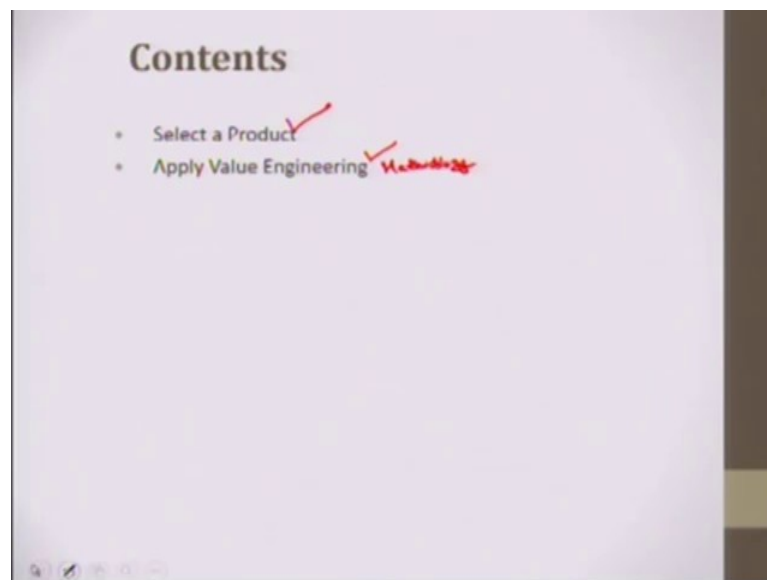


**Product Design and Manufacturing**  
**Prof. J. Ramkumar**  
**Dr. Amandeep Singh Oberoi**  
**Department of Mechanical & Design Program**  
**Department of Industrial and Production Engineering**  
**Indian Institute of Technology, Kanpur**  
**National Institute of Technology, Jalandhar**

**Lecture – 13**  
**Value Engineering, a case study**

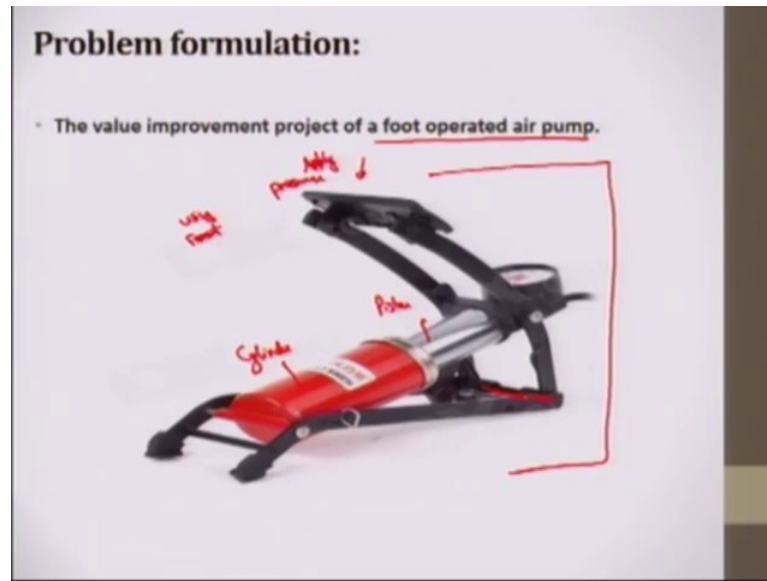
Welcome back to the course. So, in this week we are trying to study value engineering. So, today I will take value engineering case study; a case study on value engineering.

(Refer Slide Time: 00:23)



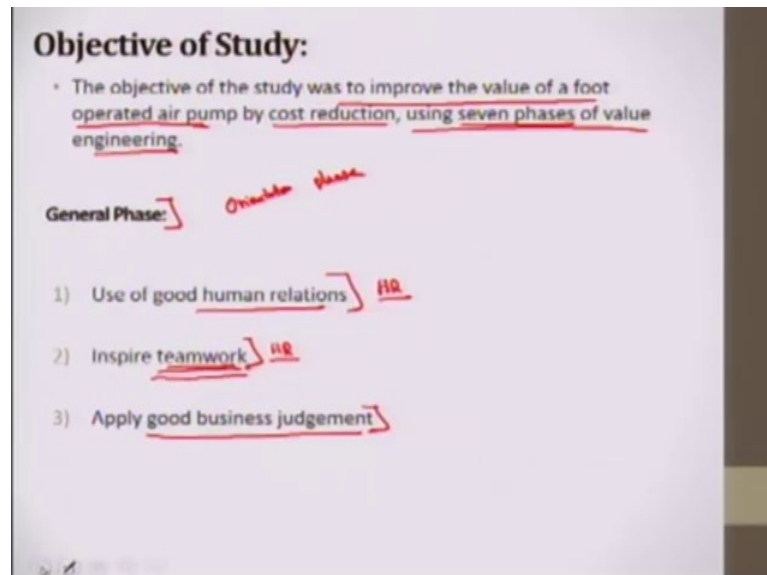
I will select a product, apply value engineering methodology.

