

Design of Machine Elements – I

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Lecture No - 01

Design Philosophy

welcome to this course on design of machine elements

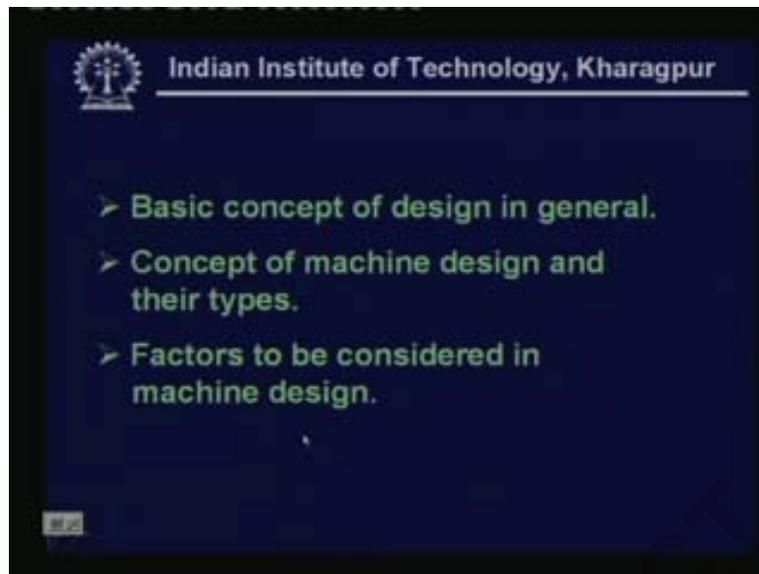
you know today we are going to give you the introductory lecture on design philosophy that is a lecture number one

now before starting this particular course let me tell you a few words that this course is primarily an elementary level course on the design and for this course the prerequisite is only you can say the ideas what you have already gathered from the basic course on strength of material and engineering mechanics

the knowledge of these two courses what you have already covered i suppose will be enough to follow this course and once again welcoming you to this course let us proceed further lecture number one on design philosophy

firstly what we understand by the design or what we are going to do in the design course or what we were objective to take an design as a whole let us have some discussion on to it

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so first of all if you look onto this board you can see we have given three points

basic concept of design in general concept of machine design and their types factors to be considered in machine design

so all these three points are you can say an overall idea that which will give us an guideline to follow our machine design or design of machine elements as a whole

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now you can just see that design is essentially a decision making process and we can see that for every problem we need to design a solution and so that if we combine together then what is

happening the design is to formulate a plan to satisfy a particular need and to create something with a physical reality

so just looking through the just the three points at what i have just told you let us have ah ideas at what is being meant by these three typical points

it is a decision making process the most vital part of a design is a decision making process and it everything is pivoted on the decision

so one designer should be a good decision maker that is one of the primary objectives in the design

now once again you have seen that what we have been talking about that every problem for every problem we need to have a solution

that is what is being meant to that one in the typical type of design or whatever you find out in your practical day to day life when you face a problem then you have to solve it

you may not be knowing many things for the problem but what you will do you will try to solve your problem building up your ideas on to the existing methodologies or existing whatever you are having in hand

you cannot simply sit idle looking for the fact that i will gather all the knowledge everything and then i will give a solution that is not a a very good design concept

the idea is that the world will go on running but you have to give some solution which is feasible which is applicable and which will be used in the mankind

yes of course you can have continuous changes over that continuous modification over that but something you have to give

so with the existing knowledge whatever you are having the tools in your hand make a decision and that decision is what is a primary objective of a machine design

that means what we once again if we try to formulate the entire idea then what we can say just have a look once again that design is to formulate a plan to satisfy a particular need and to create something with a physical reality

ah i suppose you have understood that what i have just meant to say about this design ideas that is the concept or whatever you see that why the decision making is important

let us go for another example

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say we take up an example of a design of a chair this is a very common thing you have seen in everyday life

in the design of that same chair the responsibility is given to you then what you should look into the factors

here the factors that need to be considered come out to be something like this

the purpose for which the chair is to be designed

whether the chair is to be designed for a grown up person or a child

material for the chair

strength and cost need to be determined

aesthetics of the designed chair

so let us take up those points one by one

first of all the factors to be considered is for what the chair is required is it an easy chair is it a chair used for study purpose is it a chair used in restaurants or dining tables so one has to know that means one has to define the problem

so you know what is it for the chair is being made

if it is an easy chair then you understand that its back rests its hand rests will be designed accordingly and if it is a restaurant chair hand rests may not be there because the size of the chair should not be that big and it has to fit within the small tables

at the same time is the chair required for an old person or a child then you understand that depending upon the situations your chair design also changes the size will change okay the color look will might be changing that we will come down later on in this design of chair

now again you know normally the material of the chair is wooden

well you can have the chair made of aluminum you can make the chair of wrought iron which are very common now a days

so where it comes in consideration is aluminum wood or wrought iron is not the problem

the problem is that the material or the problem in the sense what i mean to say the thinking in the line should be like this the material should withstand the load of the person sitting on the chair whether he is an old person or a child

here the material selections is one of the very primary thing in the design aspect

first of all the material should as i told you should take up the load that means it should not fail another thing is that it should not be too costly

another thing that by making the chair by that material the chair should not be too heavy so that it cannot be carried from one place to another place easily

hence we can see that in the design just simply for consideration of the chair one has to think of these things that failure that means material selection should be such that it should not fail it should not be too costly and it should not be also heavy too

so this is one of the aspects of the material you can understand in a in any other designs this is also requirement

