Product Engineering and Design Thinking
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Module - 01
Introduction and Prelims
Lecture - 01
Introduction to product engineering

Dear students, I welcome you all to this course on Product Engineering and Design Thinking. I am Dr. P. K. Dan from IIT Kharagpur from the School of Engineering Entrepreneurship. And along with me another faculty from IIT Ropar, Dr. Prabir Sarkar of Mechanical Engineering Department will deliver this course.

At the outset, let me tell you that as India has progressed from the closed economy to the open economy, we have realized one thing or the industry or the country has realized one thing that it is very important to have the value-added portion in the manufacturing that is the design aspect which would provide leverage and advantage and the products, etcetera that would be created will be more acceptable, desirable and affordable.

So, with that idea, various institutes in the world as well as in our country are adopting this. And have introduced courses on product engineering or product engineering management or in similar names. And we also thought that it would be very appropriate to introduce such a course. Particularly when we know that several institutes are revising their curriculum and are introducing courses like this design thinking or say design based entrepreneurship, product engineering all sorts of such things.

And very recently we also have read in the newspaper that AI city also is revamping its course and bringing new courses and design thinking and product engineering will be included in those and will have a centricity in their curriculum and study. With this preamble I would like to go into the course that is the 1st module and the 1st lecture which is the module you can see it is a Introduction and Prelims and the Introduction to Product Engineering will be the first lecture.

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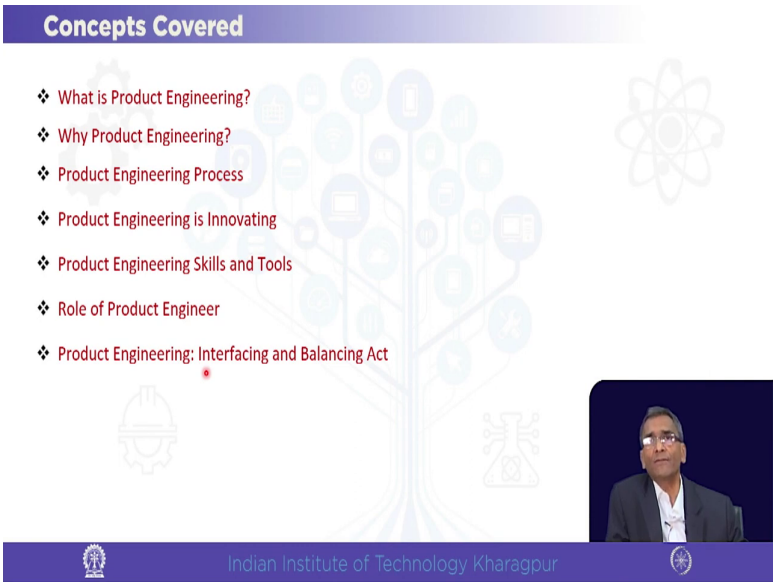

Now, having said this, we would move to the slide that concepts covered here is what we would be discussing and what will be the takeaways would be clear from the slide itself first and then we will delve into the details subsequently. So, first question actually is the question that would be a similar some kind of a definition or simply, what is product engineering?

Then very important question why is it necessary? Because whatever we study, we must understand the purpose why are we studying this? The importance of this in industry as it is going fast rapidly. So, that would be answered through the why. Then we would be learning the product engineering process and also the product engineering is innovating as a concept.

And we need also to know the how part of it that how it can be actually translated. So, what are the things required like say skills and tools for this. And once we know that it is also

important that we know that what are the rules because the young engineers who would be coming out from the colleges engineering colleges.

They would be looking for their career, career advancements and definitely to grab a coverage jobs which should be facilitated through this and that is where roll of product engineering comes in and that will be discussed. And also, as an extension of that it will also be discussed what the interfacing and balancing act of product engineering in the organization.