(Refer Slide Time: 00:32)



The product that is selected is a foot operated air pump; you might have seen this product we apply pressure here. Apply pressure using your feet or single foot and this is the cylinder and piston the air goes to this pipe and inflates your car tyre or the other object you want to put air in.

(Refer Slide Time: 01:12)



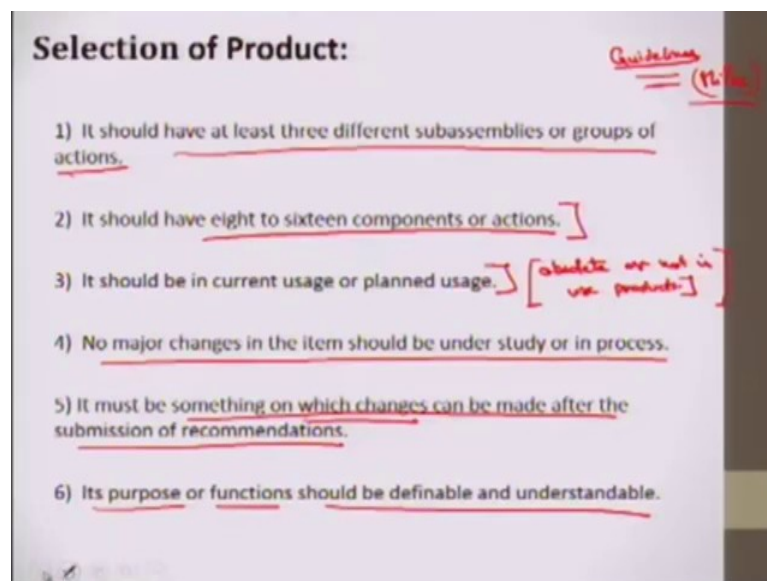
So, the objective of study here is to improve the value of a foot operated air pump by cost reduction using seven phases of value engineering; here seven phases were used that is the general phase was also used. This was the study carried out with one of my M-

Tech students; so, actually the whole study took several months to do, but I will just take some part of that to explain how value engineering is carried out.

So, in general phase there are certain general rules number one is use good human relation value engineering team is over dependent on data collection, analysis, data implementation so; obviously, the HR human relations would come into play. So, inspired team work this is also the kind of human relations thing; one of the fundamental principles of value engineering is to employ teamwork, a team can only work to conduct full value engineering study.

Now, apply good business judgement; this is a general statement that the judgement has being based upon the facts and data and used quite often in this decision making. So, this is the kind of the general phase or orientation phase.

(Refer Slide Time: 02:42)



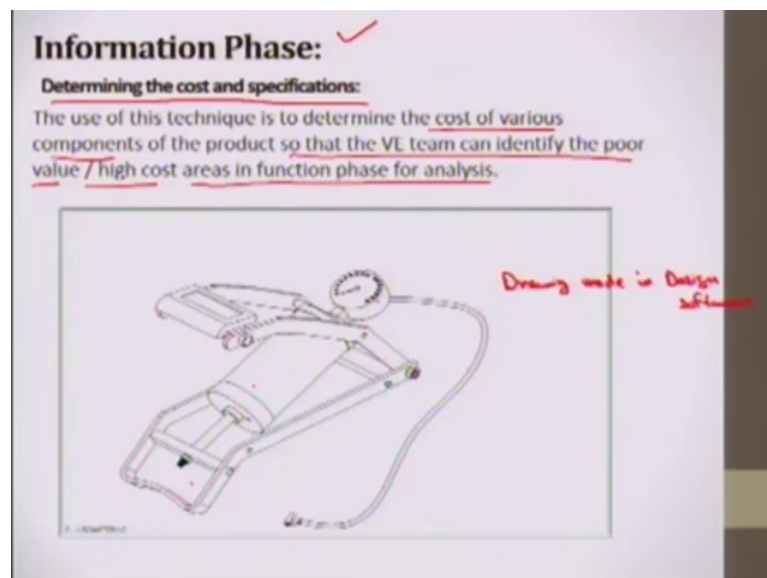
Next, we select the product; these are general guidelines for selection of the product these are also given by Miles; the founder of value engineering he says it should have at least three different subassemblies if it is a mechanical product three different subassemblies is a group of actions that is the components could be made into groups for example, if I say I selected my pen as my product before. So, in that I have 5 or 6 components body front nut back nut refill four components were there.