now you can see that we have been discussing about that aesthetic sense

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now what is the aesthetic sense you understand that means in just four legs one back rest suppose you have designed the chair simply having four legs one back rest and one hand rest without any shape or not looking very you know very attractive

now the word attractive is a relative factor i i understand but overall you have to look into the fact that means what is the fact that overall how the people's mind are there what we understand

what is beauty what is the colour concept which colours are being preferred by old man which colours are being preferred by children which colour suits in the restaurant which colour suits in a {hou}((00:12:16 min)) home dining hall or which colour suits in the seminar hall of an institute

so there comes an aesthetics part in designing the same chair what we have been talking about

similarly another aspect of the design of chair has not been pointed out over here is also the ergonomics

you understand the ergonomics of a chair means it has to have a standard height it has to be having a standard width or depth whatever you recall

or in other words in short i may say that the dimensions of the chair has to be like that that it can suppose you have designed for an old man then it can accommodate an average variety of old man in {geral}((00:13:18)) means a person having an height of say five feet should not feel uncomfortable at the same time a person having an height of six feet also should not also be comfortable in the similar manner

so somewhere you have to put the ergonomics into account

if i can say roughly you measure all the chairs you will be finding out that in general the study chairs or the restaurant chairs will have a height of around say eighteen inches sixteen to eighteen inches in general

all the reading tables study tables if you try to find out the heights then we will be finding out that it will be in the vicinity of thirty inches so this is an ergonomic aspect that if it is like that you will be feeling comfortable while walking

so you can just see in this particular example we have taken up so many aspects just simply a design of a chair has to be thought very carefully looking into some of the ideas just which came into my mind right now

however if you have a if you go through a more thinking process you should add more to what i have said so that the design is good your decision comes out to be much better than the what the decision i have taken

so this is one of the aspects of what i was considering in the design of chair

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so what we understand as a whole that almost everyone is involved in design in one way or the other in our daily lives because problems are posed and they need to be solved

so every walk of life in each and every walk of life it is a problem is a design

you are designing continuously you are designing

your mother at home is cooking she is designing she is designing new recipes and her decision of course we know is very good so you relish the foods so that is a design

so everyday we have the problems and we need to solve it

you go to the market you are you want to buy some copies pencils that is a design that is a decision making which one will be better to suit you suit your requirement that is also a design

however once we see that almost everyone is involved in design we get an overall idea is that that what you mean by design

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so once again the design or the basic concepts of design comes into the factor is the decision making every stage of design consideration of {des} ((00:16:40 min)) different factors to draw certain conclusions leading to an optimum design market survey to read people's mind study of existing norms

all these taken together you can see all these taken together considered are again reiterated reiterated in decision making in every stage of design means you take this one think of a word go to again an decision making procedure

once you are finalized all these ideas together then you come to an conclusion again the same decision making which is a basic basis of the design and that is what we call the basic concept of design

you understand a bad decision leads to a bad design and a bad product that is what is the gist of taking a bad decision as you have seen here

see for example you can see ah um there are there could be two cars available in the market of of course of the same size same range are doing the more or less the same type of work so ah do you think that one is bad another is good

do both are doing nicely in the market both are being used by the people so what is what a situation is coming up to be

some decision was there that both the designers for the cars have thought of taking the decision and then they have optimized the design and given a shape to their ideas

now one of the important factor in their design or the decision making what i have just shown you is a market survey

that is also another category of an design we will be just looking after few minutes that type of designs are very much dependent on market survey peoples mind that is also a very useful in decision making

once you have taken a decision then rest is relatively easy

suppose you have chosen that for this category of car my engine size will be such that it is creating ah sixty bhp whatsoever may be the other cars available in the market that is also sixty bhp theirs is also sixty bhp yours design also sixty bhp doesn't matter

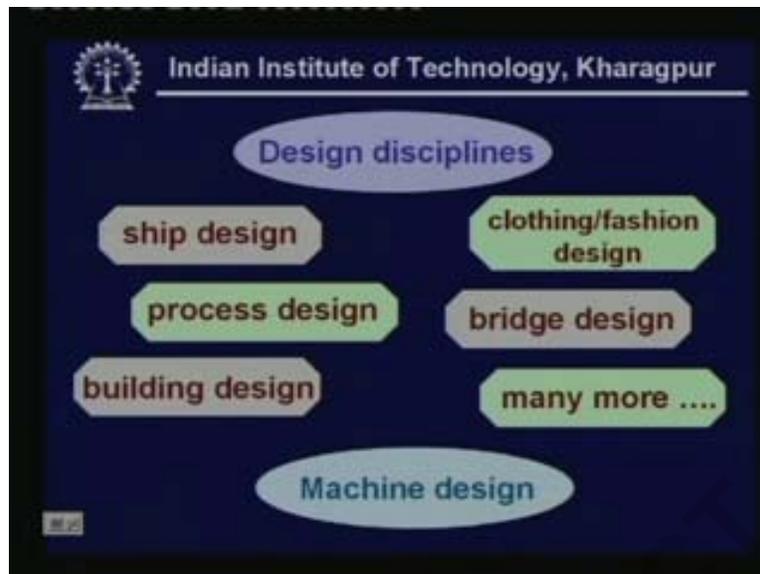
you have taken a decision and you have launched your product and they have take a decision they have launched a product both are going parallely

now the difference may be there in the sell ability because someone might have taken a better decision while implementing the design looking into people's mind and looking and reading the people's mind for one of them could be better so his car might be selling little fairly than the other one

so all this leads to a single point what i is trying to say is the repeatedly i'm telling the design is an decision making

again we look to the other one is that the design disciplines

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so design may be of different products and with present specialization and knowledge bank we have a long list of design disciplines

see to pick a few ship design clothing fashion design which is very common in today's life you can see process design building design bridge design and many more and lastly we concentrate on our machine design or design of machine elements as the course suggests

anyway the overall we call it as an machine design

now you have seen so many disciplines of the design

every field whatever has been shown in the slide are based upon certain knowledges acquired by the people in that particular discipline and they have taken some decisions from their knowledge of their discipline and are designing ah in an are designing the required products in their specialization

