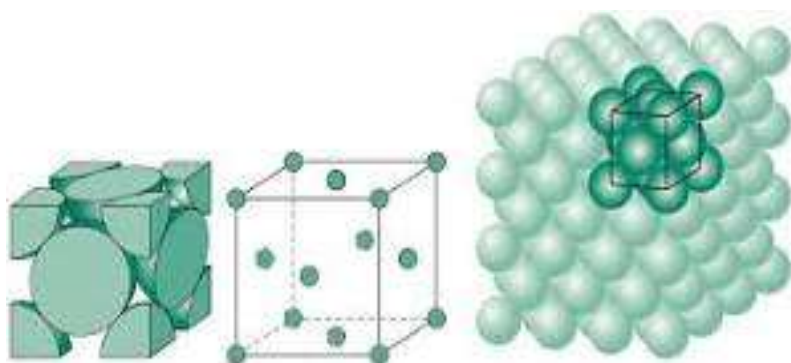


Figure 1 shows unit cell concept

3.2HERITAGE CENTRE CONCEPT

At I.I.T, Madras, there is a heritage centre, where the history of I.I.T(M) Is showcased. The development of I.I.T, right from its inception is showcased using videos ,graphics and models. Eminent Professors, both retired and current speak on their experiences. In the Metallurgy Department, I was elated and proud to know that my Professor, Professor Mohammed Roshan, a world renowned expert in the field of castings was the first Ph.D from the Department. He was instrumental in working with Dr.Abdul Kalam in developing Magnesium based casings for the Prithvi missile.



Figure 2 shows Prithvi Missile

The very sight of the Prithvi missile is enough to inspire students to work for the development of our country. It certainly inspires me.

3.3CATCH THEM YOUNG

When students are in school, all they know about Materials Science is the Metallurgy part=especially the relatively dry and boring Extractive Metallurgy part. Even in college ,this trend continues. If a teacher, or a set of teachers are able to go to high schools and explain how vast the field of Materials Science is-it could create more interest in students. For Example-if students only knew how many Materials are present in an automobile, they would really be awe struck. When I joined I.I.T,Madras for a B.Tech,my friend's father was a metallurgist in a National Laboratory. Both my friend and I were fascinated at joining this exciting world of Metallurgy and materials science. There are orientation programmes being conducted in many Universities ,which include campus tours and tours of Departments. These types of tours are well received in Universities in the United States and United Kingdom, b ut it is only now slowly picking up in India. University websites also showcase virtual tours

3.4SCIENCE FAIRS ,CONFERENCES AND QUIZES

Students could be exposed to conferences in the school.

Prof .B.S.Murty,a renowned Nanotechnologist from I.I.T, Madras conducts lectures and demos for science students belonging to the 11th and 12th grades. The students are offered food and accommodation in SSN College and they listen to lectures for 1 or 2 days. This will definitely inspire them. Similarly, the Indian Institute of Metals conducts regular quizzes, contests in Metallography and gives awards every year for the Best Micrograph (Optical, SEM and TEM).I have also heard and read that elsewhere in the world, American Society of Metals, American Welding Society, American Foundrymen's Society and a host of other Professional bodies do the same in their countries. International Institute of Welding conducts workshops very often, India, which is a member of International Institute of Welding is also hosting many programs through its Indian Institute of Welding. IITs in India have what is known as GIAN courses which are conducted over 4 or 5 days by experts from all over the world. Students are encouraged to attend these courses. These courses give an idea about the current status of research in a particular field of work. These courses are highly motivational both for the students and the faculty.

Even during the regular classes, informal quizzes can be conducted once in 15 days. I have followed this procedure in my class at SSN College of Engineering with reasonable success. A quiz is also a way to break the monotony of the subject. In fact, during one of the informal feedback that I conducted in the class on how to improve and plan course delivery better ,there was a suggestion to hold quizzes in the class.As an added incentive, small cash awards can be given to students who win the first three positions in quizzes.

3.5INTERNSHIPS

Students go for Internships in Private companies where they are given a small task to do. It is only when they go to Industry that the value of Metallurgy and Materials Science is felt. For any application, one has to choose from a wide range of available materials. When this kind of a situation arises, students generally search their Design data books for a Chapter on Selection of Materials. They go to various websites and search for data. In this way, their interest is aroused. There are students who even do two or three internships in their four year course in order to get a feel of different Industries. They can then choose their area of interest in order to pursue higher studies.

