

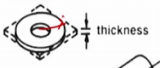
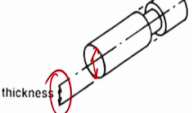
Design for Quality, Manufacturing And Assembly
Prof. Palaniappan Ramu
Department of Engineering Design
Indian Institute of Technology, Madras

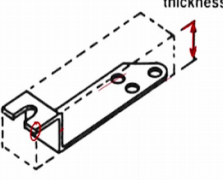
Lecture - 33
Quantification of Part Size & Thickness

(Refer Slide Time: 00:16)

Part thickness

- The thickness of a cylindrical part is given by its radius.
- A cylindrical part (other than perfect cylinders) is one with circular/regular cross-section with 5 or more sides, whose length is more than its diameter. $l > d$



- The thickness of a non-cylindrical part is defined as the maximum height of the part with its smallest dimension extending from a flat surface
- If dia > length → non cylindrical



Adopted from PDMA, Booth

So, the next guideline that we saw or we discussed in general I mean we did not express explicitly discuss about the thickness part, but we talked about size in general right. So, thickness, so people look at usually a cylindrical part and a non-cylindrical part that is how they decompose a particular part ok. So, for a cylindrical part the thickness is given by its radius, it is obvious ok; what is the radius of that; that will be the thickness of your cylindrical part. But not always you are going to have a cylindrical that is completely cylindrical, sometimes you might have a break in between and they call it non-cylindrical ok.

A cylindrical part other than perfect cylinders is a one with a regular or a circular cross section with 5 or more sides ok. So, imagine that it is not a circular cross section, but it has a rectangular cross section ok, so that is a non-cylindrical part in that sense, because you need to have a circular cross section right. So, how do I see whether it qualifies for this is, I look at the number of sides. So, if it is a square cross section, it has 1, 2, 3, 4, 5, 6, so minimum 5 sides with 5 or more sides that is what it says.

Whose length is more than its diameter that is how you define a cylindrical part. So, if it has 5 or more sides and its length is more than its diameter, then I would still call it cylindrical; it is not a cylindrical cylinder cylindrical, but I would still call it cylindrical provided it satisfies these two conditions ok.

How they talk about the cylinder is we will discuss what I have here, but just look at this. Let us say that you are going to give this to someone, what will you do? You will put a box around it that's all this one says ok. You take a part and imagine that you are gift wrapping it, but a very snuck gift wrap; you are taking a box that just encloses this writer on that then you go and measure what is the thickness of that box that's all, that is what is the thickness of your part. So, if you take this particular part, you do not know whether to take this as a thickness, whether you will take this as a thickness, these are thickness of the sheet metal, but you are talking about thickness of the part itself.

Then what I need to do is I need to put this box you see this dotted line, imagine that that is a box that is a gift wrap that goes around it. Then the thickness of course, you know what the thickness is right, smallest dimension compared to the length that is called the thickness. Similarly, you can take this washer for instance, imagine that you are gift wrapping this guy it is a small box or Flipkarting or Amazon whatever the boxes and you measure the thickness of that guy. Whereas, if you have a cylinder, you just take the radius that's all, this is what is going to be my thickness that is what shown here, just a radius will be your thickness for cylindrical parts.

For non-cylindrical parts you assume that your gift wrapping and then you find the thickness or the height of the box that is what is going to be your thickness.

Student: Sir, will non-uniform cylinders qualify as cylindrical (Refer Time: 04:17)

Sorry.

Student: Non-uniform cylinders.

Non-uniform cylinders.

Student: Radius of the (Refer Time: 04:24) and constants along the length.

Like that yeah; so, do they?

Student: Do they qualifies cylindrical parts or.

Do they have more than so they are not a perfect cylinder.

Student: They are not a regular cylinder.

Correct, they that is what they are not a perfect cylinder then you have to go with this, do they have greater than 5 sides?

Student: They have 2 sides right.

They have 3 sides.

Student: (Refer Time: 04:51).

Sorry

Student: It is a cone, like a cone.