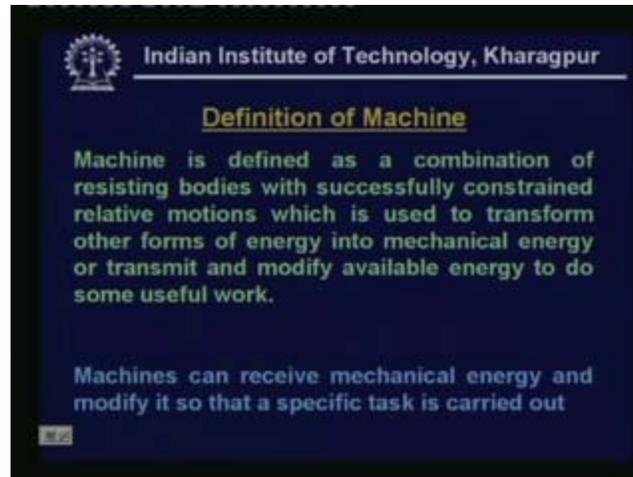
say cloth design see they know they know the peoples mind the similar manner what has been discussed there is no point in repeating and ah from that people are doing the cloth design someone is doing the ship design

now here we are for the machine design

so what we understand by the machine design now just to know about machine design one has to know what is machine first of all one has to know what is machine

let us look onto a definition of a machine as a whole

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so as i have given over here is of idea of the definition of {ma}((00:22:31 min)) machine

machine is defined as a combination of resisting bodies with successfully constrained relative motions which is used to transform other forms of energy into mechanical energy or transmit and modify available energy to do some useful work

now here you can see that we have defined in this second paragraph the machines can receive mechanical energy and modify it so that a specific task is carried out

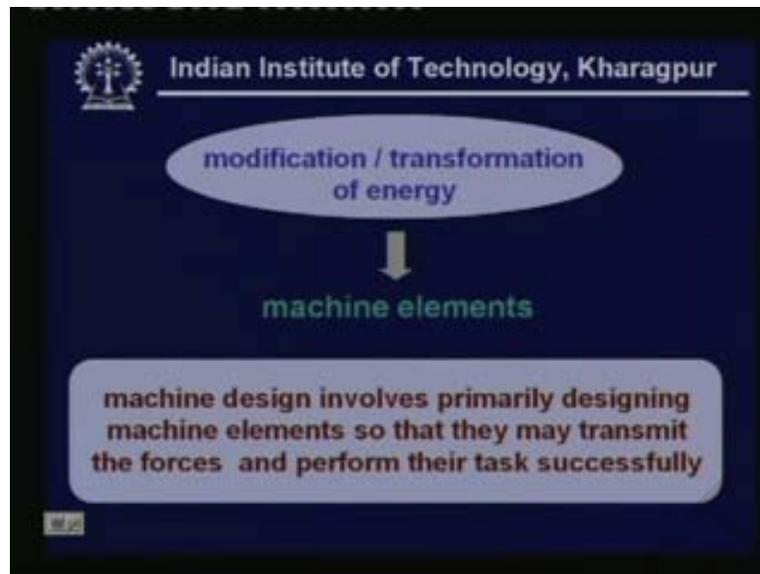
so you see that the machine definition lies in the fact that we are in general we are getting an some sort of energy at the input device and then we are getting some useful mechanical works

in the particular process the transformations are being done by various machine elements which are put together in a combination in a coherent manner in such a way that one machine element responds nicely with the other {res}((00:24:00 min)) machine element and thereby creating the ultimate effect in the terms of some mechanical work done in general

so that is what we understand as a machine

now so what we understand once again you can just look at that particular slide

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where it has been given in the form of a picture which says a modification transformation of energy that is what I told you utilize machine elements

so that means this machine element is our primary duty which has to be designed

so machine design involves primarily designing machine elements so that they may transmit the forces and perform their task successfully

so this energy what you get you use some machine elements and then you {th}((00:25:13 min)) and this machine element will give you the output in terms of mechanical work done

now that is the idea of machine design as it has been written here so before we go to this particular aspect of machine design once again now ah let us have a look at something else

now you can see that here here you can see ah person riding a cycle

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so we can think of that he is giving some sort of energy and just take a look at this one if you are giving some sort of a energy and you can see the paddle which is transforming the energy to give you a rotation of the cycle and that is his that is the output work he is getting that means this is one machine design problem

here what you are getting that the energy or mechanical energy being transformed to another form of mechanical energy and as far as the design is concerned what you will be getting that you have to design the paddle

you have to design the chain sprocket arrangement you have to design the wheel you have to design the bearings so that your specific problem of moving a person through a machine which rotates and moves on to the road

well this is {whas i}(00:27:13 min) is the problem which in one term we call as an bicycle

so this is one example of what we can say a mechanical energy is being transformed to a mechanical energy

so this is a simple situation all of you know and since all are machine elements

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here you can see a aircraft this aircraft was used in nineteen seventy one in Bangladesh war so this is also a machine and primarily this machine runs on fuel aviation fuel

so the aviation fuel is being utilized primarily to give you an mechanical output in terms of flying the aircraft

now this one you can see is a locomotive engine

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nowadays is not in operation however it has got very interesting machine elements so that we will come to see