3.6INVOLVING STUDENTS IN ACTUAL RESEARCH

It is possible to give a small part of a research problem to work on as a project for the undergraduate students. In the Anna University curriculum, we have two practical subjects which offer scope for such a work. One is called The Design and Fabrication Project, where students have to design a small project. The product can be as simple as a gear. As an example for student motivation in research in Metallurgy and Materials Science, they could design the Jominy end quench apparatus, which is used for hardenability studies. They can design simple microscopes for observing metallurgical microstructures. They can design furnaces for heat treatment like Annealing or Normalizing.

3.7PRACTICAL EXAMPLES OF STRUCTURES

Stainless Steel is being used extensively in the construction of skyscrapers. It was reported in 2016 that an eight floor building was constructed in Gurgaon, India within 48 hours by using Stainless steel.

Fatigue failure is characterized by beach marks, which are similar to the round marks left on beaches.



Figure 3 shows comparison between Beach marks in fatigue failure and Actual beach marks

Welding can be compared to firecrackers used during Deepavali festival. The sparkler suddenly catches fire and then burns for some time. Everyone in India is familiar with the Deepavali festival and so I am sure that this analogy will be appreciated by the students.

Blast Furnace-One of my Professors Dr.Ramakrishna Iyer used to compare a blast furnace with a human body. What you input comes out as output. If you input the right material mix ,the output will be good quality steel.I remember this analogy to this day, almost 30 years after I heard this.

Archeometallurgy

Many advances have been made by Ancient Indians in the field of Metallurgy. In any branch of study, if the students know their ancient history and culture, they will definitely be motivated to do better and more interest will be created in the subject. This being the case, ancient monuments like the Iron Pillar in Delhi are worth mentioning to the student. It is now established that the iron pillar was subjected to some kind of nitriding, but it is a great wonder how the exact composition of the coating was arrived at and how the pillar has not rusted even after decades. Ancient times did not have the advanced microscopes and characterization techniques of today and they have still achieved so much. This kind of information will definitely motivate the Indian student to be more interested in research in Materials Science. Dr.Balasubramaniam has researched upon this wonder and taken microscopic analysis,XRD,FTIR and Mossbeur Spectroscopy of this pillar.He found self healing phosphides in the analysis.These,he believes,could be responsible for corrosion prevention.[2]

The Sword of Damascus is another study in question. It is also called Wootz steel and it is believed that the word Wootz itself came from urukku, which in some South Indian languages means-melting.A lot of research has been done on this steel and it has been more or less established that this teel was commonly made in some places in modern Karnataka and Andhra Pradesh ,which are two South Indian states. Open hearth furnaces have been found in several villages in South India. However, it should be mentioned that with the advent of modern Blast furnaces, which are suitable for large scale production ,these open hearth furnaces slowly dissapeared. This may be due to the fact

that these furnaces are suitable only on a small scale. But, it still remains a fact that much before western civilization discovered scientific melting techniques, there existed in India techniques which made good steel. We are not sure whether rule of thumb was followed or formulas simply passed down from generation to generation, but Metallurgy was fairly advanced in ancient Indian culture



Figure 4 shows Iron Pillar, Delhi and Damascus sword[3]

Structure of Materials

The structure of materials is really wonderful to look at. The multicoloured micrographs that we get these days is fascinating to study. We also have image analysis software to bring out all details of a microstructure. When I was working in a private college in Chennai many years back, I had bought this software and demonstrated to the students, the utility of the software. For example- Nodularity in Cast Iron can be found out by counting the number of nodules per square mm. Grain size can be measured. Artificial intelligence concepts have also been used in teaching materials science.[4] Software have been developed to identify casting defects, for example and a pioneer in this field is the group led by Professor H. Mohammed Roshan.[5]

