Advanced Green Manufacturing Systems

Prof. Deepu Philip
Dr. Amandeep Singh Oberoi
Department of Industrial & Management Engineering
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 13
Value Engineering Green Plan: case study

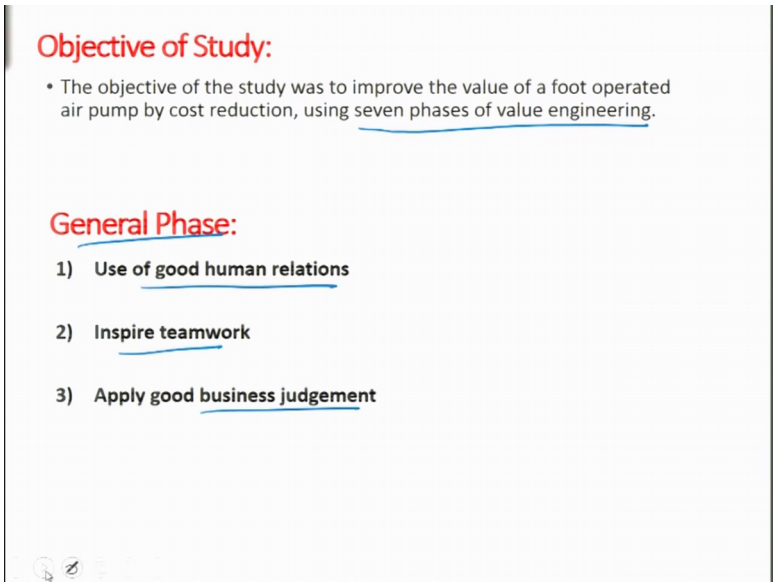
Welcome back to the course on Advanced Green Manufacturing Systems. And we are studying value engineering in this module, in value engineering we have seen what is value, what are value, what is value engineering types of values, fast diagramming, identifying the functions, and the numerical comparison of the functions those things we have done. Now, value engineering methodology and we have seen I will try I am going to show you case study in this lecture on value engineering application.

(Refer Slide Time: 00:49)

So, the case study here is presented and the product that is chosen is foot operated air pump. As I have said, the value engineering concept could be applied to both manufacturing and services. So, more applications in manufacturing are generally found. And also we are talking about manufacturing systems in this course. So, because a manufacturing the quantification is quite easier ok; however, quantification can happen in services as well, because sometimes in services the data is in a subjective form, but in manufacturing it is found more application.

Value engineering has more applications in manufacturing in construction as well, construction, manufacturing services and so on. So, this is a product that is selective it is various components I will show you what are the components in the information phase and the cost for each component.

(Refer Slide Time: 01:59)

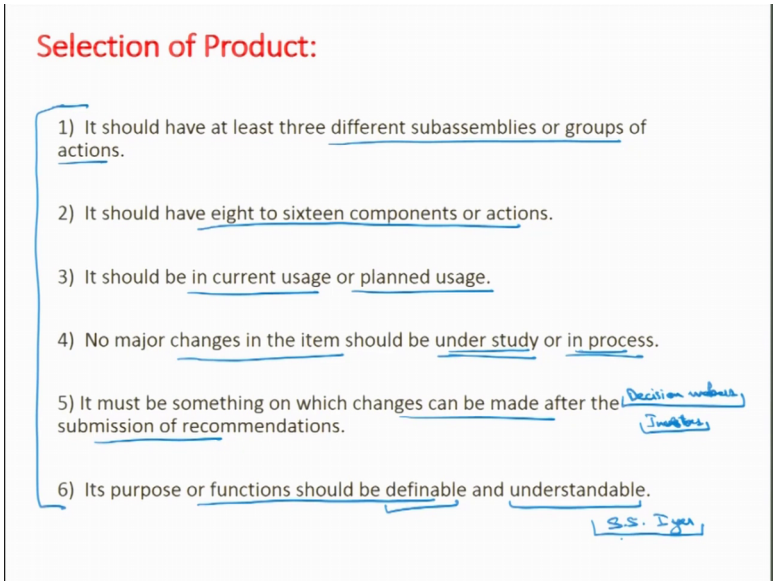


So, the objective of the study was to improve the value of a foot operated air pump by cost reduction, using the seven phases of value engineering. Actually this is a work that I did with one of my M.Tech students. And the seven phases as suggested by mudge were used, the seventh phase this general phase actually is started from the information phase, before information phase mudge (Refer Time: 02:26) general phase ok.

A general phase is just an overview just an introduction to value engineering or just to just gather the resources like people, documents, just data collection can be one of the per value engineering, team is more dependent upon data collection, and analysis and data implementation.

So, using good human relations is one thing is suggested, is that inspire teamwork, because one of the fundamental principles of value engineering this is to implied, teamwork and to work with the team from different sections of the manufacturing concern. So, apply good business judgement is one of the rule judgement has been based upon the facts or data that is quite often used in decision making, this is just a general phase.

(Refer Slide Time: 03:19)



Next is selection of the product. Selection of the product, a product that is to be used in value engineering, it their certain resistance given by the researchers who have been working in value engineering in manufacturing. They said, it should have at least three different subassemblies to have a proper value engineering application.

However, this is not something that is mandatory, but for a big projects or for the projects like foot operated pump it has certain subassembly there is piston arrangement that is pedal and we have base different subassemblies are there, they at least should have at least three or more subassembly. It should have eight to sixteen components or actions ok, it should be in current usage or planned usage and think that is outdated working on that would not help, so that is currently being used or it is to be use in future those things already be worked.

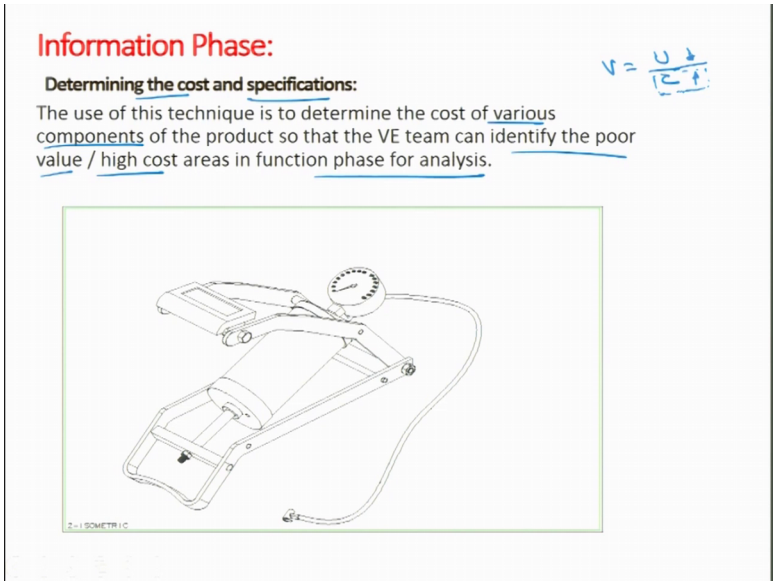
No major changes in the item should be under study or in process, because we are applying value engineering, we are starting from the very scratch, we are trying to identify the functions, we might come up with some solution, there is the functions of the overall design of the product can be changed. So, is there any change that is still under study that has to be first seen? This is this comes in general phase before we are gathering information, we need to know that whether the product is actually work able or not. So, it must be something on which changes can be made after the submission of recommendation.

So, the top management or the you know decision makers, decision makers should be the part of value engineering thing. At least one member should be there who should be able to persuade the investors to invest value engineering, because sometimes in value engineering this is actually the case study of cost reduction while implementing sometime in the initial phases in the in the beginning, the cost reduction is not very high.

Sometimes they are certain changes for which certain setup is to made. And therefore that setup the cost or the expenses which are for that are little higher and sometimes the it in very first few months the payback is not good, but yes if the product is produced for a longer period; obviously, the pay would be higher, payback would be higher.

So, its purpose of functions should be definable the products from purpose of functions should be definable and understandable. These are general suggestions given by SS.Iyer ok, who also wrote a book on value engineering, I have suggest you to read this book. So, he you has mentioned these suggestions in his book.

(Refer Slide Time: 06:15)

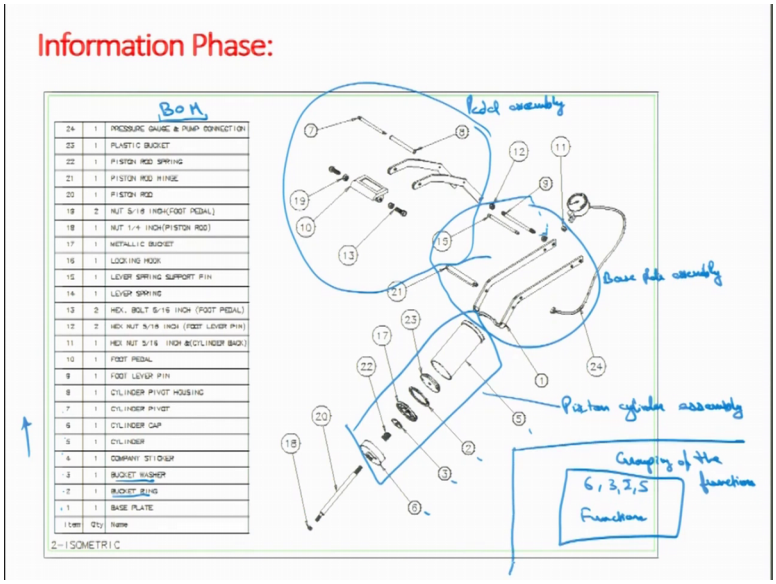


So, information phase. In the information phase as I said, the data and information related to the project is collected all the guidelines of general phase are very much helpful in this phase. The very first thing is securing the facts, the facts first step is to secure all the relevant data and information regarding the company number of employs, now this company has 50 employees in which case study was carried out.

So, determine the cost and specifications the use of this technique is to determine the cost of various components of the product, so that value engineering team can identify the poor value or high cost areas in function phase, as I said value is equal to utility per unit cost. So, if cost is poor cost is high, if cost is high the value would be poor if utility is less, the cost would be higher.

We are just not taking into account the utility viewpoint, because this is the cost reduction study. So, high cost functions are to be seen and to be actually identified, then we need to work on that to provide them in a lower cost if possible.

(Refer Slide Time: 07:31)



In information phase as I said, we develop the bill of materials, so this is bill of materials ok. Bill of materials is list of the materials with this is a phase search from the bottom number 1, 2, 3, 4, 5, 6 and so on. So, this list of material is developed and we have the very first component as base plates, secondary component is bucket ring, third component is company sticker, cylinder.

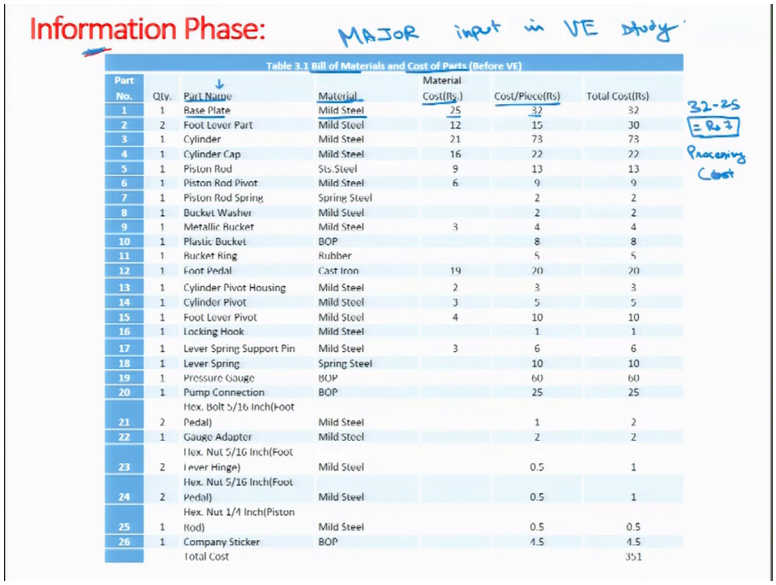
And in the second column we have the quantity there is only 1 base plate ok, there is only 1 bucket ring ok, there is only 1 bucket ring, there is only 1 bucket washer. Similarly, we can have we have 2 hexagonal nuts and component number 12, 2 hexagonal nuts here and 2 hexagonal bolts here.