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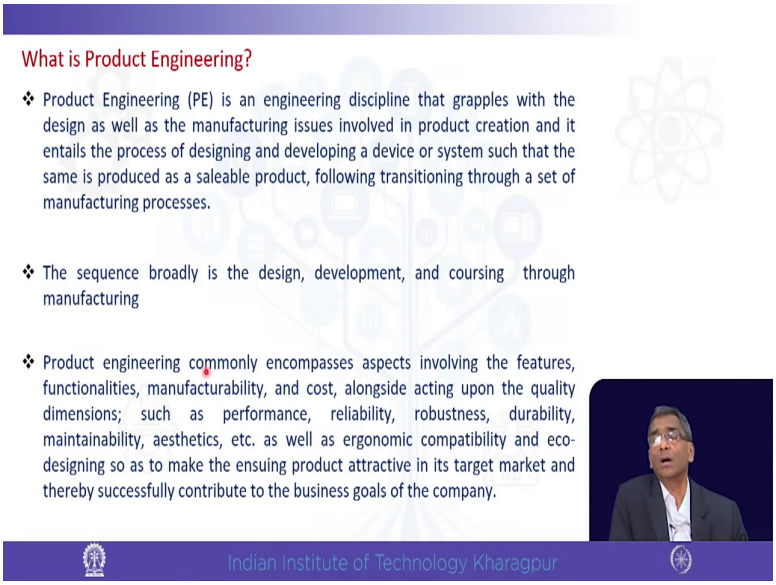

So, with this we proceed to the subsequent sections one by one where this ideas will be clear, what is product engineering? If we start with that in fact, I have prepared the slide in a semi textual format so, that when you study later, it would be very useful for you to understand the concept and accordingly it has been put in the bullet points. Product engineering is the engineering discipline that grapples with the design as well as manufacturing.

So, now the thing is that if we isolate out the manufacturing then as I said the real value addition will be very small. What happens a company or a country where from we are getting the design suppose like in the closed economy mostly that used to be the case that the design will come from some advanced countries or so-called developed countries industrially developed countries.

And we will be the only place for manufacturing. And not only manufacturing this is the consumption zone; that means, it will be sold in the country itself hardly there will be any export. It means the quality of manufacturing manufactured products will not necessarily will be very competitive because it was a closed economy. Now, the thing is that in such condition the design naturally got was you know not came in the forefront because the manufacturing was the main focus.

But now as the country and as the economy as a whole is realizing that unless we bring that component as a whole and design and manufacturing both are brought under the same umbrella the real gain is not possible. Real gain only not locally, but I can tell you that real goal actually globally also is possible if these two components are brought under the same industry or umbrella or in the ecosystem. So, when we are seeing product engineering, we essentially, we are combining the two major components: product design and product manufacturing.

So, this is what is the essence of the first bullet point that with this the idea is to create a sellable product. That means, when we are saying sellable; that means, it has a market desirability. And when it is sellable? That means, constantly if sustainability is sellable; that means, its feasibility and viability is also there. We will talk about that later, but primarily we now understand that these two major components are together.

Therefore, the sequence broadly is design development and thereafter transitioning or coursing through manufacturing. So, these are three broad you know activity heads. So, first we create the design, then the prototype or fabrication is done, prototype development is done and then it goes for mass manufacturing. So, these are the three important steps.

Product engineering commonly encompasses aspects involving the features, functionalities, manufacturability and cost and alongside acting upon the quality dimension. So, when we are talking about. So, what are you saying we are saying that these are the steps, but while we are proceeding through the steps the quality aspect is to be always complied with.

And therefore, it becomes an imperative, it becomes a fulcrum. So, therefore, if we analyze why are what is the quality product or quality system these are the you know some of the component's elements of it comes out dimensions we call as a performance reliability, robustness, durability, mental ability, aesthetics etcetera.

Also, for a product other things under which comes under industrial design apart from the engineering design we were talking about the industrial design mainly primarily covers these two areas that ergonomics and the aesthetics or also the eco design is now being you know considered in a big way. So, we would also take that into account.

Finally, again with this to make product attractive in the target market and let us not forget because engineers and technologists would be working to translate the goods for the consumers and only by satisfying the needs of the consumers whoever is doing that the business or the company should be should remain viable and remain profitable. So, with that idea we would be proceeding further that we would be creating some value adding products or value creation in some sense that emerges in the form of product which are created and designed by the market and sold therefore.