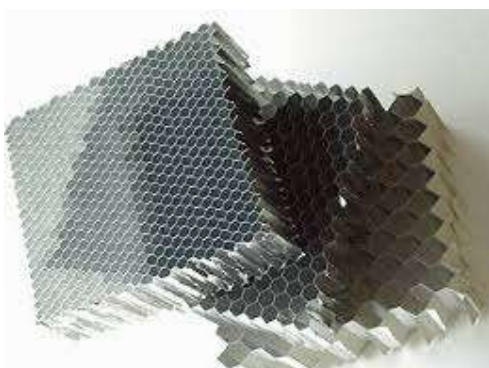


Figure 5 shows Honey comb Material in Aluminium foam

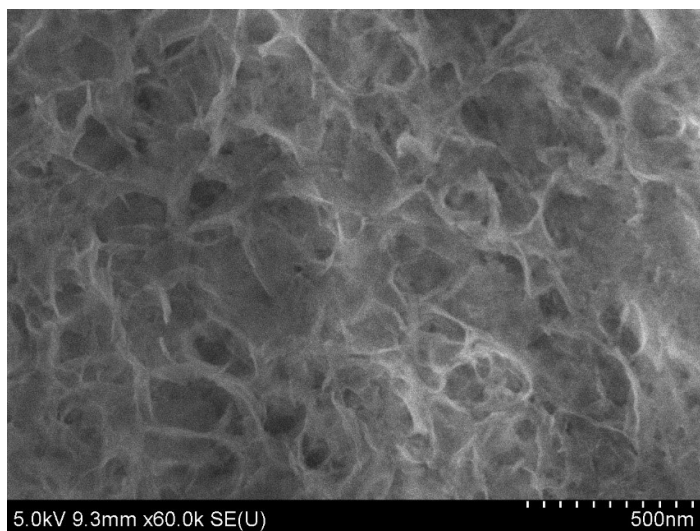
Microstructures

Microstructures are very fascinating aspects of studies in Metallurgy and Materials Science. They look a bit like modern art and in my experience teaching Materials science for 24 years,I have found that students are pretty fascinated,for example looking at twinned annealed brass, the colour of copper, needle like martensite structure etc.It was great fun to draw these microstructures on the blackboard and reproduce them in the exams too.The names of scientists associated with the microstructures like Bains for Bainite ,Martens for Martensite made it even more exciting for the student.



Figure 6 shows Microstructure of Sn-Zn-Al-La solder prepared by the author's research group.[6]

SEM images give us information about the type of fracture



- Figure 7 shows SEM of Sn-Zn-Bi-La Alloy showing porosity[7]

Confocal Microscopy

This type of microscopy is becoming common in the modern world. Direct real time imaging of solidification structures from columnar to dendritic ,can be seen in confocal microscopy. A recent workshop at I.I.T, Madras showed how columnar grains grow from the surfaces inward and also some regions of equiaxed grains, in areas where there are more number of nucleation sites.

3.8 REPLACEMENTS IN HUMAN BODY

Parts of the human body-Artificial Knee Joint

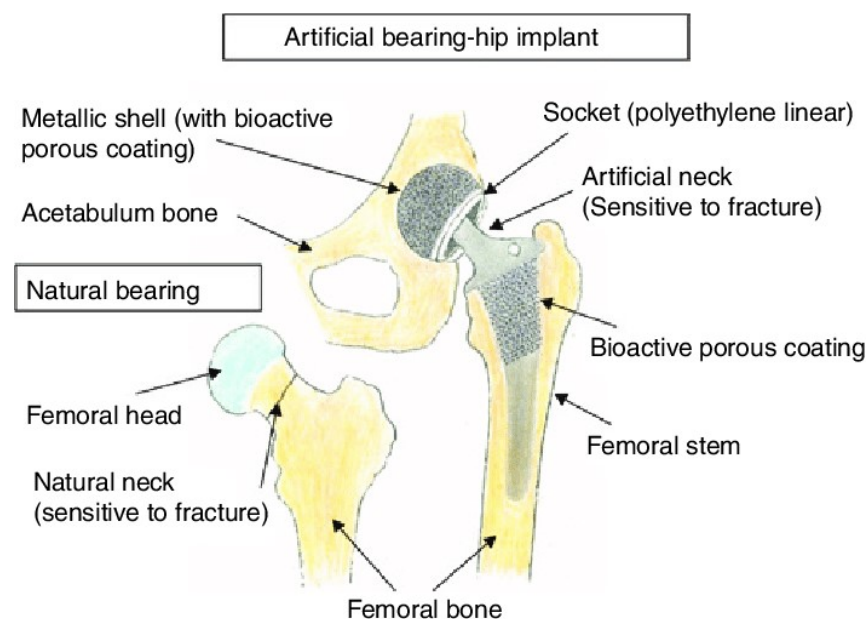


Figure 8 shows parts that can be replaced in a human body

One can see how many materials could possibly used as replacements of joints ,from the Figure given above,