Similarly, we have all these components as a 24 components, and this is the drawing this is actually the exploded view as I showed you the view of the mobile phone, this is exploded view each component if you say let me say the component number 6, component number 6 is cylinder cap for this component is cylinder cap, this component is component number 6 which is cylinder cap ok.

So, all these mixed materials are the components are there, also we can group the components. For instance, do the components come in one group and this is a piston group, piston cylinder group, this group is actually I would say assembly, because I am talking about components not functions this is pistons cylinder assembly ok. Then all this at the top, we have pedal assembly, this is the base plate assembly we have better and all those things base plate assembly can be this one ok.

So these components have different assemblies, when we develop the functions we can see that what are the functions, what are the components, when instance component number 6, 3, 2, 5 component number 6, 3, 2, 5 and their respective functions ok, these can be made as a group. We will see the group, so when will go to the creativity phase. So, this is group or grouping of the functions this can be done.

(Refer Slide Time: 10:51)



Now, information phase that was just the bill of materials. Now, also we have the cost of the materials the base plate, the material, the cost, per piece and total cost. Total cost is this much is total cost and because the total cost would be the cost per piece into the

number of pieces that this is the details of the bill of the materials, this is bill of materials plus cost of the parts. So, this is number one first component is base plate, the material is mild steel.

First column is the part name then we have the material, material is mild steel, because when we are talking about value engineering you might like to change the material and we why it have to see whether the other material works here or not. And also sometimes biodegradable material if possible in this pump, we might inculcate or we can have a some manufacturing, some choose some material that is consuming less energy in manufacturing. Material cost is there in cost per piece ok, this out of this 32 and 25, 25 is material cost, 32 is the total cost.

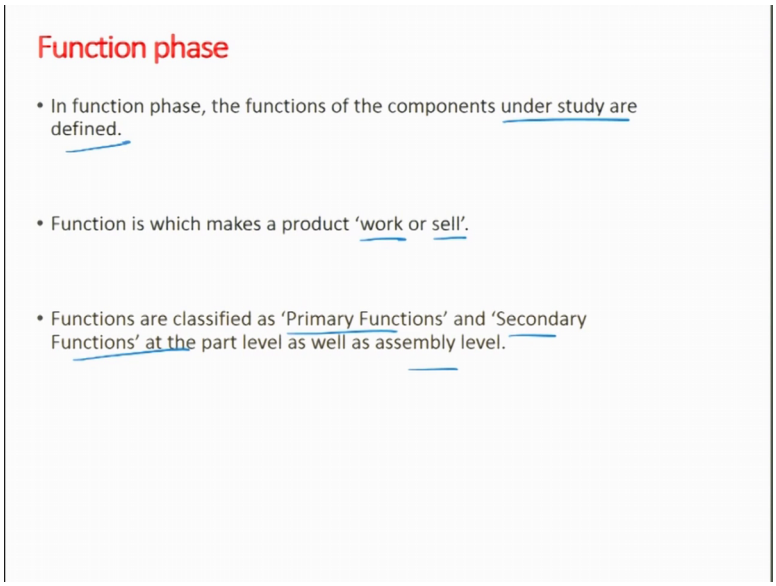
So, what does this mean? This means 32 minus 25 this is equal to Rupees 7, is Rupees 7 is my processing cost. I will again try to enlarge this thing, this first component is base plate ok. This base plate is made up of mild steel, the material cost is Rupees 25, the cost of the component is Rupees 32.

Material cost means will just weight the material, like instance let me say mild steel if is it 40 per kg, I think given time to the study it was around Rupees 25 or 30 33 Rupees per kg. Let means this weight should be around 800 grams, 800 grams into Rupees 32 25 that is the cost of the material this cost, cost of the material and this is the cost at which the component is purchase. So, the difference is the processing and all those. So, processing cost is Rupees 7 then.

So similarly the cost of different components for instance this piston rod spring, component number 7. Piston rod spring is made up of spring steel and this piston rod steel, we do not did not find the cost of the material the cost for the because this was something that was bought from the market that was not manufactured in the company.

So, make and buy decisions also are the part of the material management for the purchase management. So, this was bought not made. So, just the cost is there. So, similarly we have the cost of all the materials. So, this is the major input that we have in information phase ok, this is a major input in value engineering study.

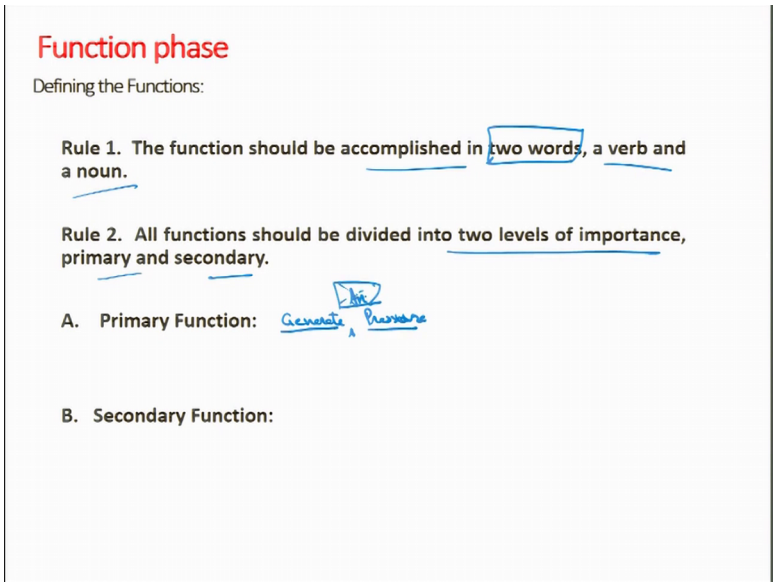
(Refer Slide Time: 14:15)



Now, comes the function phase. Function analysis is something that distinguishes and differentiates the value engineering technique from all other cost reduction or improvement techniques.

So, in function phase if functions of the components under study are defined as I said the function of a product is something that that makes it to work or that is makes it to sell. So, function may be classified as primary and secondary function this is the all is mention, I am just recalling those things. So, the key factor the key to value engineering is identification of what exactly the user or customer wants from a product. Customer is paying for the function not the product, I am again repeating.

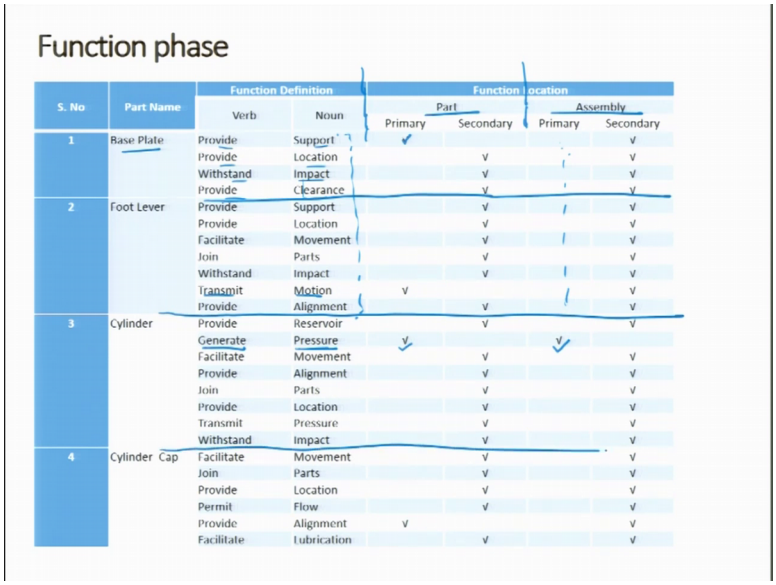
(Refer Slide Time: 15:11)



The second rules for defining the functions rule one is the function should be accomplished in two words as I said, all function will be divide into two levels of importance primary and secondary as I said. So, the primary expresses the primary function is which is only one for a part or a product. So, what does air pump do? Why do we need air pump? You need to fill air in our car or maybe wherever, we need to inflate the objects that objects can be tyre then or objects can be my yoga ball or by football or anything that is the primary function.

Secondary functions might be are into apply pressure only foot petal, I need to use my leg, force, etcetera, all those things. So, what other secondary function that will identify.

(Refer Slide Time: 16:03)



S. No	Part Name	Function Definition		Function Location			
				Part		Assembly	
		Verb	Noun	Primary	Secondary	Primary	Secondary
1	Base Plate	Provide	Support	✓			v
		Provide	Location		v		v
		Withstand	Impact		v		v
		Provide	Clearance		v		v
2	Foot Lever	Provide	Support		v		v
		Provide	Location		v		v
		Facilitate	Movement		v		v
		Join	Parts		v		v
		Withstand	Impact		v		v
		Transmit	Motion	v			v
		Provide	Alignment		v		v
3	Cylinder	Provide	Reservoir		v		v
		Generate	Pressure	v		v	
		Facilitate	Movement		v		v
		Provide	Alignment		v		v
		Join	Parts		v		v
		Provide	Location		v		v
		Transmit	Pressure		v		v
		Withstand	Impact		v		v
4	Cylinder Cap	Facilitate	Movement		v		v
		Join	Parts		v		v
		Provide	Location		v		v
		Permit	Flow		v		v
		Provide	Alignment	v			v
		Facilitate	Lubrication		v		v

So, let us try to see the functions of the components. So, function for the base plate are identified as provides support, provide location withstand impact provide clearance. First thing, I would like to mention here is that what is the function of my product? Function of my product is to generate pressure.

So, the primary function for foot operated air pump was identified as generate pressure. We are trying to inflate the objects, how do we inflate. We are generating the pressure, generating pressure like when we just press the lever it has to generate air pressure, it is actually generate air pressure, but because two words are to be there we picked, generate pressure ok. So, this air is taken away. So, this is a primary function.

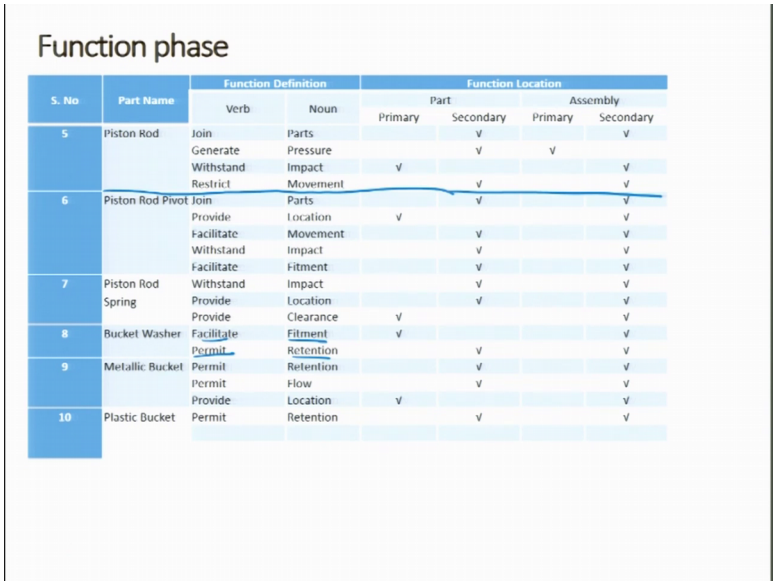
So, when we see this function definition sheet, base plate has a primary function. Only one primary function would be there for each component. Each component has one specific purpose for which it is made ok. All other functions are just supporting or those are something that is making to work make the primary function work ok, so that primary function can be the primary function for the whole assembly for the whole product you are talking or that can even not be the part of the assembly, but that is there for the component only.

So, base plate has provide support as a primary function, provide location withstand impact, provide clearance as the secondary functions. This column represents the part wise function, the function the definition and this is the assembly wise last column ok.

Part wise this is a primary function provide support, all other three are the secondary functions. Similarly, in a foot lever we have transmit motion as a primary function transmit motion, this is the primary function all other are secondary function and none of these functions none of these functions are the primary function of the assembly.