No, no I thought you are talking about something like this, it can also be a cone, it has a sharp edge that is what you are talking about. So, it has one side and then one side here so it is only 2 sides. So, it will not qualify in that sense. So, then what you need to do is this, you need to do a gift wrap and the largest one will be your this thing ok. It, it has to be a rectangular box when you gift wrap it, you cannot have a tapered one; you understand what I am saying right.

So, you can see here it is a perfect ok. So, you have to be careful, but the way I guess it is usually the other way of looking at this is your going to project light on top of this guy ok, then you will look for the projection and the thickness is the height of that product is what it is ok; so that is what it says the thickness of a non-cylindrical part is defined as the maximum height of the part with the smallest dimension extending from a flat surface. So, you put this guy it has to come from here from a flat surface you place it here, the height of the base will be your thickness ok.

Student: What about hollow parts?

Sorry.

Student: Hollow parts.

Hollow parts the in one sense this is a hollow part, it is still the thickness is thickness that's all.

Student: Then we can take the.

No it is not a weight, please understand this is thickness.

Student: (Refer Time: 06:21) When we like in this case if I have a pen with without a refill.

Hm hm.

Student: It is like a hollow thing, but if I gift wrap it at the maximum thickness would be this only right.

Correct.

Student: So.

The thickness is thickness, how does it matter whether it is hollow or non-hollow.

Student: Sir, the sides inside was (Refer Time: 06:40).

It is just the outside yeah you do not worry about the inside part yeah, it is not in it is it is geometrical only on the outside where you are going to handle it, you are not going to handle it from inside; you are only going to handle it from outside from that perspective your answer your question is valid, but we are looking at it from an assembly and handling perspective.

So, you are only going to handle it here, see the only point in this whether it is this cylinder or it is a cylinder that goes into your drainage tubes they are also hollow stuff only, but they also cylinders, but you measure the thickness and you necessarily know that that is much larger thickness than this one, this can be handled by a two fingers; whereas you need at least two people to handle that it is as simple as it is that's all ok.

So, for instance this guy is hollow in one sense, the washer is a hollow if you look at it now, if I extend this guy then it becomes hollow cylinder, but you look at only the outside any questions. Yeah, the other one is this is something that we are talked about yesterday in one sense, diameter being greater than length l by d ratio always comes into

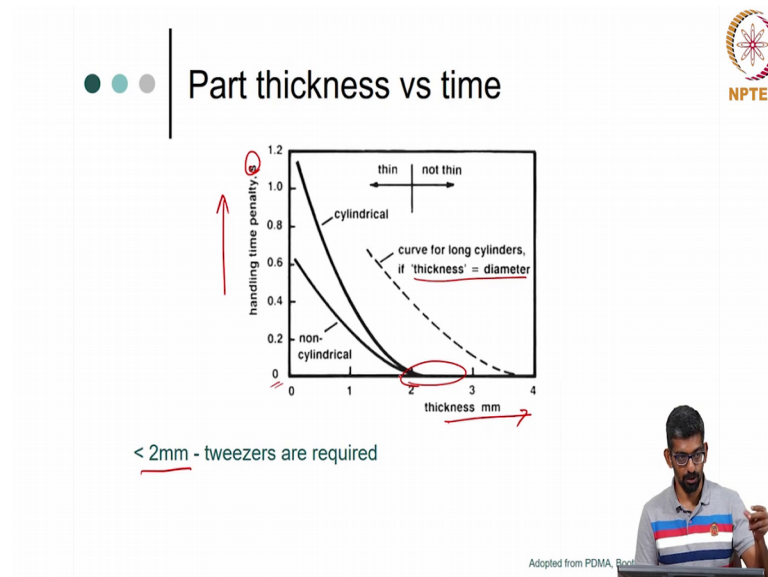
picture, in case if the diameter is greater than length, then it is a non-cylindrical part, in this case that is the case ok.

This is your diameter and this is your length. So, your diameter is larger than your length hence it is a non-cylindrical part. Therefore, I will put a box around it and I will find the thickness; if you qualify this as cylindrical part, then the thickness will just be the red line that I drew which is your radius, but please understand ok, that is not the case there is also a diameter being greater than length issue any questions, before we move it ok.