Metallic heart valve



Figure 9 shows materials used in next generation heart valves.[8]

A video showing the working of the valve could be really useful for the student. He/She will get an idea of what are the different material substitutes that could be used in valves

Dental Materials



Figure 10 shows dental materials[9]

In the modern world, the boundary between Engineering and medicine is becoming more and more blurred and interdisciplinary research is being encouraged. This being the case, a little bit of biology in the form of dental materials or materials used for heart valve replacement will not be out of place, in my opinion.

3.9.AUTOMOBILE PARTS

Younsters are excited at the prospects of owning or driving automobiles. When we expose them on how many materials are used in a typical automobile, they are bound to get more interested in the field of metallurgy and materials.

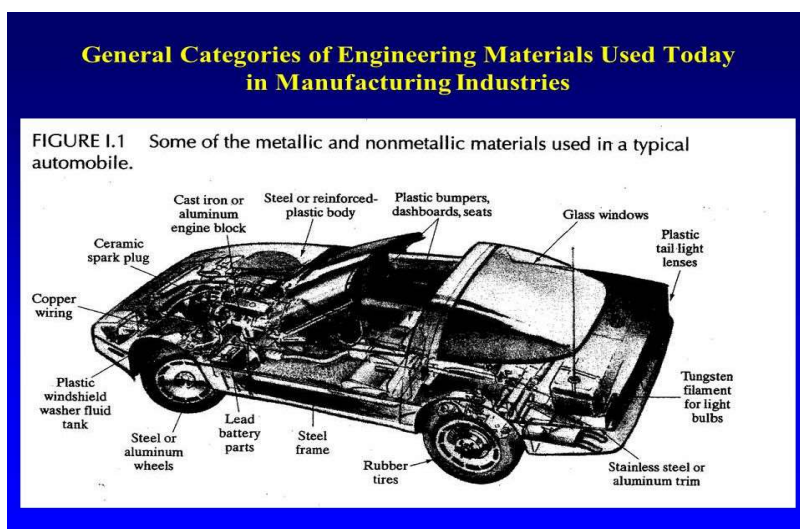


Figure 11 show the materials used in Automobiles[10]

4.0 INVOLVEMENT IN PROFESSIONAL SOCIETIES

Involvement in professional societies like ASM(American Society for Metals) brings in a lot of value addition. ASM students chapter activities are going on almost on a daily basis and there are lots of contests and prizes as well. More importantly, one develops contacts with experts in the field of Materials Science. The students chapter has various student positions and when students volunteer for positions and get involved in conducting and participating in Conferences in India and abroad, one gets a feel for International level research. In India, students from good colleges and Universities have always had a fascination for western education where the scope for growth and recognition in their respective fields are more than in India. This being the case, exposure to the western mode of education in India becomes a must. In good Universities and Colleges, Industrial visits are being made mandatory. Students get an opportunity to have a glimpse of Industry work culture. This helps them to imbibe values like punctuality, high productivity, team work, the value of time and time management from Industrial professionals. Professionals are also invited to give guest lectures and participate in project work committees. They are also part of evaluation committees. These steps give an edge to students and they are exposed to a professional environment.

5.0. CONCLUSIONS

Materials Science and Metallurgy is a very fascinating subject, with a lot of multi disciplinary concepts. However, a lot depends upon the presentation of the subject by the Professors. Applications of materials science should be stressed, more videos and case studies should be presented to the students. History of Metallurgy should be brought out. Only then, the students will really appreciate all aspects of the subject.

Overall, a holistic approach to market the subject should be undertaken in order to attract more students to the fascinating field of materials.

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