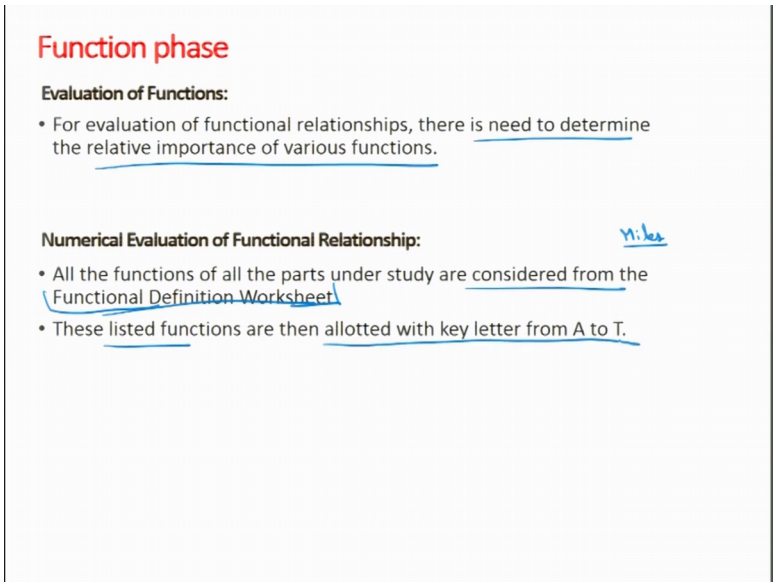
Now, come just cylinder. One of the functions in cylinder is generate pressure, which is the primary function for the part and also for the assembly. So, whenever there is a component or a part in which the primary function is the one that is a primary function for the product that would remain the basic function of the component itself. So, we will see that wherever we have generate pressure, wherever we have generate pressure that would the primary function for both the part and assembly.

(Refer Slide Time: 19:21)



So, similarly let us see where do you have generate pressure other than this. We have generate pressure here in the piston rod ok, this is something exceptional. In piston rod the major function is to withstand impact of the components. So, generate pressure is a secondary function here. So, this sometime let us actions also come this is one of those. So, similarly we have functions for each components and we have also seen that the functions are not redundant, no none of the functions is repeating. For instance, permit retention and facilitate fitment are separate, how are the separate will see when will see numerical comparison.

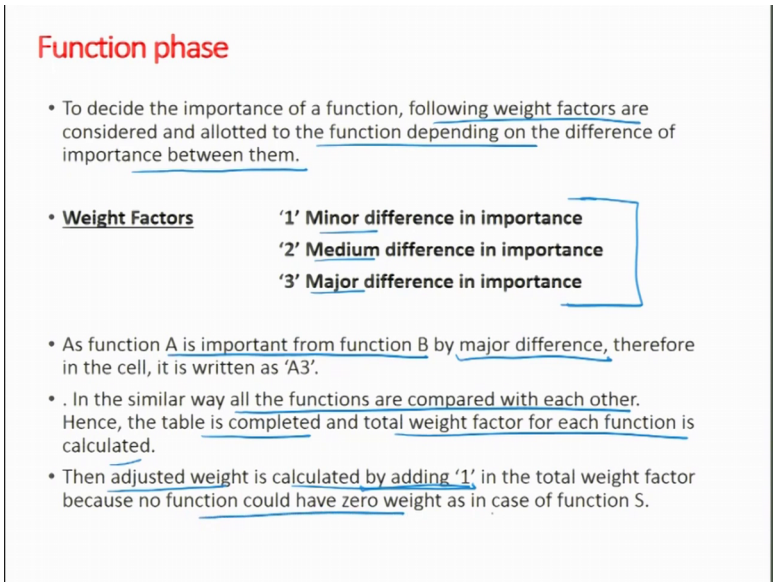
(Refer Slide Time: 20:03)



So, evaluation of the functions I have only shown 10 components here. If you see this, we had 24 components. Just for the 10 components, I am giving you this one and will provide you all other in the notes. So, evaluation functions for evaluation function relationship there is known, there is need to determine the relative importance of various functions. The numerical evaluation is one of the methods that we did. So, this evaluation is determined to a paired comparison technique which in turn leads to the ranking of the functions.

So, numerical evaluation of functional relationship this is a if like miles the major figure in value engineering is said, if there is no comparison, then there is no evaluation. Evaluation has always to be ran a day, so that functions as to go pair, so that is why numerical comparison technique was used in value engineering. So, all the functions of the parts under study are considered from the functional definition worksheet. Function definition worksheet, what is this? We will just see these listed functions are then allotted with the key letter from A to T.

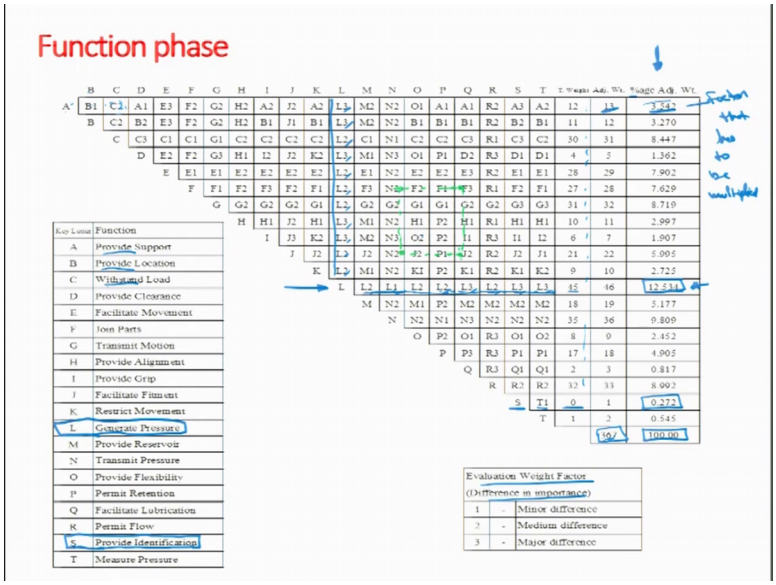
(Refer Slide Time: 21:23)



We have functions, picture allotted the letter from A to T, T means T is the Twentieth letter in English, T means that twenty functions. So, to decided what are all the function following weight factors are considered an allotted to the function depending both difference of a importance between them as we discussed in the numerical comparison, we only use the three level scale; minor difference in importance, medium difference in importance or major difference in importance ok.

So, as function A is important from function B by using major difference, therefore in the cell, it is written as A3. A is important than B by a major difference, it is written as A3. This is what I have defined, explained in the previous lecturer numerical evaluation. In a similar way, all the functions that compared with each other. Hence the table is completed in the total weight factor of each function is calculated, then adjusted weight is calculated by adding 1, why we do this? Because in the total weight factor no function could have 0 weight as in case of function S.

(Refer Slide Time: 22:25)



Let us see, the numerical evaluation. Let us see the numerical comparison sheet ok, this is numerical comparison sheet when A is compared with B here, B is importance than A that is provide location is important than provide support by a minor difference it is B1.

Similarly, function C is important than A with a medium difference that is withstand load is important than provide support with a medium difference. Now, you see this is from the customers view point, when we develop a numerical evaluation see this is from the viewpoint the way or the function for which the customer is willing to pay, you know the basic thing is the customer requires somethings to something to generate pressure.

So, generate pressure would always be the highest order function. The primary function has to be the rank 1 function, if that does not come that means, there is some error or some ambiguity in the development of the numerical comparison sheet.

So, if we see this generate pressure that is function L ok, function L is here. L is generate pressure, L is always the priority in this whole row and in this whole column L is the priority. And how do we get this value 45? This is 3 plus 3 plus 2 plus 3 plus 2 plus 2 plus 2 plus 3 plus 2 so on, plus 2 plus 1 and a row here, 2 plus 1 plus 2 plus 3 plus 2 plus 3 plus this is will be 45 ok.

Similarly, we have the weight for all the functions, the total weight the weight of importance actually. So, evolution of weight factors this is differential importance. So,

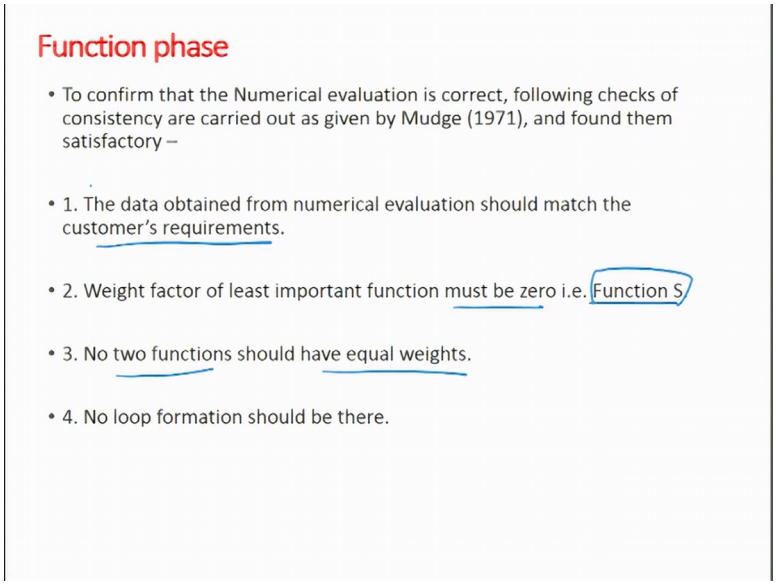
this is a weight for importance and one of the functions S, S is provide identification customer is not paying for provided identification, we have the stamp of the company on the body of the pump or body of the product, customer is not paying for that customer is paying for the purpose, number 1 is for generating pressure they need to have a product that is something that is reliable, that is a proper fitment, that is a something that can be carried the size and all those things.

So, it is not paying for providing identification that is why provide identification that is the company stamp for companies mark is a 0 value function here, come function as a 0 ok. As mentioned in the previous slide, he add 1 to all these functions to get these it, because you know this value is 0 and this has to be a factor. Each function value each of these value this percentage adjusted weight this has to be a factor multiplicative factor.

Factor that has to be multiplied that is why we cannot have 0. So, so we add 1 here to get these values, now these adjusted weight and the total value is now this is these values are normalized. Normalize means these values are taken from the 100 we have for just put the percentage. So, this is the normalize with respect to the value 100 and that means, 13 out of 367 this 13 out of the total 367 is equal to 3.542 out of 100.

So, in this case we can see the highest value as come for the function L, it is 12.534. In the lowest value would come for the function S that is 2 7 2, so this is the ranking. Now, will put these values will adjusted weight in an ascending order and give them a rank.

(Refer Slide Time: 26:35)

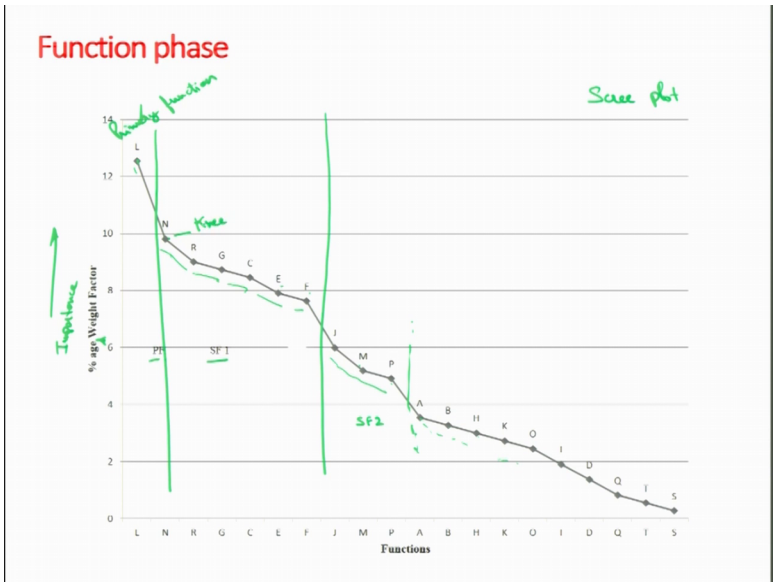


To confirm that the numerical evaluation is correct, following checks of consistency are carried out as given by mudges found, and found them satisfactory. The data obtained from numerical evaluation should match the customers requirement ok. Weight factor of at least important function must be zero that is function S, in this case.

No two function should have equal weights, as I said in the previous lecture if two functions are having equal weights that means, the functions of performing kind of a same purpose or they are made for might be made for same purpose or the functions a sometimes the purpose might be different, but the weights are equal, then we have to adjust our numerical comparison sheet a little, they two have the difference in the weights.