Student : What if diameter is similar to length?

Let me think little bit before answering that if your diameter is equal to length, I guess they might work out to be the same. If you imagine this guy to be of the same stuff, it will be the same; you can either take the length or the diameter, they will be the same value, so it does not matter. So, you will actually have confusions only the other way around meaning, if it is close, should you really take this or should you take that ok.

(Refer Slide Time: 09:30)



So, as usual in symmetry we saw time right. So, with any guideline that is being quantified, you also need to have a time element that is mapped out. So, we will see in terms of part thickness, it is a same idea right. So, the thickness in the x axis and the handling time they call it penalty, because they say that the ideal is will be a cylinder and from there we will see non-cylindrical parts and all that.

So, if you look at it, this is the handling time and this is for the cylindrical parts right. So, somewhere around here if it is 2 mm, they classified as thin and after that they classified as non-thin, please understand these are all again only manual assembly ok. So, what they are saying is if the thickness is greater than 2 mm here, actually the handling time penalty is almost 0; if it is thin ok, it is less than 2 mm. You can imagine what 2 mm is, 2 mm is probably this much; if it is less than that it is actually a headache. After carefully handle it, I might require two fingers or I might need a force of to handle it that to if it is long it might buckle, you need to handle it carefully. So, there is a problem with that ok.

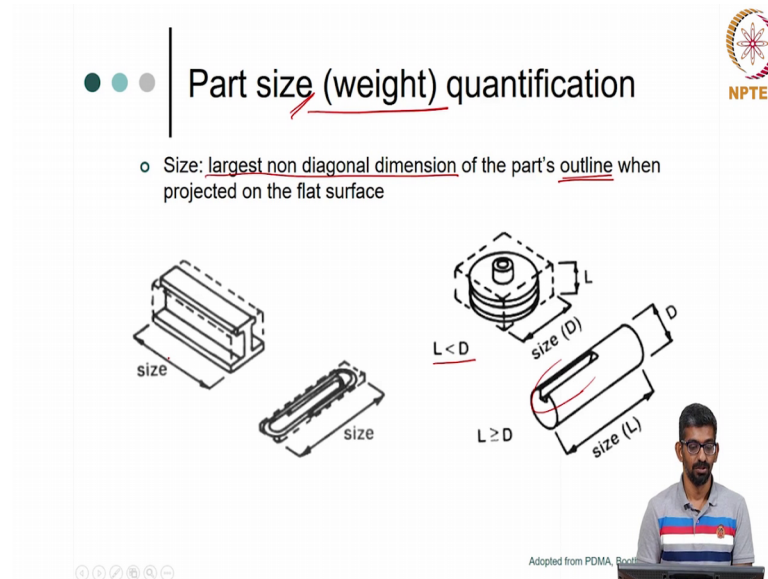
And as the thickness decreases you can see here, as a thickness decreases the penalty time keeps increasing, but we are only talking about seconds here 1.2 second that is 1 second. We are talking about 1.2 second, the curve looks big like it goes from here to here, but it has gone from 0 which is nothing to 1, this is 1 second 1.2 second that's all the handling time.

This is not handling time for say, but it is the penalty that is associated with it more additional time that you will need that is 1.2. The catches please remember you do not do one assembly, you do what did we discussed yesterday few thousands a day. So, this will translate into for easy calculation let us say 3600 seconds, 1 hour ok.

So, if I can design it, if I am somewhere here and let us say that I am not going to lose cost material in terms of material and manufacturing and all that by going here. I will save so much in assembly time. So, I should actually move my design from here to here; so that I will save on my assembly time that becomes important. And please always remember that we are talking about manual assembly here, not the robotic assembly not yet. In robotic assembly these graphs will change, but the ideas still the same. So, these are cylindrical parts and these are non-cylindrical parts that you are talking about.

And the other one is these are the curve for long cylinders, if thickness is equal to the diameter that is the one that we spoke about. It is slightly you know it is going to you know it is going to take some time some penalty is there if it if the thickness is equal to the diameter case ok. You see this if it is less than 2 mm, you usually require a tweezer or a forceps to handle it that is where the penalty comes into picture, because now I have to handle that tool, there is some time for it then I will have to handle this guy and then put it back.