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so here also you are using ah combustion coal combustion to make a steam just coal combustion to make a steam and that steam you know through a steam chest it is giving an reciprocating motion to a piston arrangement and that piston while reciprocating giving a circular motion you can see very carefully that this piston coming out these are the links which creating the reciprocating motion to a circular motion in the wheel

these are all what you can see the missing machine element okay so have a we have a look on to this one

so this is another example that all the machine is being and see a synchronous coordination what was as telling that this machine element is coordinate coordinating with this machine element and gradually you are getting one from one form of the energy

i am just pointing out this form of energy because this is i this i suppose as is a steam energy you are getting and then we are getting an mechanical work output in forms of rotation of the wheels those these are the different machine elements

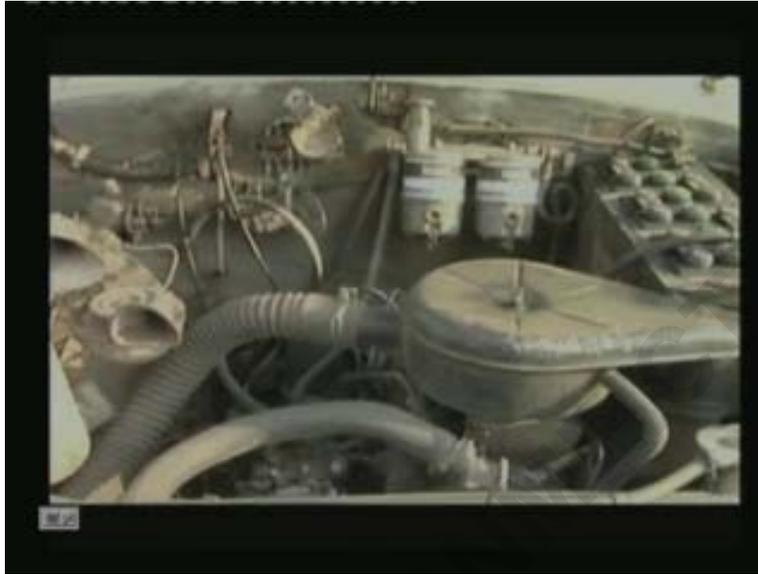
so the entire one is a machine however these are machine elements

so that was shown in the definition that how we can what is that idea or the what is the definition of the machine as a whole

so just have a very quick look on to that one yes it is a closer look at that machine elements

well here you can see a car of the same ideas that means you are using an fuel to drive a car and these are some of the internal components of the car

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so you understand that this is the a filter this is a battery for giving you the this is the source of power and ah (Refer Slide Time: 00:30:55 min) few more we can see

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while this is a very close look this {ari}((00:31:07 min)) i think this is from the back side and it is a radiator and so and so forth all the other component this is the main engine well just missed it

okay this is this is the this is the portion where we have we have seen the engine we have ((already)) (00:31:31 min) seen earlier

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a closer looks to some other units this an bail drive you can see here this is a bail drive it is a mechanical drive and ah so this this machine is also build up of so many machine elements so one again we can see how nicely the machine elements are being synchronized to perform a operation and that entire one we call as an machine and you are going to design such machine elements and put it together to form a machine

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well once again this is the filters oil filters

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this is a close look at the battery

ah see here is an arrangement where you can see a rotary ah {s}((00:32:44 min)) see a rotary motion is being giving an reciprocating motion see this is the the inner crank is giving an rotary motion on outer side

see this is the slot on to which the bar is moving and this is another link which is actually rotating this link as you can see in the figure

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its need not to be described all the things

here is the lathe machine

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what you can see we have seen in a workshop this is a machine and interestingly at this moment the specimen it is making or the job it is making is a specimen for tensile tensile test okay specimen for tensile test

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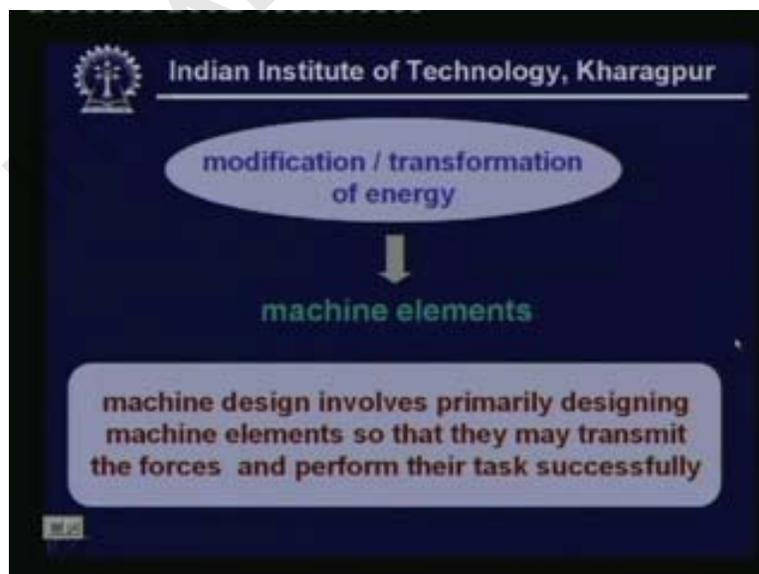


so this is this particular lathe is driving power an electrical power so the transformation of electrical energy to an mechanical form

so these are few of the machine elements that what we have seen so that gives you the idea okay