No loop formation should be there. Loop formation is that for instance if it is suppose it is 2, 2, 2, 2 something like this loop formation is therefore instance if I pick this loop, any loop ok. At this node I have and to a this node I have F3, J2, N2 ok. Loop formation that there cannot be like 2, 2, 2 over the same values here.

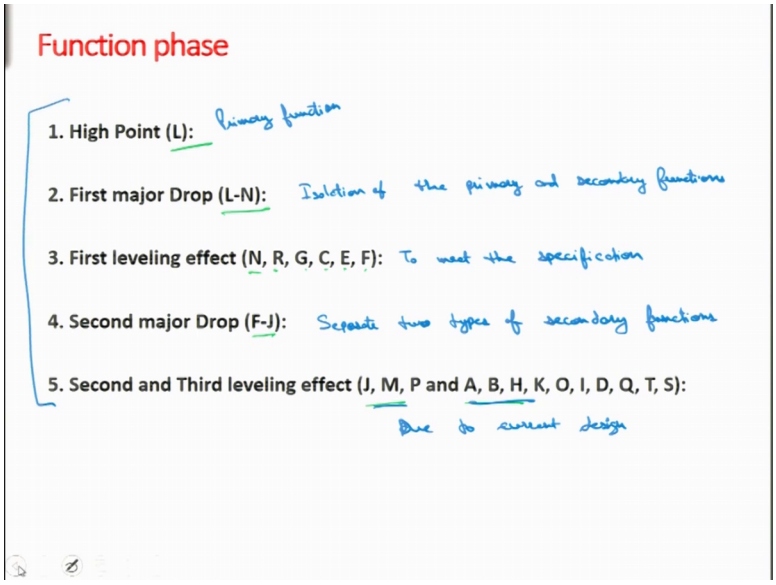
(Refer Slide Time: 27:51)



Now, we develop the scree plot for the functions or what does this help us to do, this can help us to differentiate between the primary functions and the secondary functions. Now, you can see the first drop is here that means, this is the primary function. The second drop comes here that means, just ignore this thing this is PF is Primary Function, this is secondary function 1 and these are secondary function 2.

So, functions N, R, G, C, E, F are the secondary functions. And these are secondary functions too J, M, P, A, B, H we can even divided into further categories, but let us have only three sections here; primary function which is the basic function, secondary functions 1 and the tertiary function the secondary functions 2. So, this is scree plot that can help us to just have a visual field of what is the difference and what is the slope in the difference of the importance of the functions. This is percentage weight factor, percentage actually importance weight factor I would put here ok, percentage importance weight factor.

(Refer Slide Time: 29:35)



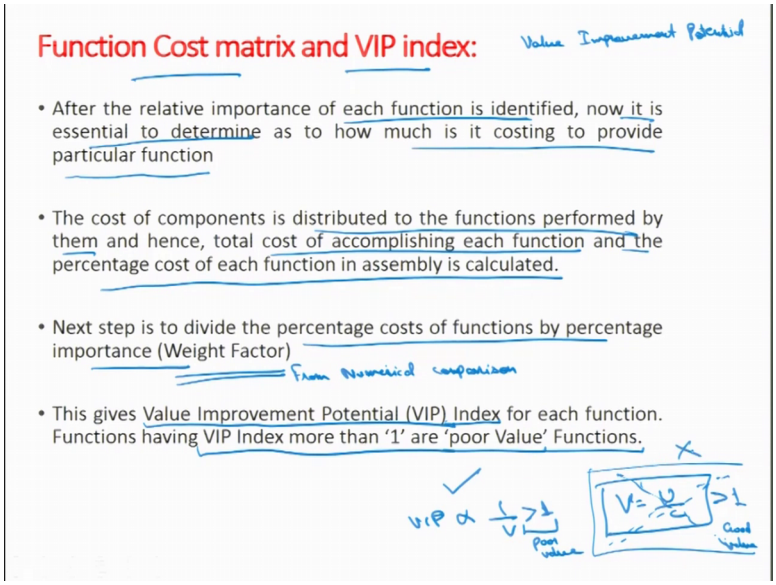
We can see here the high point is L, major first drop is from L to N, this L to N is medium drop, second drop is from F to J. After leveling effect, first leveling effect is this actually first leveling effect is N, R, G, C, E, F; N, R, G, C, E, F. The second major drop is F-J, the second and third leveling effect can be this J, M, P and after form A; J, M, P is second level effect after this is third leveling effect ok, this is known as scree plot and this drop is also known as elbow or knee.

So, again this is the primary function. This is actually first major drop, major drop means the isolation of the primary and the secondary functions. Leveling effect is this includes secondary functions though there in the project to meet the specifications and requirement, to meet the specifications ok. This is the second major drop, so this is

separation of the two types of secondary functions. Separate two types of secondary functions.

Second and third leveling effect are the functions these are secondary functions those are in the project because of the present approach, due to current design this is actually general take away from this scree plot ok, from this scree plot.

(Refer Slide Time: 32:11)



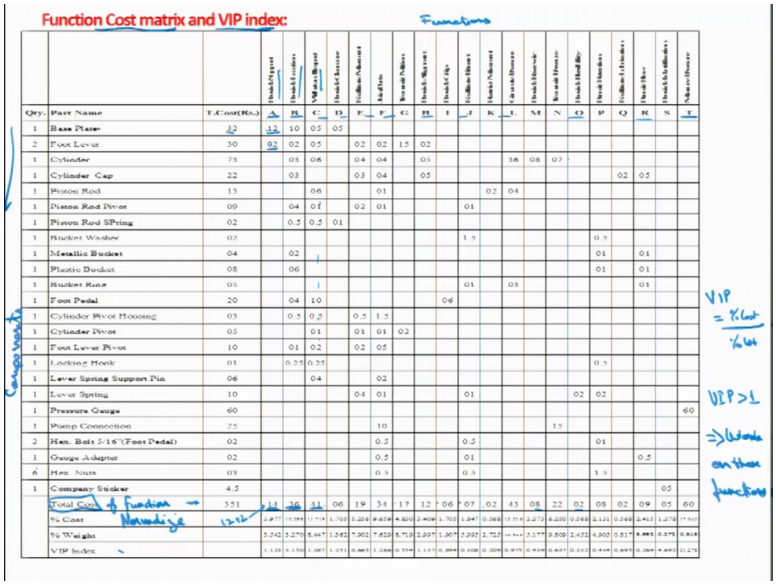
Now, function cost matrix and V I P, V I P is Value Improvement Potential. I did not explain this in the value engineering methodology when I was just giving the overview, but this is a detailed study that is why I am trying to explain that how do we develop the cost for the functions and we develop the value improvement potential.

So, after relative importance for each function is identified. Now, it is essential to determine has how much is it cost into provide a particular function the cost of components is distributed to the functions performed by them and hence the total cost of accomplishing each function. And then the percentage of cost for each function assembly is calculated, I will show you in the table in the next slide.

Next step is divide the percentage cost of functions by percentage importance that is a weight factor that where generated in the numerical comparison from numerical comparison. This gives the value improvement potential index, V I P index for each function functions having V I P more than 1 are poor value functions.

V I P means improvement potential if improvement potential is more than 1, because this is a ratio of the cost and the importance cost to importance, value is actually I can say importance utility per unit cost, but V I P is proportional to 1 by V value is something separate. The functions which are having this value greater than 1 or poor value functions greater than 1 employees poor value this greater than 1 employees good value. So, we are talking about V I P index here not value ok, we are putting a cross here we are talking about this not this.

(Refer Slide Time: 34:49)



This is function cost matrix and value improvement potential, this was developed for the whole product. All the function are listed here functions from A to T in this line, and these are the components base plate 24 components are there, quantity is also here ok. These are the components here, I will put it here these are actually functions, these are components.

The cost of the components we know, the total cost of the component for the base plate is Rupees 32, provide support for this base plate has a having total cost of Rupees 32 that is performing these functions provide support, provide location, withstand impact ok; A, B, C, function D is provide clearance and that is all ok.

Similarly is second component foot lever, this time to perform this functions. Foot lever is costing Rupees 30, it is providing support, it is providing location, it is withstanding

impact, it is facilitating movement, it is it helps to join part, it has to transmit motion and so on.

So, any function that is not in the part that element is left blank, like this element is left blank. So, out of Rupees 32 what is the cost of providing support Rupees 12. Rupees 10 is the cost of providing location, for instance providing location to provide location the material has to be part of that we need to drill holes to provide a location, what is the cost of drilling holes and what this what the strength of the material for instance, it is taken the material for the first component base plate is was mild steel.

So, mild steel why mild steel is selected, because this size of mild steel was required the material is divided material cost is divided into this components or this is done by the production people. People who are involved in the purchasing, who are expert in material, material strength, the people from mechanical background, they can help to divide the cost into functions.

So, in this way we develop the cost for each function for provides support if got this cost, it is in base plate, it is in foot lever, total cost is this is 14; 14 is actually 12 plus 2 14. So, the total cost for the functions is here. This is the total cost for provide location 36 is a total cost for so 13 14 is the total cost for provide support, 36 is a total cost for provide location ok.

And withstand impact 41 is the cost for the function withstand impact, function C is Costing Rupees 41. In this way we get it total cost for each function, we have the percentage cost we are normalizing this again. So, this is total cost for each function is there or total cost for the components all these components the total cost for component is Rupees 351, which is the cost of my product.

In total cost of function as also have to be this one, it is 351 for this is the total cost. For each function separately in the columns, this 7 is the total cost for one function, 6 is for the other function. And we have again normalize this, the value 3.977 this value comes from this ratio 14 by 351, 14 by 351 is 3.977; 36 by 351 is 10.292. Again we are normalizing the with respect to the total cost on the value 100, so we have got the percentage cost and we have got the percentage weight, percentage cost and percentage weight.

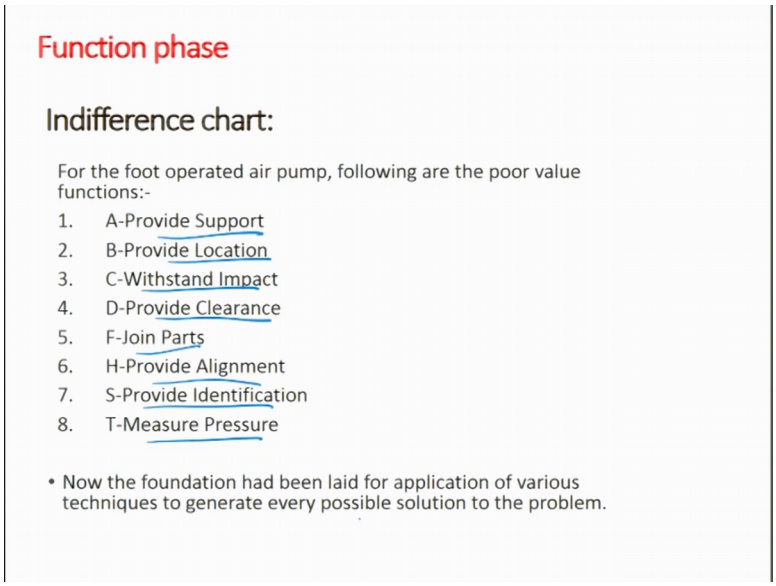
Now, the cost to weight ratio is V I P – Value Improvement Index, this 3.977 divided by 3.542 is 1.123 this value. Similarly, in the function C 11.719 divided by 8.447, it is 1.3 ok. Any of these value, value improvement index improvement potential actually, this is potential are the functions where there is an improvement potential, where there is a scope of improvement and this value is a quantified scope, the level of scope.

If the value is for instance one of the functions here provide location, there is a very high scope the V I P is 3.150, we can see it in this way as well from the percentage weight, so the percentage weight was a importance weight, this was a importance weight. From the customers viewpoint, customer is willing to pay Rupees 3.27 for this function, but we are spending Rupees 10.29 ok. Around three times of money is spent on accomplishing this function, sometimes this is important when it is know the way this has to be done, but we this is one point where the potential of improvement is there ok.