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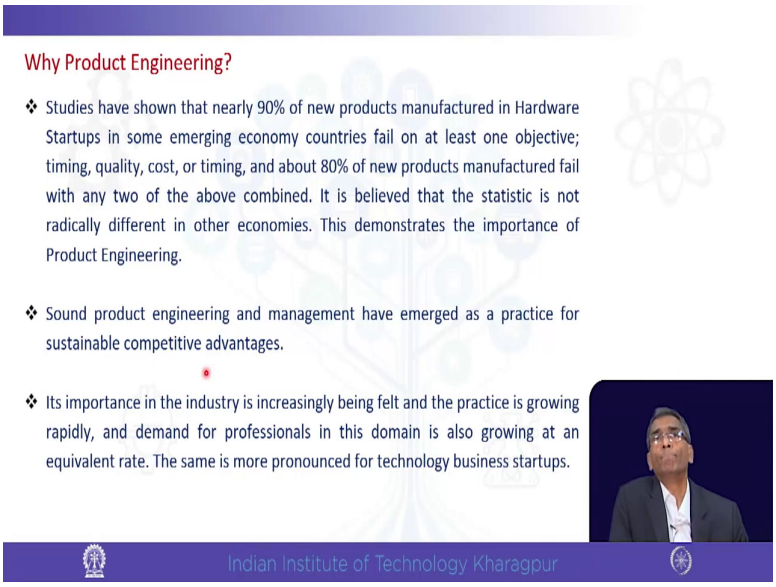

Now, the question is why product engineering? This is quite known now that out of 10 ventures 1 succeeds and rest fails. The question is that it has been seen found that 90 percent of the new products manufactured in hardware start-ups particularly if we say fail either in terms of its timing or launching some I or the cost aspect or the quality aspect effects. Even if we take another statistic that if we take two of them out of the three variables timing, cost and quality 80 percent fails.

So, naturally the failure means it is a big loss or wastage. So, to prevent that be it a corporate organization or be it a start-up that needs a sound product engineering and management practices and that is the need of the day. Therefore, its importance in the industry is increasing and that is being failed and young professionals and professionals are being are demanded and it would open a great career opportunity prospect and scope.

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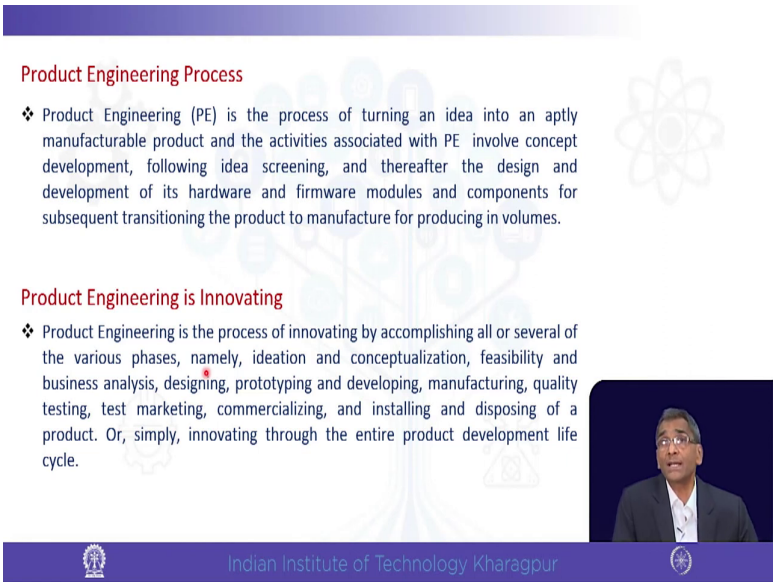

Product engineering process it is basically to turn an idea into the manufacturing product. And if it can be done that way then that is the that is actually satisfying the objective. The design and development of its hardware and firmware modules and components for subsequent transitioning of the product manufacture for the producing in volumes are done in this.

Product engineering is innovating. So, it has that innovation component or it is embedded rather I would say that the product engineering is the process of innovating by accomplishing all the several of the business phases starting from the ideation and conceptualization, feasibility and business analysis, designing, prototyping and developing, manufacturing, quality testing and also test marketing, commercializing and installing and disposing of a product or simply innovating through the entire product development life cycle.

So, the innovation is the key and we would take that forward subsequent in subsequent discussions where the innovation through product design, innovation through design thinking we will be talking about those in future sessions.

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Now, we will just discuss about the product engineering skills and tools. The product engineering process commonly is divided into multiple phases with work distributed in several different groups, activity groups or expert groups. Who would say for example, a group would be doing the mechanical portion of the work, another group will be developing its electronic or control system, firmware or these software based firmware's may be developed by another group, etcetera.