(Refer Slide Time: 13:29)



So, look at the intricacy, the level of intricacy they have gone into ok, but because this is a detailed study there entire career was based on this and today they have this DFMA you know toolbox which is a commercial version is available that many of the design companies rent sector, lease sector, buyer to use it.

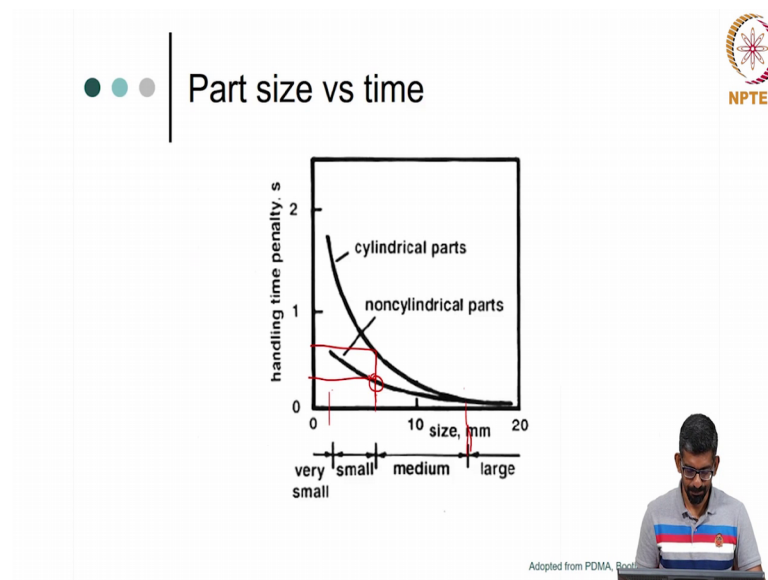
The next one is part size. So, we have spoken about symmetry, we have spoken about thickness and the next one necessarily is, because he also asked this question of hollowness. Just, because your thickness is more, does it mean that I need 3 people to carry this no not necessarily it has a very thin sheet of element ok. So, just what you call like a sheet of aluminium sheet that I folded into like this. So, I might still be able to carry it as a single person, it is not a concrete stuff.

So, I need to be able to bring out my weight that is called size. So, please look at the terminology that their using thickness is not size, size so you will look into this one. It is very similar though what size says is largest non-diagonal dimension of the parts outline, not the inside surface the outline when projected on the flat surface. This is a second one that I told you for thickness, you remember I said that you take a light and project on a tribe that is that is usually used for size. So, you keep the component you keep the component and then you project light over it, and you just need to look for the largest non-diagonal dimension not other than the diagonal you need to look for the non-diagonal. So, what would be the size for this guy?

Student: The length.

It will be the length. So, you can see here it is very similar whatever I showed you, in spite of all this thing it does not matter. You see this cut out right, it does not matter. When you project light, it will just say that this is a largest dimension. Similarly in this one ok, in this case it is L is less than d ; so your size is d , because that is the largest dimension and this is a kind of a gym club, what is the size? This is my size. So, the size kind of represents your weight that is there catch ok.

(Refer Slide Time: 16:03)



Now part size versus time similar to the previous one; you can see that now at around 10 mm, there kind of around that 10 to maybe around 15; around 15 they are saying that greater than 15 mm is large; less than 15 mm is medium; somewhere around I do not know 7.58 it become small; something less than 2 mm is very small ok. And there are non-cylindrical parts and cylindrical parts. So, you can see if you were to design at this region, you would rather choose a non-cylindrical part instead of a cylindrical part, because your assembly time or the time penalty that you pay for is less in a non-cylindrical part compared to a cylindrical part ok. Cylindrical parts has some limitations, because they are symmetrical you do not have grips to hold them ok; where as if it is was a non-cylindrical part, you might have sharp edges so that not sharp you have you would have defined edges, so it easier to hold it.