so we have seen once again just quickly look at the board i mean this one

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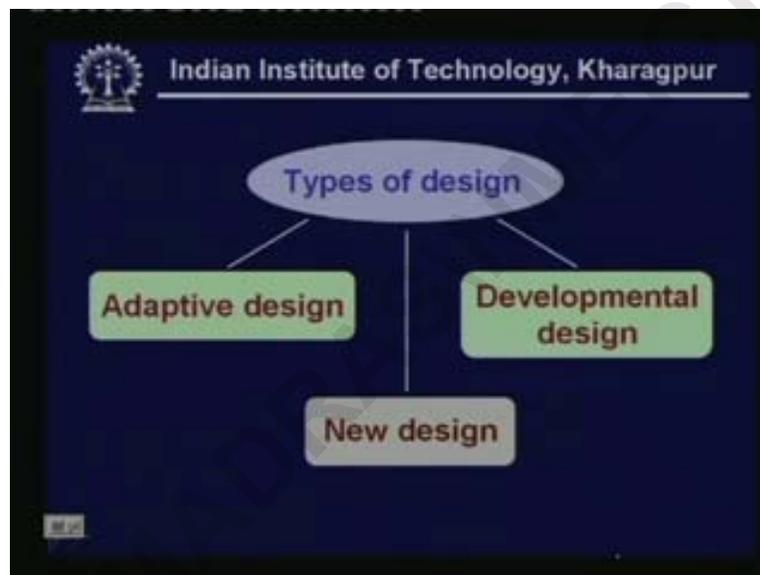
machine design involves primarily designing machine elements so that they may transmit the forces and perform their task successfully

so after looking at these particular video clips now you got the idea that means what we meant by machine elements how it is transmitting the forces to perform the task successfully

what are the successful tasks we have seen a bicycle aeroplane car etcetera

so this is the concept of the machine as a whole and we are now clear what we are going to design

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so once we see see that we are defined in that our job at what we are going to design that is a design of machine elements

now we come down to the idea that the types of design what are the types of design we can see one is an adaptive design another is developmental design and another one we call as an new design

so these are the types of design one can think of

let us have a quick look at what we mean by these terms adaptive design developmental design and new design

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now adaptive design is based on existing design standard products or systems are adopted for a new application

conveyor belts control systems of machines and mechanisms or haulage systems are some of the examples where existing design systems are adapted for a particular use

so basic thing is that let us ah discuss on these particular point that what do we mean by adaptive design now

so adaptive design is just we have seen the definition something is available you put it together and let it performs it duty it is an adaptive design

see you have got a pump purchased you want to run the pump to lift water

you require to rotate i mean run the pump how you run the pump obviously if you are having an electrical power with you

let us assume you have an electrical power with so you utilize an electrical prime mover

now this electrical prime mover has to be attached to the pump shaft so that the pump shaft rotates it rotates the impeller and your purpose of lifting water is being satisfied

in this particular case how you are joining these two ideas i mean how you are transmitting the power it could be directly coupled so you have to design a couple

we will be learning later on how to design a couple or you have seen a bail drive just now what we have seen in the car in the video clips similar a bail drive is required to run the pump

so you can do in either way either using coupling or you use a bail drive

now interestingly the pump the motor the belt or the coupling everything is available its standardized

so what you do you just put it together to solve your purpose

all those the designs of examples of conveyor belts haulage systems etcetera are given over here

i am giving an another example just what i have stated right now this is what we call as an adaptive design

the next one in the line is the developmental design

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now this developmental design is something that a existing design is being is there and you are going on developing or modifying the design

so new model of a car is a typical example of a developmental design

at the very i mean ah the ((dawn start this might)) (00:39:13 min) this lecture i was telling that you have to give a solution to the world you have given it later on you thought that moment the

decision what was you have taken was correct but it could have been better if i have considered certain other aspects

there is an ample opportunity to do that and that is what we understand as our developmental design so you go on developing the design and get a newer and newer and better and better products

the last one is an new design just have a look into this one

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this type of design is an entirely new one but based on existing scientific principles that means you are not creating any innovations okay it is given later

no scientific invention is involved but requires creative thinking to solve a problem

examples of this type of design may ah include a small vehicle for transportation of men and material on board a ship or in a desert

some research activity may be necessary

so what you understand by the new design that is ah the product is not available in the market

but there is an possibility that if you can look or ah if you can design something a like that it might helpful to the mankind as a whole people as a whole like that so you go on thinking give

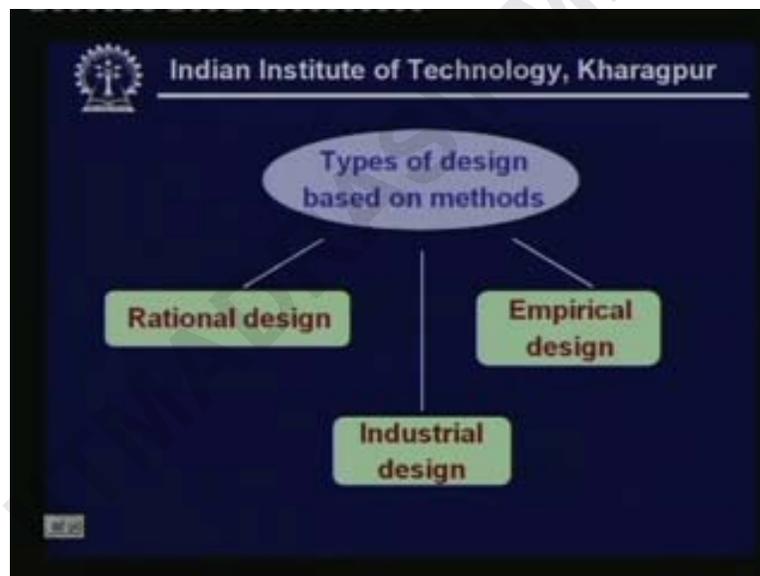
some innovative ideas and for which you are not creating a Newton's law means a new invention but what is exactly you are having in your hand the tools you are utilizing that

however whether your ideas are crystallizing or not you can have some tests on models you can make some research activities and that is where you have seen the scope of research and development in the industries and many other places

so here is the idea of the new design something which is not exactly existing you can think of that one with available ideas, knowledge and your innovative thinking and some research activities so this is what we understand by a new design

now you can see

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the design when we classify the types of design based on methodologies

earlier we talked about what could be the types of design and this is what is the method based designs means what are the methods by which we do our design problem

here you can see we have given three such sets of ideas one is rational design another is empirical design and another one is the third one is industrial design

let us have a look once again that what we understand by these three terminologies namely rational design, empirical design and industrial design