So, the hardware design would typically be completed by CAD or CAE which perhaps you have studied to some extent or if necessary, you can brush it up again or add some knowledge

to that if necessary. But simpler things can be used. For example, the you know there are several CAD software that is Computer Aided Design and Computer Aided Engineering which is a simulation software computer aided design or simulation software those are used.

For example, a digital camera or DSLR that is if we consider that then it means that how different expertise group, expert groups with different expertise will integrate joining and would develop. Product engineering is not about product design, but beyond it. Extending to the phase of commercialization involving various tasks throughout the process necessitating specific skills.

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Now, here I am presenting certain skill sets which you can see on the slide. So, I essentially do not have to read out, but generally it is design thinking, it is obviously, product specific knowledge is required DFM Design for Manufacture. Actually, DFX means design for X, X

stands for manufacturability, reliability, then serviceability or say its eco-friendliness or eco-designing, etcetera.

But here we would talk mostly about the manufacturing the design for manufacturability because it influences the cost to a great extent and affordability is very important issue. So, similarly the CAD you have CATIA solid works etcetera and quality design tools techniques that we will be discussing. Software and firmware development is another important area that is needed defining and developing product design specifications.

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And in the next slide I will continue with the skills, system integration and implementation and mechatronics. Many of which you have studied, but some maybe you have to add in your skill portfolio. Product reliability and qualification, physical product testing, testing analysis

inspection those are part of the thing, cost analysis, problem solving skills, TQM, risk analysis and product control project control are the needed skills here.

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Role of product engineer as I already had said in the beginning that say a for any product creation concept engineering and industrial design or the forerunning activity. Very commonly as we see in the industry and adept mechanical engineer would transform the concept developed into engineering and industrial designs. For assembling components and say with a complex product such as electromechanical product which we normally see as I was referring to the digital camera etcetera.

They that requires the hardware development as well as the software or former development in many cases. Hence mechanical engineering covering study fields namely design, manufacturing and production, quality system, and industrial engineering plays a salient role

in the entire product designing extending into the development. It is virtually the determinant of success or failure of the product. So, if this aspect is not taken care of done well then it would affect the outcome or development.

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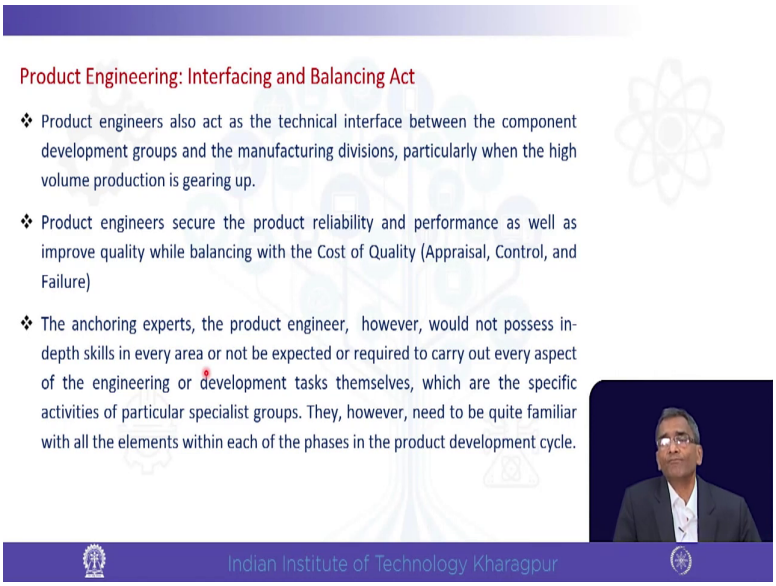

And the extended role is that interfacing and balancing product engineering also act as the technical interface between the component supply or component developing and the production division which are actually mass manufacturing it. So, these two aspects are brought together. So, the manufacturing and design are seamlessly integrated through the product engineering activities.

Product engineers secure the product reliability and performance as well as improve quality while balancing with the cost of quality. Cost of quality is very important term that cost of

quality, if the quality is bad then cost goes up cost means it has got three components inspection or testing which is called appraisal.

And when we that is a cost that need is needed, control is a cost. But if we do not do them then the failure will be both internal as well as external, we will talk about that later, but then. So, we have to balance how much quality we should maintain and for that how much cost it will incur. So, we have to make a trade off. That is the job of the product engineer.