So, this is V I P index or value improvement potential, chart and function cost metric as for this is the function cost the cost of the functions ok. These are the cost of the functions and this is the total cost of the functions, this is total cost of function, this is normalizing is V I P. V I P is this V I P is equal to percentage cost by percentage weight V I P greater than 1 employees to work on these functions.

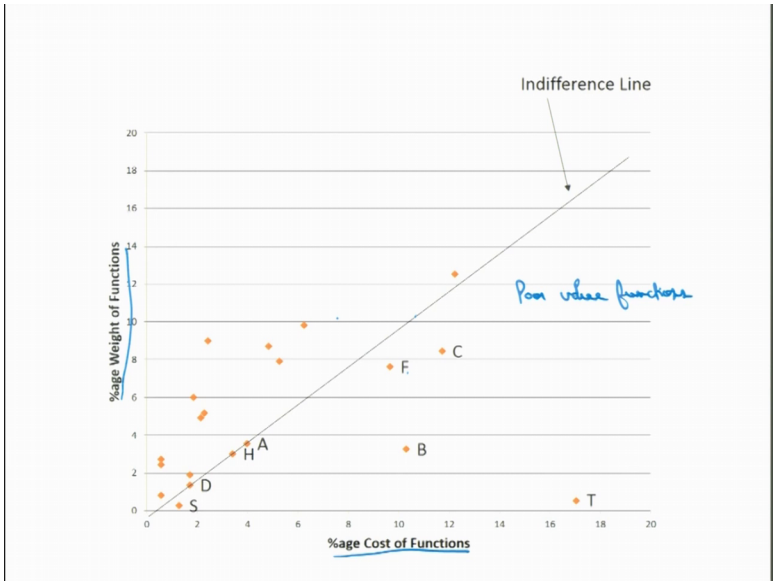
So, this is value analysis people have different definitions of value engineering and value analysis of some people say that when we are talking about and engineering applications or manufacturing applications it is value engineering. Value analysis is whenever we talk about services or something that is not in manufacturing or not in construction that is value analysis, but some people also have come up with this definition that value analysis is that when we have analyzed the poor value functions till that point it is value analysis, but when we move forward from that and try to also suggest the alternatives that is engineering, so this is analysis part.

(Refer Slide Time: 42:17)



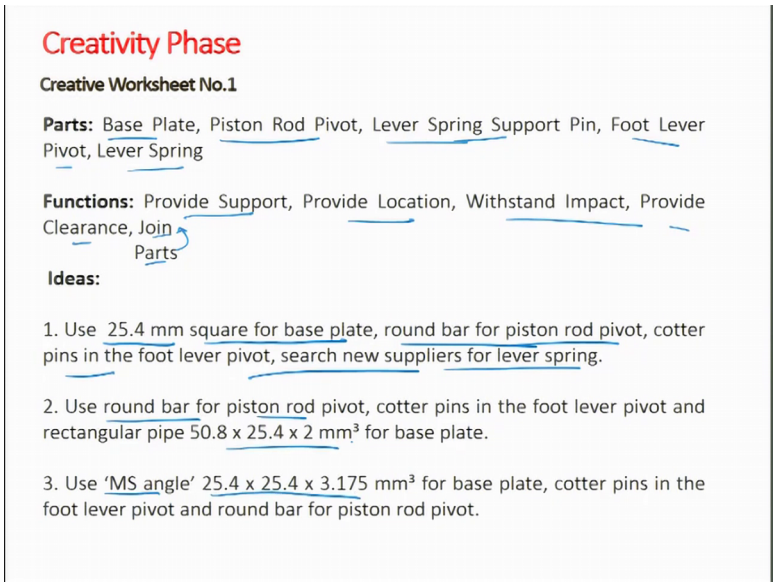
Now, we have identified the poor value functions to make it more clear we can even develop a indifference chart. Indifferent chart for the foot operated from following are the poor value functions, provide support, provide location, withstand impact, provide clearance, join part, provide alignment, provide identification, measure pressure these are all the function which are having V I P value more than 1. So, now the foundation has been laid on for application of various techniques to generate every possible solution to the problem.

(Refer Slide Time: 42:45)



So, this is indifference line in which we have profit percent weight of functions against the percentage cost of the functions. And this is the indifference any function below this line, because this is the ratio of weight to cost now that is a poor value function. So, these are poor value functions. Indifference is the value is exactly 1 less than or greater than 1 would be at the lower side, in more than 1 would at the upper side. So, this is one of the way to see the functions now.

(Refer Slide Time: 43:23)

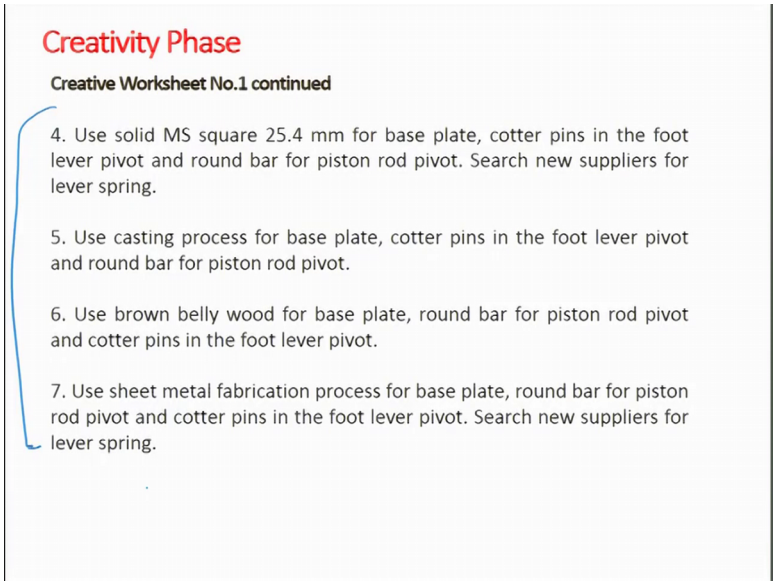


Now, comes the creativity phase. In creativity phase, we need to work on these functions which as the poor value functions for a support. Now, we can make groups of this function we need to see which components carry these functions. Those components if they can be grouped together, we have picked this worksheet first group the parts of base plate, piston rod pivot, lever spring support pin, foot lever pivot and lever spring functions also performed are provide support, provide location, withstand impact, provide clearance and join parts.

So, ideas other than the current design now can be speculated. So, these are the ideas which were the feasible for instance in creativity worksheet 1, these are done in conjunction or which resistance of the manufacturer from the various people who were in the manufacturing concern and the friends. So, these are the specific ideas for the specific product use this size, square for base plate, round bar for piston rod and cotter pin for this. So, unknowns search for new supplier for lever spring, use round bar for

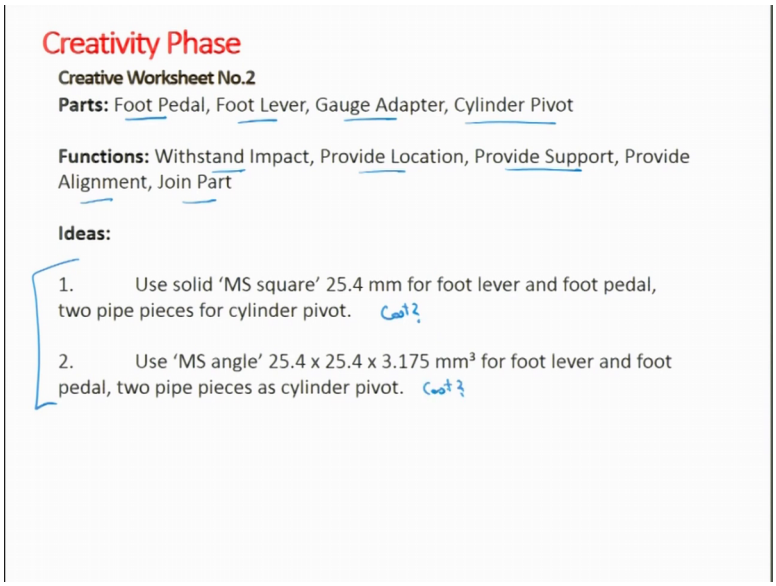
piston use MS angle of this size. So, these are the specific design (Refer Time: 44:42) because we are talking about the mechanical component here this group of components.

(Refer Slide Time: 44:51)



So, these are the ideas. For instance, there seven ideas which have come however I think being creativity worksheet 1, they were around twelve ideas. When we talk about creativity, we just talk about the fact as I said and we just come up with the ideas without in thinking that whether it is implementable or not, but sometimes in a preliminary feasibility test the some ideas are just eliminated, just the taken off for their just kept an record data, they can be taken in future if the variability or it is possible to implement those in future. So, this seven ideas were taken which would be taken to the evaluation phase.

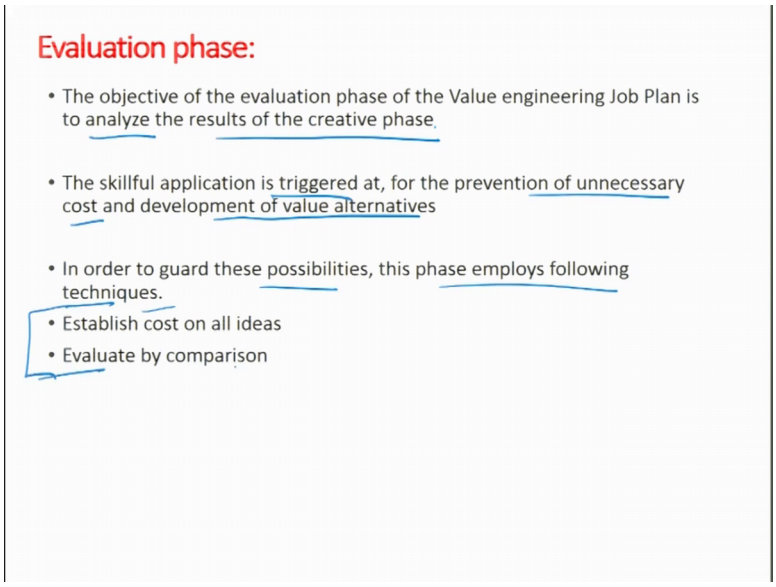
(Refer Slide Time: 45:25)



Similarly, we have creativity or creative worksheet number 2, in which we have these two ideas, two actually not two (Refer Time: 45:32) there was again seven ideas and missing of slide here, I provide you the detail worksheet in the notes.

So, this has these parts foot pedal, foot lever, gauge adapter, cylinder pivot. So, the functions where withstand impact provide location provide support provide alignment and join part these are the ideas for them.

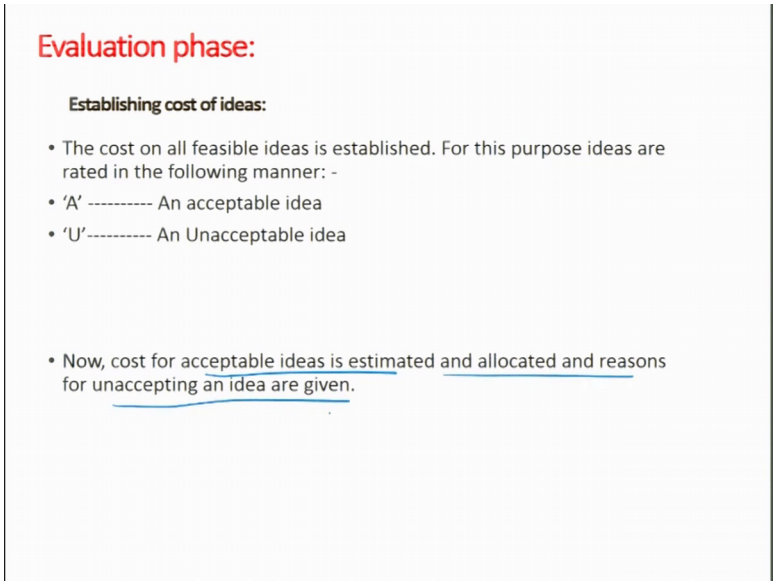
(Refer Slide Time: 45:51)



Now, evaluation phase comes into the picture. In evaluation phase, the objective is to analyze the results of the creative phase. So, this is why thorough review of various alternatives to select the best idea for the cost reduction. The skillful application is triggered at for the prevention of unnecessary cost development of value alternatives, though this is done while keeping in mind on in sharing that the product is not cheap and or degraded we cannot just reduce the performance or quality that means, to make sure that there is no reduction durability or is a preparation other aspects.