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rational design based on determining the stresses and strains of components and thereby deciding their dimensions

what it is meant by the standard design methodologies or overall what you have learnt so far in your earlier strength of material i can i can say that is one of the examples of a rational design

how you know {thes}((00:43:50 min)) you know stress is how much stress is defined by ah um load divided by the area so you have some load onto a say a circular rod and then having an cross-sectional area say A so you know that P divided by A is a stress generated

now you do a tensile test for that material find out its yield point means the point where the material is going to fail

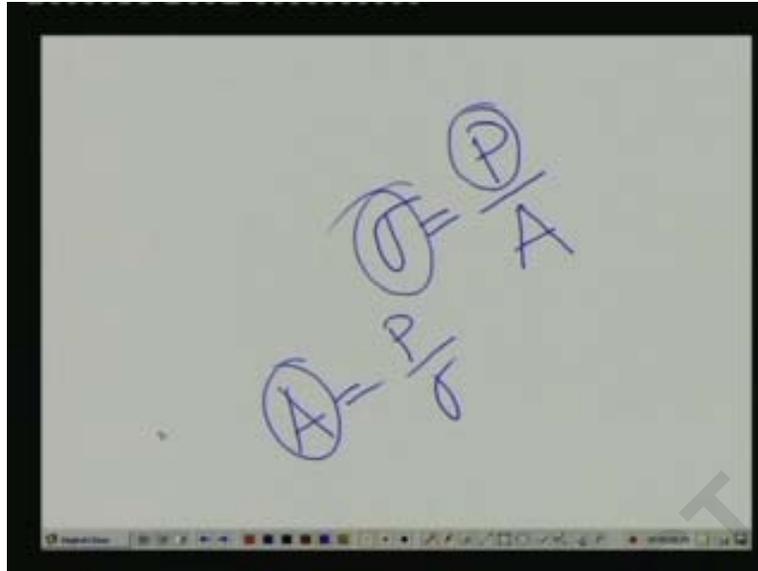
so this value is sigma the value is sigma

so sigma equals to so if we look into this one then we find that ah what we understand that is this excuse me

so we what i was trying to say sigma equals to P divided by area

so what you understand is that if you know the load if you know the design strength or the material property so area comes out to be P divided by sigma

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so this is your design that means what should be the cross-sectional area you can immediately tell provided you know the material property

so that is what we are ah trying to say about this that based on a this is the one

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Rational design

- Based on determining the stresses and strains of components and thereby deciding their dimensions

Industrial design

- Based on industrial considerations and norms viz. market survey, external look, production facilities, low cost, use of existing standard products

yes this is the based on the {determ}((00:45:48 min)) i mean this is the rational design slide ah sorry ah its went to other slides

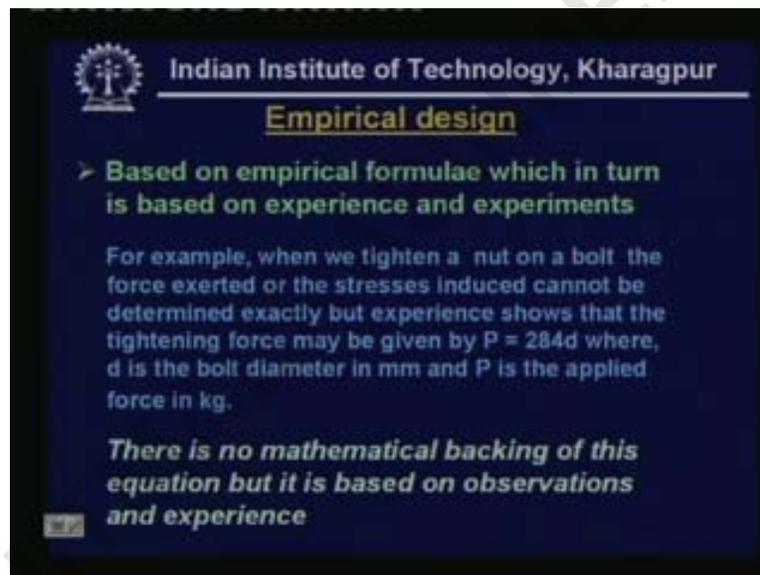
anyway now come down to the industrial design industrial design is based on industrial considerations and norms that is the market survey external look production facilities low cost use of existing standard products

this we have already discussed earlier in some other form that while designing a copy market survey ((means))((00:46:20 min)) people's mind what should be the external look which people want more okay what could be the productions facilities that will make my ah product cheaper all these considerations are the what we understand by industrial design

of course this design is based on existing standard products no doubt but you have to have an extensive knowledge base for all these ideas of the market production facilities newer developments in production technologies and the primarily the cost factor

so these are all what we understand by the industrial design

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now the another one the last one is an empirical design this is based on empirical formulae which in turn is based on experience and experiments