So, one has to very carefully do that. The anchoring experts, the product engineers or the anchoring experts the would not although this is a skill I mentioned, but they may not have all the skills themselves in great depth or detail. But they have a idea about the individual elements in that. But they should have a fair idea of these elements so that they can ultimately assimilate, integrate, correlate and harmonize and orchestrate the whole process, that is the purpose.

So, one would be to some extent expert journalist with a good degree of exposure in those individual field components or domain expertise. They however, need to be quite familiar with the elements, that is, I emphasize once again. Now, as we have discussed this points, I would rather focus a little more on this. That now I will just take these points up. Now, the component develop groups.

Here the judicious decisions are to be taken by the product engineer. Like that when I am saying product engineer it is meant in many organizations now that the design is you know merged into this product engineering. So, I am speaking from that perspective and then with that I would say, design as well as manufacturing engineering not production per se.

And there the design aspects is to be judiciously assessed, that the whether such an certain components are to be manufactured in house or that is to be procured from outside or bought out components. So, while preparing the bill of materials the bought-out components and the items to be made in house that is to be very carefully examined.

And then it is always preferable that the standard parts components if available as a bought-out item would be very useful. There are two reasons. One is that it will straight away give the economy. Say for example, when we talk about simple things like say bearings or say resistance or say some kind of say other items say pumps, gear boxes the standard items are procured.

In fact, in say the various electronic components which are required in product and product control system. They are quite standard materials are available in the market different diodes, transistors so many things. So, it is it attempt should be to use as much as possible those standard components for two reasons.

One is that it will be cost effective because those companies were supplying those particular items those are producing in large quantities. So, economy of scale would give them the advantage of low cost and therefore, you can procure that the you know manufacturer can be procure at lower cost that is one. Two is that if is already there established so technology is proven.

So, if the technology is proven whatever the technology is the attempt should be to make it affordable and robust and reliable to include as much as possible of the standard parts and components or technologies. Something which is needed to differentiate or which is particularly unique for the design and which will give the product a special functionality or a feature for that the item that is customized to be made and that judicious decision is to be taken by the product engineer in a very thorough and critical manner.

So, again the question is that for example, when the product engineer is interfacing with manufacturing is also to be understood that often we talk about tolerancing. So, whether the tolerance that is being used is right; that means, is the tolerance is tight or the unnecessary precision is being used that also is need to be same.

As we also have to see that the tolerance should be appropriate. So, with loose tolerances much is not wasted scrapped because it fails. So, but the process should be capable. So, the

product engineer should also be able to do the statistical analysis and arrive at the process capability of the system.

The process capability today is very well known particularly for the implementation of ISO 9000 in various companies. And ISO 9000 provides a good branding and a certification that allows or that helps the companies even the startups to do business with larger companies and with other companies and with government companies as well and for exports very importantly.

So, there the tolerancing becomes very important. So, while there should not be loose tolerances. There should not be very tight tolerances also; that means, two precise tolerance unnecessarily will increase the cost. So, there one has to be very careful and therefore, the process capability analysis for example, the is to be conduct by the product engineer that is also very important.

So, why these things I am particularly referring to because these also affects the cost, cost of quality as I was just was mentioning. So, the cost of quality as we have already said that appraisal control and failure is a very important aspect particularly the failure. In fact, in a new product often if the testing is not done adequately, there is a heavy chance that many products supplied to industry will be returned. And that is very expensive situation.

Imagine if such a large big switch gear say for example, is supplied elsewhere and the defects are identified. Then how it would be rectified? Again, if the whole thing is to be collected back at the company's cost it would be extraordinarily expensive. And therefore, it is very important that the failure is prevented as much as possible particularly outside after supply, after the delivery when it reaches the customer, if then it fails then it is the cost is very high.

But at the same time internal failure is also there. What is that internal failure? That is when the final inspection or inspection is being done to screen out the bad product from the good one. Then if large number of products are failing because if only the good products will be shipped out.

So, if the large number of products are failing and being therefore, disposed of a scraped or reassembled or re-walked upon all these would add to cost. That is the failure cost. Now, you can understand from this that if we do the other two aspects that is the prevention that is appraisal and control.

But then also we have to make a trade off. That if we do too much of inspection, too much of testing then that also is a cost. Although we may think that ok, that is actually preventing my ultimate failure both internally as well as externally. Similarly, the control the process during the process control that when the work the inputs are inspected, components are checked, but then it is undergoing some kind of operations.