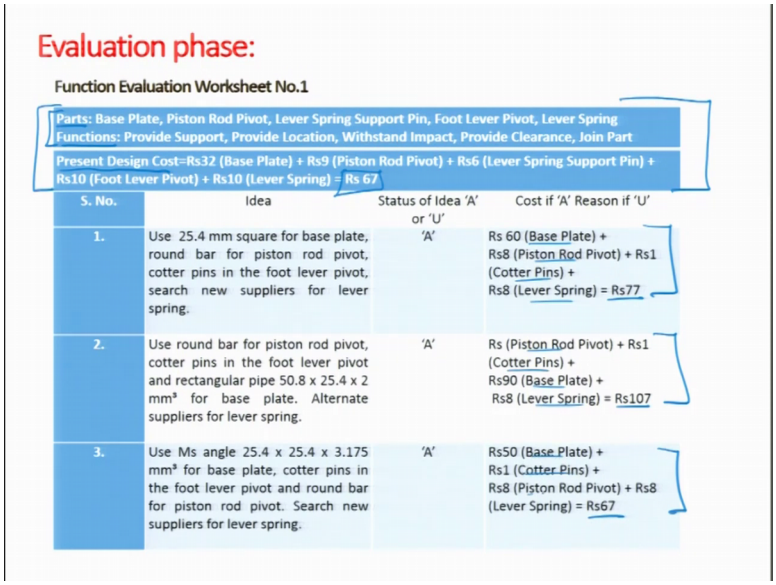
So, below the requirement of consumer or the customer we cannot go. Say in order to guard, these possibilities this phase employees following techniques, establish cost on all ideas evaluate by comparison, this is 1 and 2. So, each idea is there now what is the cost of this idea? What is the cost of idea number 2? Into establish cost for this idea, this is done in evaluation phase.

(Refer Slide Time: 47:03)



So, establishing cost for ideas the cost for all feasible idea this established for this purpose ideas are written in the following manner. Now, the cost for acceptable idea is estimated allocated and reasons for unaccepting an idea are given.

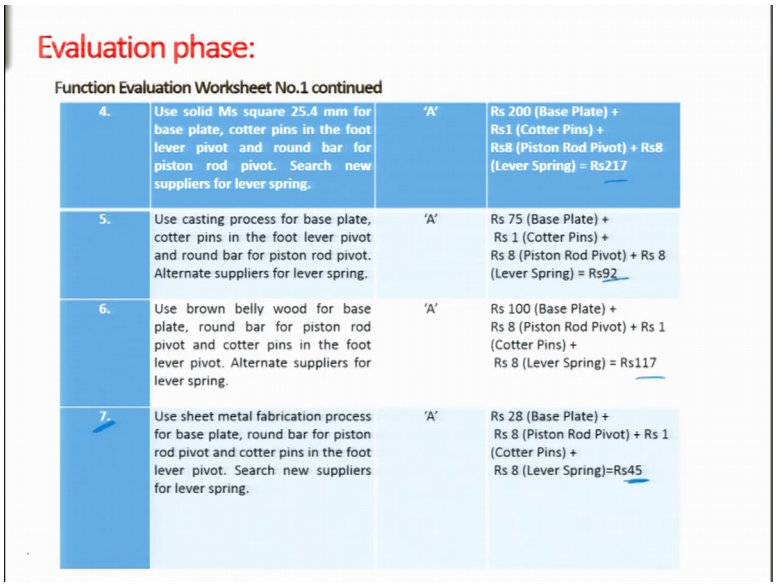
(Refer Slide Time: 47:17)



So, we develop this kind of function evaluation worksheet. This is again parallel to for corresponding to creative worksheet 1, these are the same function and parts which were there in the creative worksheet 1. In this case, the present design cost is put in the present design cost for these components, what is the cost and what is the cost of our idea ok.

So, present design cost is Rupees at 67 and our design is Rupees 77, Rupees 1 or 7 Rupees 67 and so on ok. This is the if we try to implement our design, what is the cost of the components or the suggestions that we have given base plate, cotter pin, piston rod, lever spring and so on.

(Refer Slide Time: 47:59)



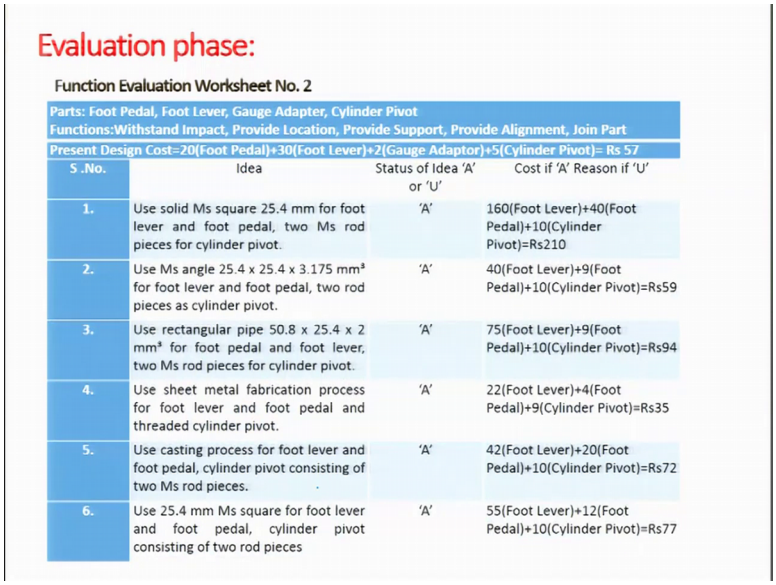
Evaluation phase:

Function Evaluation Worksheet No.1 continued

4.	Use solid Ms square 25.4 mm for base plate, cotter pins in the foot lever pivot and round bar for piston rod pivot. Search new suppliers for lever spring.	'A'	Rs 200 (Base Plate) + Rs1 (Cotter Pins) + Rs8 (Piston Rod Pivot) + Rs8 (Lever Spring) = Rs217
5.	Use casting process for base plate, cotter pins in the foot lever pivot and round bar for piston rod pivot. Alternate suppliers for lever spring.	'A'	Rs 75 (Base Plate) + Rs 1 (Cotter Pins) + Rs 8 (Piston Rod Pivot) + Rs 8 (Lever Spring) = Rs92
6.	Use brown belly wood for base plate, round bar for piston rod pivot and cotter pins in the foot lever pivot. Alternate suppliers for lever spring.	'A'	Rs 100 (Base Plate) + Rs 8 (Piston Rod Pivot) + Rs 1 (Cotter Pins) + Rs 8 (Lever Spring) = Rs117
7.	Use sheet metal fabrication process for base plate, round bar for piston rod pivot and cotter pins in the foot lever pivot. Search new suppliers for lever spring.	'A'	Rs 28 (Base Plate) + Rs 8 (Piston Rod Pivot) + Rs 1 (Cotter Pins) + Rs 8 (Lever Spring)=Rs45

These are other ideas we have develop cost for each ideas. We can see that the present cost you Rupees at 67 and the purpose of this study is actually reducing cost using value engineering. So, 67 is the present cost all this cost 77, 1 or 7. So, only 67 idea number three is equivalent to the present cost and idea number seven is lesser than the present cost, but these are all acceptable, acceptable means these are feasible.

(Refer Slide Time: 48:29)



Evaluation phase:

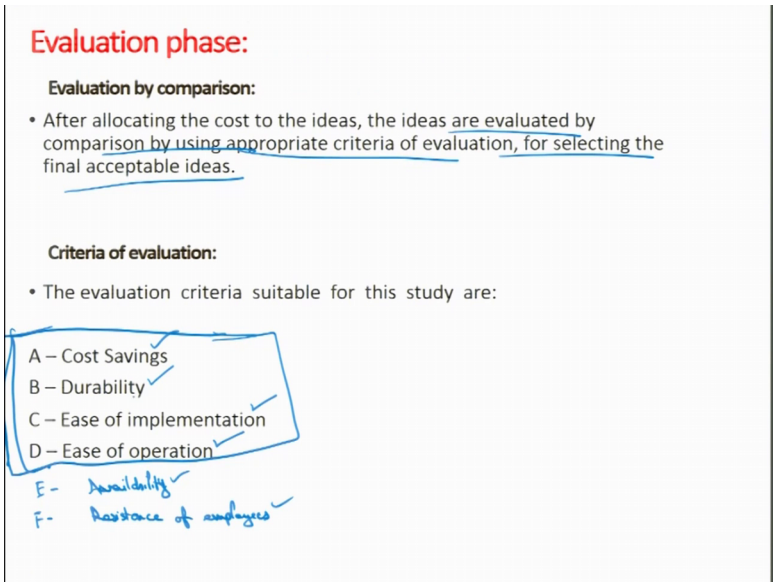
Function Evaluation Worksheet No. 2

Parts: Foot Pedal, Foot Lever, Gauge Adapter, Cylinder Pivot
Functions:Withstand Impact, Provide Location, Provide Support, Provide Alignment, Join Part
Present Design Cost=20(Foot Pedal)+30(Foot Lever)+2(Gauge Adaptor)+5(Cylinder Pivot)= Rs 57

S .No.	Idea	Status of Idea 'A' or 'U'	Cost if 'A' Reason if 'U'
1.	Use solid Ms square 25.4 mm for foot lever and foot pedal, two Ms rod pieces for cylinder pivot.	'A'	160(Foot Lever)+40(Foot Pedal)+10(Cylinder Pivot)=Rs210
2.	Use Ms angle 25.4 x 25.4 x 3.175 mm^3 for foot lever and foot pedal, two rod pieces as cylinder pivot.	'A'	40(Foot Lever)+9(Foot Pedal)+10(Cylinder Pivot)=Rs59
3.	Use rectangular pipe 50.8 x 25.4 x 2 mm^3 for foot pedal and foot lever, two Ms rod pieces for cylinder pivot.	'A'	75(Foot Lever)+9(Foot Pedal)+10(Cylinder Pivot)=Rs94
4.	Use sheet metal fabrication process for foot lever and foot pedal and threaded cylinder pivot.	'A'	22(Foot Lever)+4(Foot Pedal)+9(Cylinder Pivot)=Rs35
5.	Use casting process for foot lever and foot pedal, cylinder pivot consisting of two Ms rod pieces.	'A'	42(Foot Lever)+20(Foot Pedal)+10(Cylinder Pivot)=Rs72
6.	Use 25.4 mm Ms square for foot lever and foot pedal, cylinder pivot consisting of two rod pieces	'A'	55(Foot Lever)+12(Foot Pedal)+10(Cylinder Pivot)=Rs77

Similarly, we can we have all this acceptable ideas some other idea might be not acceptable that we have taken off from the worksheet.

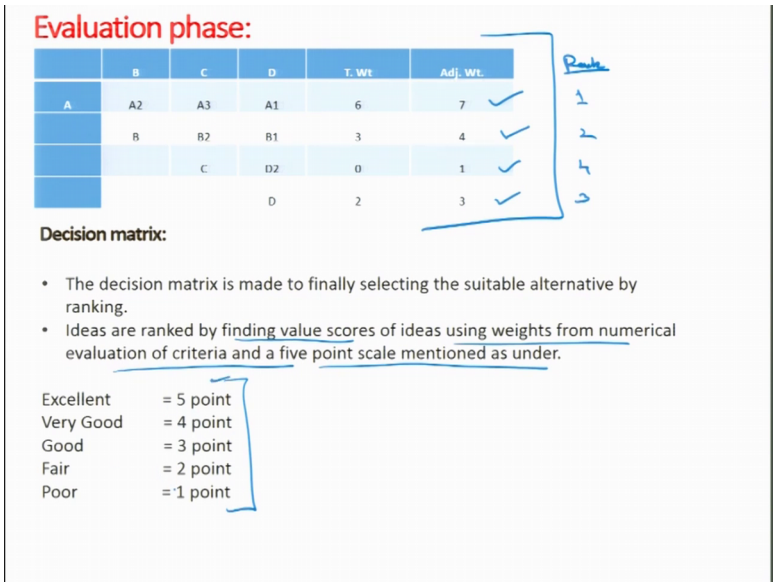
(Refer Slide Time: 48:33)



In a evaluation phase, after allocating the cost to the ideas, ideas evaluated by comparison using an appropriate criteria of evaluation for selecting the final acceptable ideas. The criteria for selecting the idea is the cost savings, durability, ease of implementation, ease of operation, people can have many like availability. Then you can have a resistance of employees, some ideas that we can have any number of ideas here ok, but these were the major four criteria not ideas is major four criteria those were taken.