here is an typical example what we can site

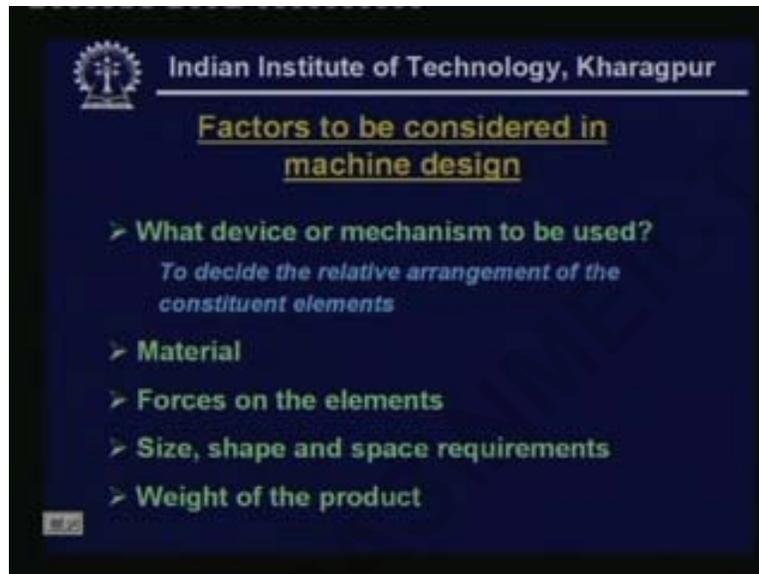
when we tighten a nut on a bolt the force exerted or the stresses induced ah is ah very difficult to um you know find out that is {re}((00:47:38 min)) exactly but experience shows that the tightening force may be given by P equals to two forty eight d where d is the bolt diameter in millimeters and P is the applied force in kg

here {ly}((00:47:51 min)) surprisingly there is no mathematical backing of this equation but it is based on observations and experience

so what we find that this one the empirical design is purely based on the experience of the people experience of the designers

similarly like this in our later course we will be finding out ah there are so many other empirical relations developed from the experiments and from the {experi}((00:48:26 min)) i mean from the experiences of the people or the designers which we call as an empirical design

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now one of the most important thing also comes into picture is the factors to be considered in machine design

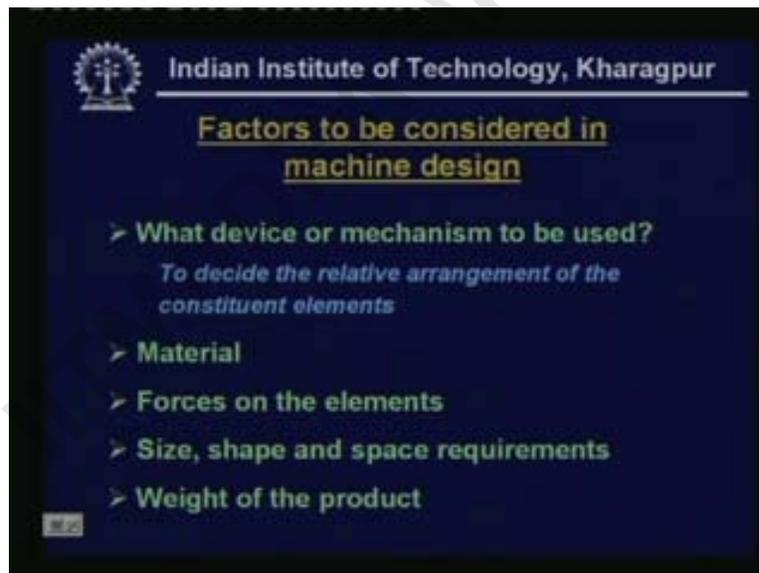
what device or mechanism to be used okay to decide the relative arrangement of the constituent elements material forces on the elements size shape and space requirement weight of the product

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the method of manufacturing the components and their assembly how will it operate reliability and safety aspects inspectability maintenance cost and aesthetic of the designed products

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so all these points what has been written over here let us have a quick recapitulation

in somehow or other this has been spelt in this lecture the earlier stages but now let us look into look in ah categorically

first of all what device or mechanism to be used

this is a very important aspect because a same work can be carried out by two different type of mechanisms so here comes a decision making that which mechanism to be adopted of course this which mechanism to be adopted for a better performance

as i have told you earlier here comes again the same old factor the decision making

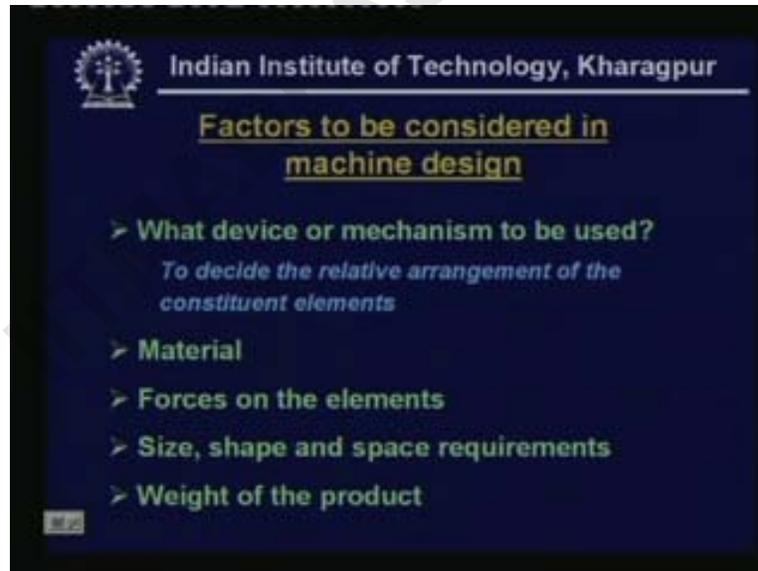
however or the mechanism and thinking of the mechanisms as a whole is a knowledge based means what i mean to say that you should have an idea of the what are different types of mechanism available

next comes the material we had a long discussion on this particular material while considering the example of chair

now this material selection has become a one of the ah one of the research areas you can say almost the metallurgists are day by day everyday they are giving new materials new developments the reason you know why

suppose you want to fly an aeroplane your material should be such that it should withstand a strength at the same time it should be quite light the entire machine should be light so that you have a laser force to you require an laser power to fly the machine in air