Be it machining, be it fabrication, welding, be it painting, polishing or other finishing operations whatever it is that control is very important that is quality of process control. And therefore, that is also to be guided by the product engineer as to what kind of control system quality control system will be in use the statistical quality control processes are very much there.

Maybe many of you have already studied that or if you have studied statistics learning statistical quality control or statistical process control is not difficult at all, because with the minimal knowledge of statistics also one can grasp that idea.

Basically, the idea is that it should the process should behave in a steadily behave steadily and it should lie within the control limits the desirable control limits and not cross or touch this specification limits that is the tolerancing that I was talking about, the outer limit and lower limit should not be touched.

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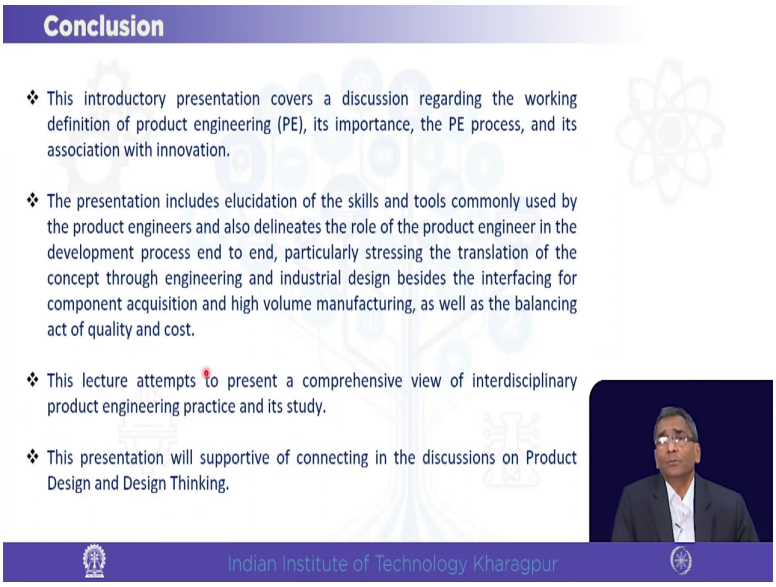

The conclusion if we intend to draw from today's discussion would be that this presentation is showing it is what it is and highlighting its importance. The presentation includes the illustration of skills, tools that we have discussed. Stressing the translation of the concept through engineering and industrial designs and balancing the cost and quality.

The lecture attempts to present a comprehensive view of the interdisciplinary product engineering practice and its study. And finally, this presentation will support you will be supportive of connecting in the discussions on product design and design thinking which we will take up in the subsequent discussions.

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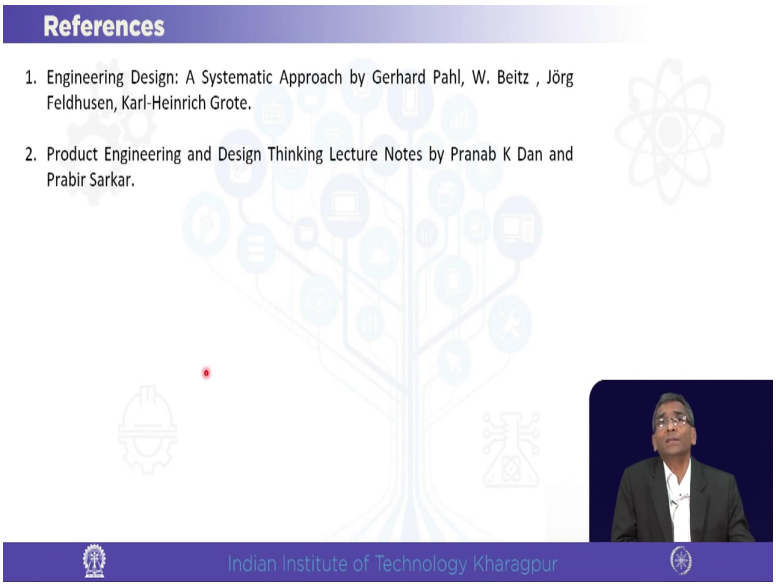

References are here and we would be sending assignments and that would be responded. And I would thank you for attending the session.

Thank you very much once again.