Also we can have green criteria that I will just both coming sides here. So, based upon this first of all we need to rank this cost savings, durability, ease computation, ease of operation these are again rank using numerical evaluation phase.

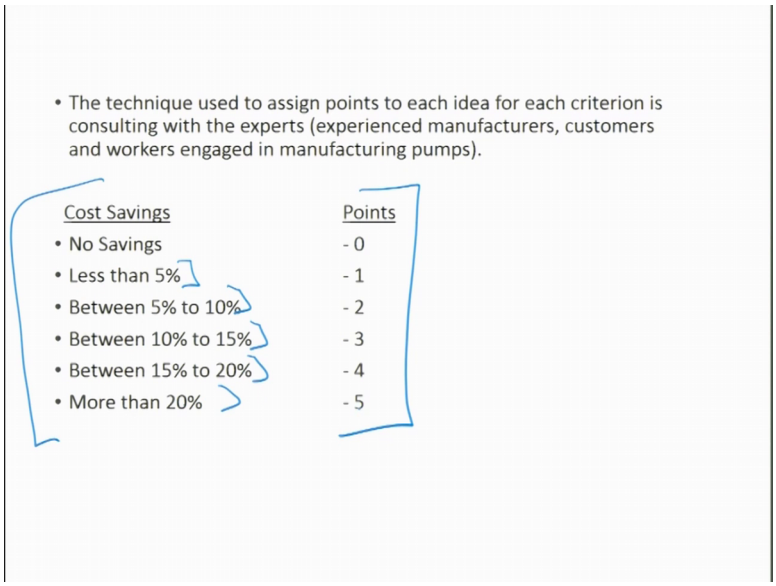
(Refer Slide Time: 49:33)



So, A, B, C, D; the highest rank is for A cost saving, the second rank is for B which one is durability ok, this is the third rank, this is the fourth rank ok. This is the rank 1, 2, 3, 4 this is a rank here ideas and decision matrix is finally, made decision matrix is the matrix that finally, it has as the score of the final idea that we will taken to the implementation stage and then we will see.

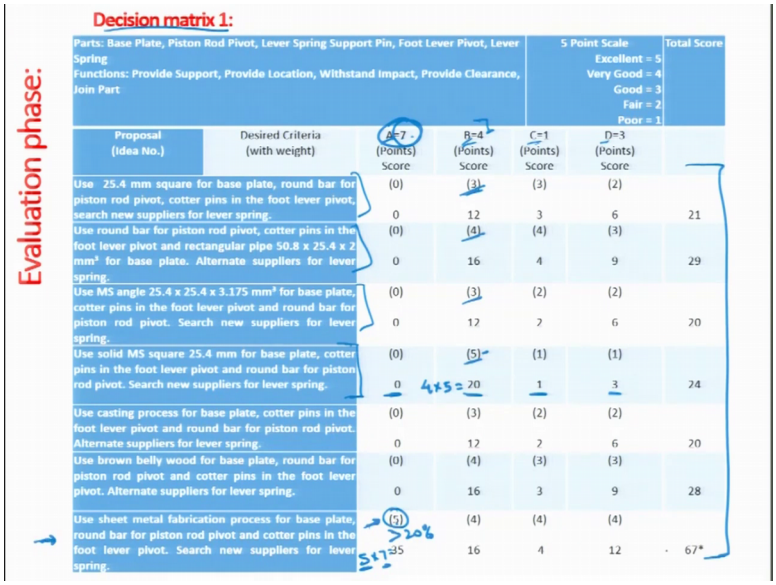
So, the decision matrix is made to finally, select the idea the ideas are ranked by finding value scores of ideas using weights from numerical evaluation of criteria and a five point scale is mentioned as under the idea is accident the idea is very good, good, fair, poor, how are this used.

(Refer Slide Time: 50:27)



I will show you the decision matrix for the cost savings, these points are given as no savings is 0 percent we are just quantified in this way between 0 to 20 percent. 0 no saving is 0, then these are the 5 percent classes between, so like less than 5, 5 to 10, 10 to 15, 15 to 20, 20 or more full five points are given this technique is used to assign points to each idea for each criterion.

(Refer Slide Time: 50:53)



So, this is the way we try to find the final score. So, this is again decision matrix which is corresponding to function evaluation matrix, which is intern corresponding to the

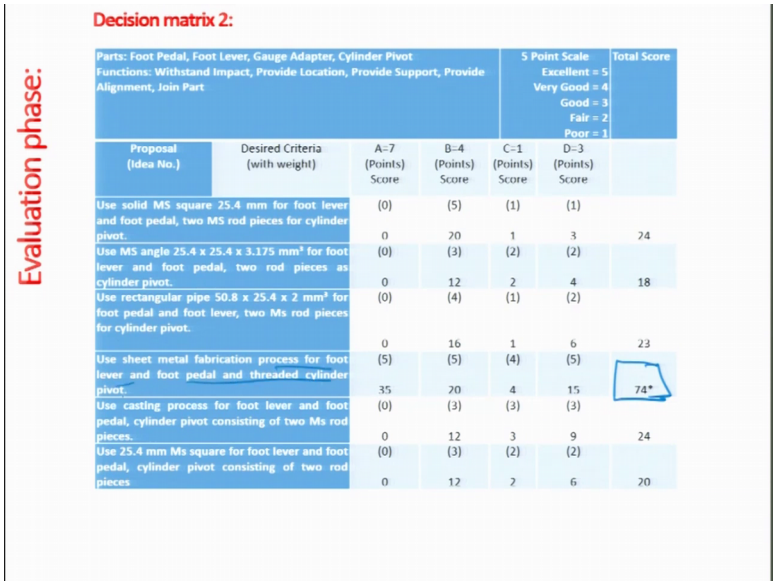
creative worksheet; creative work street number 1, this is decision matrix 4 1. So, these are the criteria A, B, C, D; cost saving, durability, ease of implementation, ease of operation. So, these are the ranks which are given we need not be rank we have just having these values 7.

So, this is value 3 the points in durability or the cost savings are 0 for all this things, all these ideas if you remember only this was having cost 45 ok, which was in cost 45 and a savings for more than 20 percent, more than 20 percent saving, so that is why it is given the value 5 here. And this 5 into 7 this 35 this is 5 into 7 equal 35, this 7 into this 5, this 5 into 7 is 35.

Similarly, cost where just quantified and the other criteria durability, ease of operation, ease of implementation were seen for this idea, what is the durability? For this idea, the durability is a given the point 4 out of 5, for this idea durability is given point 3 out of 5 this is very durable idea and it is given point 5, the how it is actually again a subjective rating given by experts.

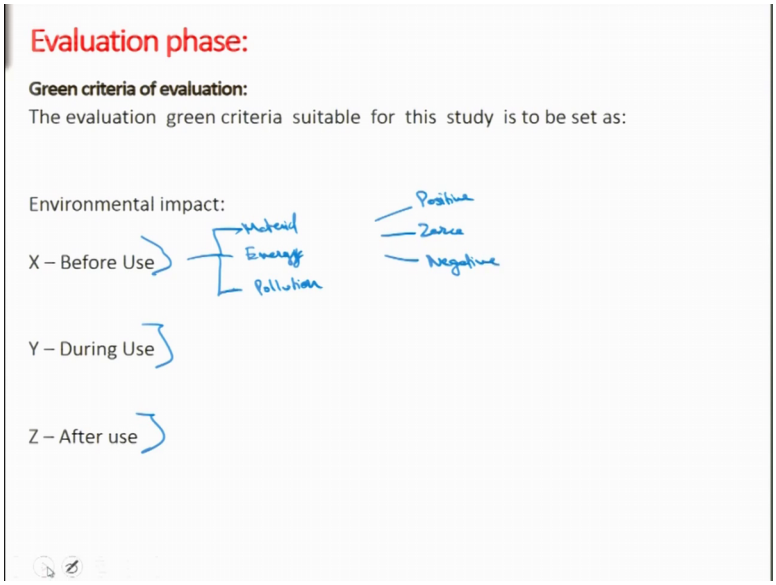
Now, this 5 into 4. B is equal to 4, this 20 is again 4 into 5 is equal to 20 ok. Now, all these values are summed up 0 plus 20 plus 1 plus 3 is equal 24. So, this is the score highest score is got an this idea, choose sheet metal fabrication. So, this is the idea that is selected to be taken to the further development and implementation phase.

(Refer Slide Time: 52:55)



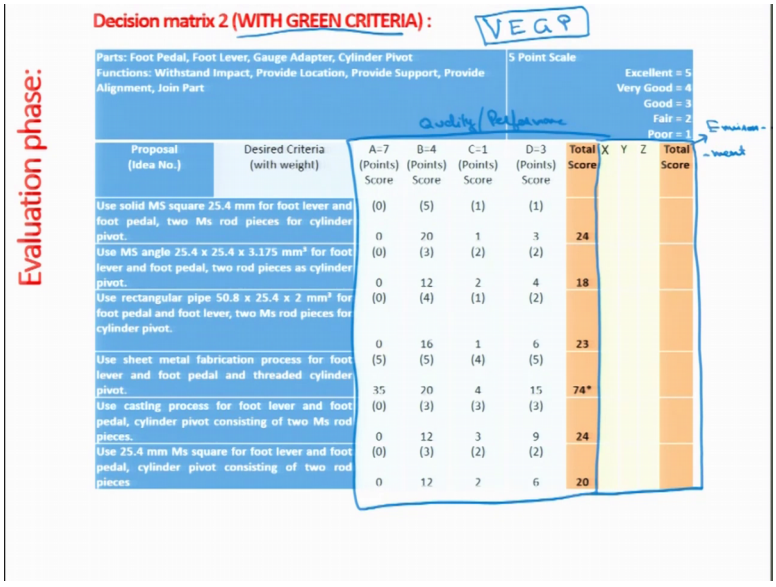
Similarly, we have decision matrix 2 in which this again selected use sheet metal fabrication process for foot lever and foot pedal and threaded cylinder pivot.

(Refer Slide Time: 53:03)



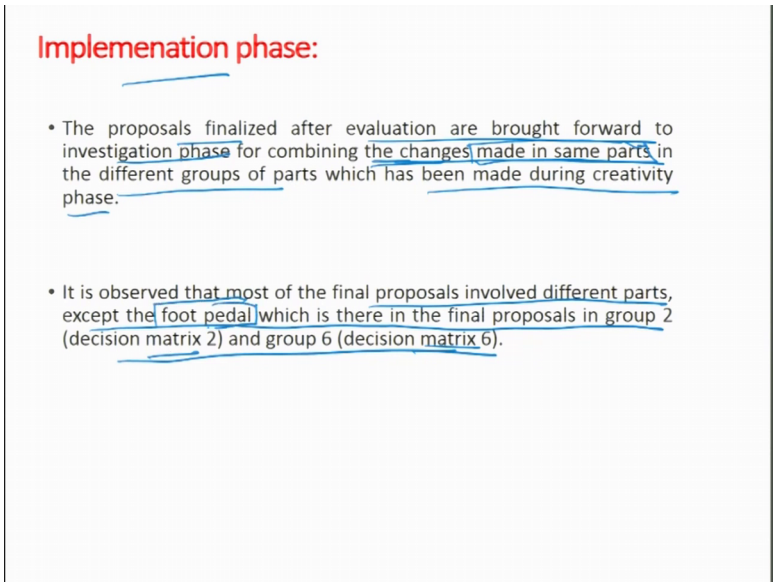
And we can have the green criteria in the evaluation. In this study, we did not actually worked on the green criteria, but yes we can have these three, areas here before use, during use, after use, again for each one we can think of the material, we can think of energy and pollution, we can think of these as positive, zero and negative for each one.