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next comes the ideas of the shape size and space requirement and forces on the elements weight of the product and these situations are also to be described

so we can understand that material we have discussed force on the elements that could be various types of forces that comes into picture and this forces could be either a static type of force or it could be a dynamic force as such

so what we understand is that the next one comes out to be the size

size is one factor that one has to also consider very carefully

you understand the size shape and space requirement are again interconnected with material force on the elements means these are all interconnected suppose you you have a material of lesser strength the sizes increases okay that means choice of material gives you the idea of the size either oversize or undersize

another thing is that if you are designing a machine element and following certain standards then what happens you know that this design size what you get from your calculation you will use a next size so that it comes out to be within the standard sizes

a machine what has been designed depends where you are going to use so obviously the space requirement comes into picture that we can intuitively understand what it is that

weight of the product of course is very much required to be considered because it determines some of the cost on to the product particularly so material cost is an {tremendou}((00:53:53 min)) i mean one thing one should keep in your mind

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the method of manufacturing the components and their assembly that is also very important in the sense that you can use an various procedures we will be discussing like casting forging machining which one will give you the same situation is a economics

a better machine eh economics comes out to first and how your design ah will be withstanding the strength etcetera

of course you can take up {methodol}((00:54:35 min)) manufacturing methodologies depending upon the component but anyway which gives you a better {batc}((00:54:42 min)) batch production which gives you ah ah ah material behavior in a better way so all these things are dependent on to the manufacturing technologies

how will it operate the operation should be very smooth just you press a button up {th}((00:55:04 min)) entire system starts nowadays we find in so many machines

well ah that may not be that simple but still you one has to keep in your mind reliability and safety aspects this is one of the situation which has to be taken care of

now what is reliability it is basically a probability that machine will not fail in its life duration

now this requires that you have to be very careful that how much wear is taking place whether the force is taking place on to the machine elements how it is taking ah ah {ma}((00:55:44)) ah taking place onto the machine elements so that none of the safety norms are being violated so that is what is the reliability

so all safety aspects starting from environment to design strength as a whole should be taken up to make a machine reliable

inspectibility that means you have to check the machine time to time so the machine assembly should be such that you should not have a difficulty in inspectibility of the machine

maintenance cost and aesthetics of the design products are the {la}((00:56:26 min)) this last three points have to be discussed

however maintenance is indirectly related to reliability and safety aspects

the more and more you have the maintenance proper maintenance then ah some or other reliability and safety aspects will of course increase in this matter

cost and aesthetics we have already discussed in the in this lecture at the earlier case file we were talking about the chair and

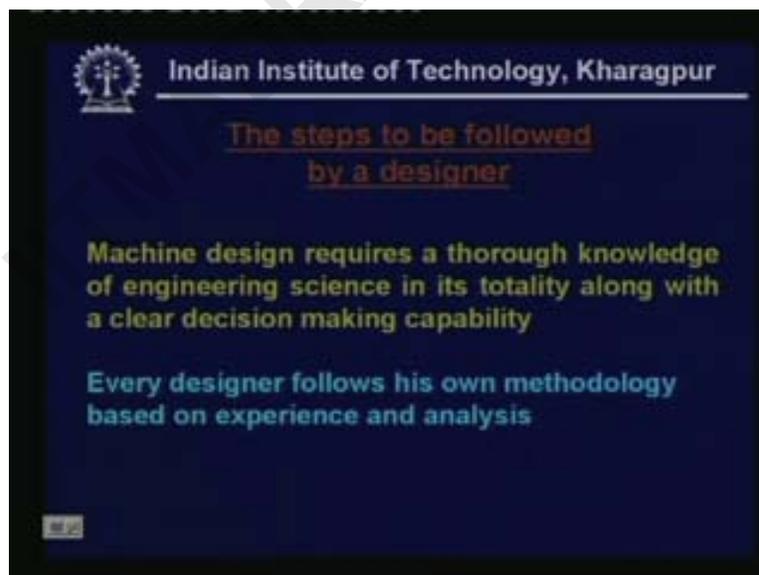
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so what we can just very quickly recapitulate the ideas what we have learned in this lecture that overall we have learnt that machine is a combination of several machine elements arranged to work together as a whole to accomplish specific purposes

machine design involves designing the elements and arranging them optimally to obtain some useful works this is what we understand by the machine and machine design as a whole

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the steps to be followed by a designer as such machine designs require a thorough knowledge of engineering science in its totality along with the clear decision making capability

every designer follows his own methodology based on experience and analysis that we all know

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next the main steps to be followed in general are define the problem first you have to be understanding the problem make preliminary design decisions which repeatedly i have told is decision is an very important factor

make design sketches carry out design analysis and optimization design the elements for strength and durability prepare documentations to be followed for manufacture

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the reliability in machine design that this one is the reliability of the designed machine is concerned with the proper functioning of the elements and the machine as a whole so that the machine does not fail in use within its designed life

overall safe design approach at every stage of the design is needed this is the reliability in machine design this is an very important factor

so with this we end the lecture on design philosophy

thank you

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