So, you can see pens that has non-cylindrical cross, non-circular cross sections actually they have better grip. Even if you see even the cylindrical pens often times, they have very minuet linings around them ok. The old pens they used to have or even the new ones Cello pens, you have a grip near where you hold it, because if it is a pure cylinder, then you will not get a grip on that ok. And any kind of a ballpoint pens that you see, you will have linings there that is to provide grip for you ok. Instead they are there are also people are now coming up with triangular cross sections they actually have a better grip. Still, still for you to hold it in this 3 fingers, you need something that is very close to a cylinder, because from an holding perspective cylinder is still a classical design ok.

But then from a grip perspective, you need to introduce grips either on the cylinder or you need to modify the cylinder a little bit; so that it will give you grip at the same time it is easy to hold. So, there is a very nice design paradigm there ok.

(Refer Slide Time: 18:35)

and...

- Insertion difficulties
- Handling difficulties
- Restricted vision
- Restricted access
- Tools used
- Types of fasteners
- Etc..

Leading to a decomposed chart of likely time to be taken

NPTEL

Adopted from PDMA, Boothroyd

The slide features a list of assembly difficulties on the left, a hand-drawn diagram on the right showing a fastener being inserted into a hole with labels for 'force' and 'motion', and a small video inset of a presenter at the bottom right. The NPTEL logo is in the top right corner.

These are just some introduction right. I have just uncovered a little bit of discussion, it is up to you to go back to the text and see for this there are the classical book that we discussed is a Boothroyd's PDMA Product Design for Manufacturing and Assembly that is a book ok, all these pictures are taken out of that book. So, if you want that is a text book that you need to refer to and there are questions on insertion difficulties. What you think could be a difficulty in insertion?

Student: Coefficient of friction.

No, see all this correct coefficient of friction is one thing, what I am trying to tell is again you need to have this stuff, there is a time penalty on this side and this is the difficulty stuff ok. So, what is the in that sense what could be the insertion difficulties that you can think of?

Student: Thickness side (Refer Time: 19:42).

It is basically the resistance that is offered, we discussed yesterday right if there is a air trapped in, you need the air to be let out. So, you need to have a passage for that are you have holes in the screws that let us you do that ok, these are insertion difficulty; sometimes handling difficulties.

You have a component like this ok, your size let us say that it was the thickness was like this ok, size thickness everything is beautiful, but you have difficulty in handling this guy these are sharp edges ok, for this guy so that also need to be quantified. Restricted vision certain things cannot be removed or adjusted without specific projection of light on that that is, because it is a restricted vision.

Now, you imagine going to a doctor ok, you tell him or her that I have pain here have you ever seen that they take a torch light and put it here and then see what happened, because either they should be able to see it in naked eye or they need a X-ray, the torch light is not going to work. If you go and tell them that I have pain here, I have pain there, immediately what they do they take a torch first and then they see; so that is restricted vision, you cannot just see like this ok. They see do like this and they cannot see like this, they really need a torch light to look into it. So, that is a restricted vision ok.

Even surgical setups ok, sometimes what happens is even when you cut open, you really need to cut open some part to look at a particular organ, because that is restricted vision that is the idea. Restricted access is also a problem ok, restricted access any organ inside is restricted access, you cannot just see it just like that, but there is a reason for it and then you have other ways to look at it; so that is one thing and you cannot keep everything for easy access, they have to be kept inside right. So, sometimes tools used what is the different types of tools; I need to use a screwdriver, I need to use a wrench ok, you need to have special tools, special type of screwdrivers you need.

And I told you right like for the Mac desktop, you cannot just have a screwdriver or a special type of a screwdriver you need a vacuum puller to remove, but I need a special tool. Then the costs is more, the penalty is more in that that is the catch ok. Types of fasteners ok, so for instance you know you can have a nail, you can have a screw, in screw itself you have so many different types of screws and there is a time penalty for each one of them and etcetera it keeps going.

So, basically leads to a decomposed chart of likely time to be taken, for each of this there is a research ton and they have a graph like this. So, for each one of these you know what it is, in terms I mean any anything you can imagine probably it is like this for something else and then they will say here is a value and I have some numbers here.