(Refer Slide Time: 53:53)



If we have this green criteria, then we have two different ratings, this one is for quality or performance, quality or performance and this one is for the environment. So, this green criteria helps us to have a green product that is why we have mentioned here decision matrix 2 with green criteria, and this makes it to be called as value engineering green plan ok. We have not done this for this complex product, but I will just do the green criteria and quality criteria for a simple product for a chart or for a pen.

(Refer Slide Time: 54:53)

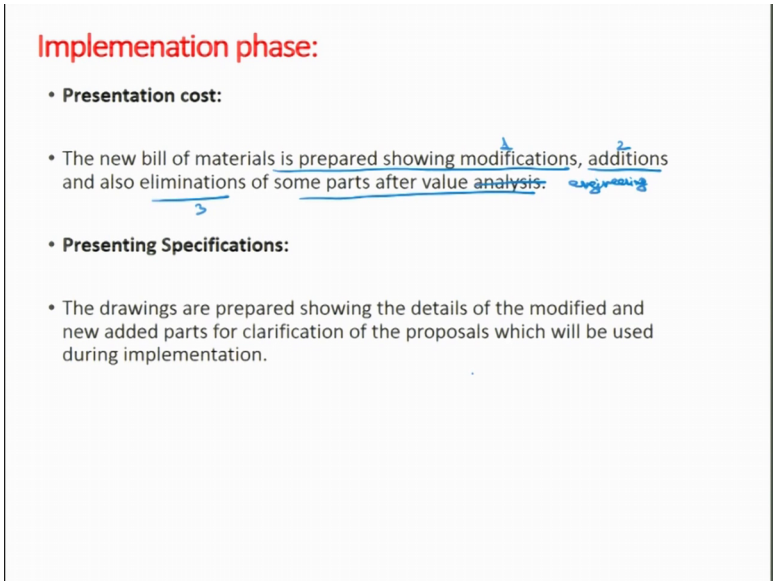


Let us see, what is the final decision that in taken from the current and that is why taken. In implementation phase, the proposal those are finalized after evaluation and brought forward to investigation phase for combining the changes same parts for instance, they certain creative worksheets. They were actually 11 creative worksheet, which were developed of which 7 were used out of this 7 creative worksheets. For instance, if this creative work sheet number 2 and worksheet number 3, there is some idea that is selected and this parts as again to be component for combined actually. This again to be combined because of those are combined on the same parts to do not changes are to be identified.

So, those who are in different groups of parts. So, they have been made to creativity phase, but those have to combined here. So, it is observed that most of the final proposals involved in different parts accept the foot pedal, which is there in final proposal in group 2 and group 6 these are to be combined. So, specifically group 2 and in decision matrix 2

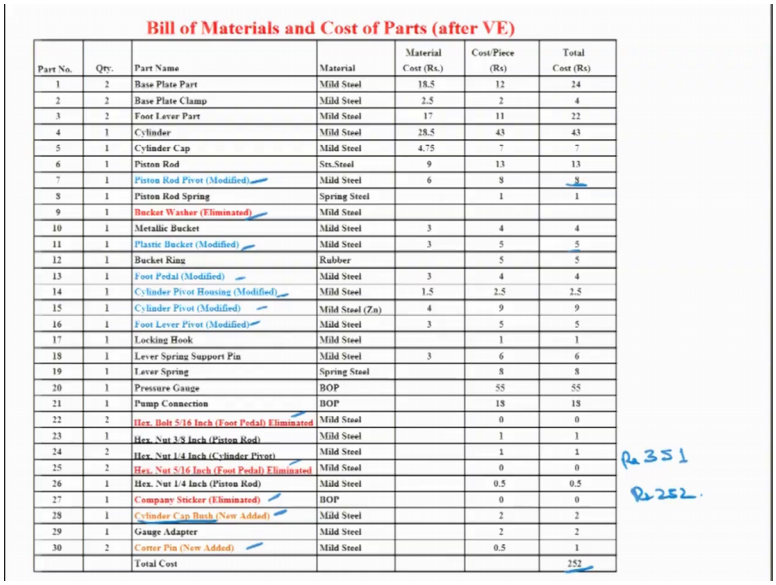
and decision matrix 6, there was different parts they were the foot pedal was a common part here. So, these were combined here.

(Refer Slide Time: 55:59)



So, next the present the cost on new bill of materials is developed and showed. Let us shows the modification, additions, eliminations; modifications, additions and eliminations of some parts after value analysis this is actually value engineering. Presenting specification the drawings are prepared showing the details of the modified and new added part for clarification of the proposals, which will be used during implementation these are presented before the management or the people who are going to invest for the new setup of the new components.

(Refer Slide Time: 56:41)



Bill of Materials and Cost of Parts (after VE)

Part No.	Qty.	Part Name	Material	Material Cost (Rs.)	Cost/Piece (Rs)	Total Cost (Rs)
1	2	Base Plate Part	Mild Steel	18.5	12	24
2	2	Base Plate Clamp	Mild Steel	2.5	2	4
3	2	Foot Lever Part	Mild Steel	17	11	22
4	1	Cylinder	Mild Steel	28.5	43	43
5	1	Cylinder Cap	Mild Steel	4.75	7	7
6	1	Piston Rod	Sts.Steel	9	13	13
7	1	Piston Rod Pivot (Modified)	Mild Steel	6	8	8
8	1	Piston Rod Spring	Spring Steel		1	1
9	1	Bucket Washer (Eliminated)	Mild Steel			
10	1	Metallic Bucket	Mild Steel	3	4	4
11	1	Plastic Bucket (Modified)	Mild Steel	3	5	5
12	1	Bucket Ring	Rubber		5	5
13	1	Foot Pedal (Modified)	Mild Steel	3	4	4
14	1	Cylinder Pivot Housing (Modified)	Mild Steel	1.5	2.5	2.5
15	1	Cylinder Pivot (Modified)	Mild Steel (Zn)	4	9	9
16	1	Foot Lever Pivot (Modified)	Mild Steel	3	5	5
17	1	Locking Hook	Mild Steel		1	1
18	1	Lever Spring Support Pin	Mild Steel	3	6	6
19	1	Lever Spring	Spring Steel		8	8
20	1	Pressure Gauge	BOP		55	55
21	1	Pump Connection	BOP		18	18
22	2	Hex. Bolt 5/16 Inch (Foot Pedal) Eliminated	Mild Steel		0	0
23	1	Hex. Nut 3/8 Inch (Piston Rod)	Mild Steel		1	1
24	2	Hex. Nut 1/4 Inch (Cylinder Pivot)	Mild Steel		1	1
25	2	Hex. Nut 5/16 Inch (Foot Pedal) Eliminated	Mild Steel		0	0
26	1	Hex. Nut 1/4 Inch (Piston Rod)	Mild Steel		0.5	0.5
27	1	Company Sticker (Eliminated)	BOP		0	0
28	1	Cylinder Cap Bush (New Added)	Mild Steel		2	2
29	1	Gauge Adapter	Mild Steel		2	2
30	2	Cotter Pin (New Added)	Mild Steel		0.5	1
		Total Cost				252

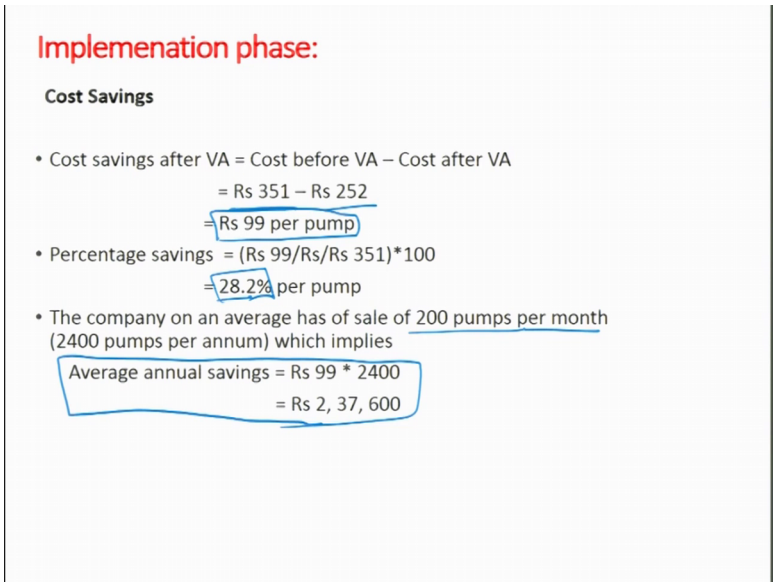
Rs 351

Rs 252.

So, this is the proposed bill of materials and cost of parts. The colour blue is the modified parts ok, piston rod if it is modified and new cost is here, plastic bucket is modified, foot pedal is modified, these are the modified parts ok. Bucket washer is eliminated, because the purpose of which is bucket washer was being used is now fulfilled by some other assembly, some other arrangements.

So, this is eliminated again this hexagonal both etcetera are eliminated, company sticker is eliminated that is not required here they said. So, these are new added parts cylinder cap bush, a cylinder cotter pin. So, the total cost is Rupees 252 if you remember the previous cost was it is Rupees 351 and the new cost is Rupees 252.

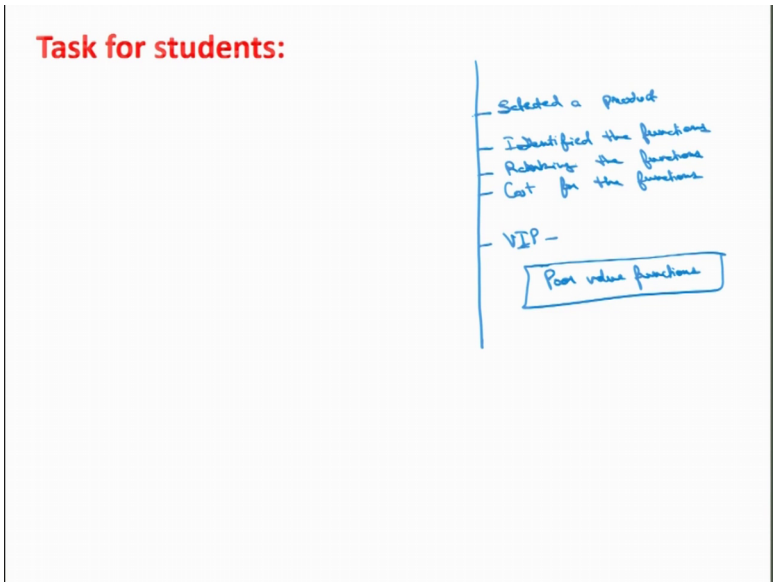
(Refer Slide Time: 57:37)



Then we can present the savings Rupees 351 is the total cost of the current design this is the proposed design. So, saving is Rupees 100 per pump this is quite high, 28.2 percent savings is here. So, to present the facts the company on an average has sale of 200 pumps per month. So, per month savings could be this one using value engineering approach.

When we talk about the implementation, the such an difference between the actual and the plant things as I said, implementation phase that was in things have to be taken into account, because we are set up and there is a change in the setup rate or the plant layout sometime there was things have to be made. So, there is resistance to change sometimes people do not implemented things.

(Refer Slide Time: 58:31)



So, this is value engineering methodology for a foot operated air pump. Now, I have a task for you people. Now, you have seen the methodology I would just request you the product that you are selected, you have already selected a product, selected a product, next you have identify the functions. Now, try to find the cost for the functions and rank also you have developed for the functions. And try to find V I P – Value Improvement Potential V I P and try to find the poor value functions, is a task for today.

So, I believe most of the value engineering green plants tough is covered now and by this while watching this lecture, you are you have seen how the study or value engineering is carried out. And how the green criteria can be instituted, while we talk about the criteria in evaluation phase. I will definitely come with study using the green criteria, a while taking a simple product and just picking 4, 5, 6 maximum 10 functions.

So, will meet in the next lecture and will discuss more value engineering. And further will discuss the other modules of this course and we also have this software presentations, when will discuss the life cycle assessment or green factory design, wale have this of implantation of their in that and life cycle assessment definitely we have the online available tools we will discuss.

And the open access software's and the some software's which are available in our Institute IIT, Kanpur which are which are not of open access, but those are very a good

tools to work on the green design. So, let us meet in the next lecture, and we will discuss more on advanced green manufacturing systems.

Thank you.