So, these four components can be grouped into maybe I am working on the body front nut and back nut one group; second group is body, front nut and refill; third group might be only refill in only refill we have ink, the tube and tip these are the groups. So, these are kind of subassemblies here; so, it should have at least eight to sixteen components or action these are the guidelines given by miles, but it is not very much necessary that these must components have to be there.

It should be in current usage or planned usage that is the absolute products are not recommended here absolute or not in used products. No major change in the item should be under study or in process if the item is already under study that is some major change is going to happen that conducting value engineering that would not help.

It can help if we know that change; if we know that what change is going to happen and if value engineering can even help in that way as well; it can enhance that process the change that is being carried out. So, it must be something on which changes can be made after the submission of recommendations that is the decision maker should have the power or authority to make the changes its purpose is or function should be definable and understandable; these are general guidelines for selection of the product.

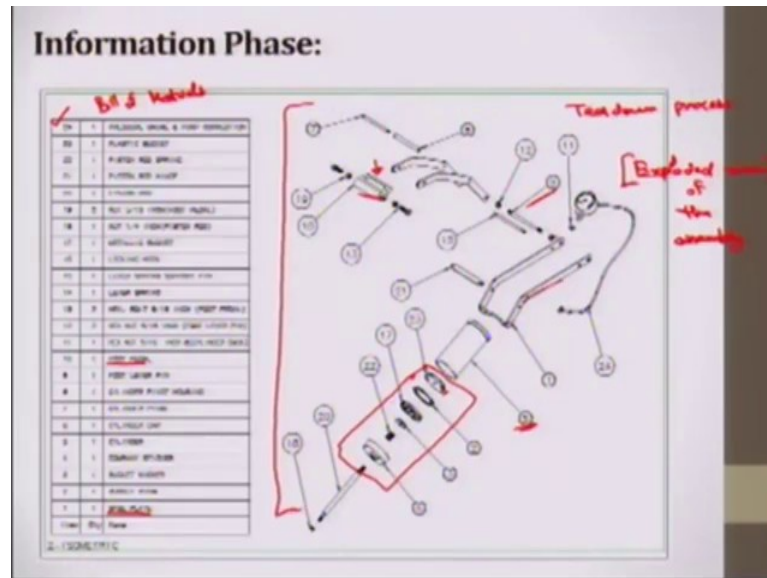
(Refer Slide Time: 05:03)



So, the next is information phase information phase the first step we are what we doing is determining the cost and specifications; specification is this drawing is made drawing made in design software. All the components here are made and they are then assembled

the use of this technique is to determine the cost of various components of the product. So, that the value engineering team can identify the poor value and high cost areas in function phase for analysis.

(Refer Slide Time: 05:41)



So, this is the table that gives us the material details; so, this is called bill of materials. So, if you see we have various components this is again the tear down; tear down process or in design software's, we call it exploded view exploded view of the assembly.

So, this product has these much number of components 24 components are there for this is the component one here is base plate. This base plate is connected using this component nine that is pin with this lever the lever is further connected with the component 10; that is foot pedal this foot pedal is here foot pedal we apply pressure this foot pedal and also we have component seven and eight has the pins or pivots; then we have the piston here this is the cylinder component 5 is cylinder cap is there and in between in this we have this piston mechanism here this all is piston mechanism these are the components of my product.

(Refer Slide Time: 07:09)

**Information Phase:** ✓

$TC = \text{Material Cost} + \text{Operation Cost}$

*Bill of Materials and Cost of Parts (Sheet 1)*

Qty	Qty	Part Name	Material	Material Cost/Rs.	Cost/Piece/Rs.	Total Cost/Rs.
1	1	Base Plate	Mild Steel	25	7	32
1	2	Foot Lever Part	Mild Steel	12	15	30
1	1	Cylinder	Mild Steel	21	77	77
1	1	Cylinder Cap	Mild Steel	18	22	22
1	1	Plunger Rod	M. Steel	9	11	11
1	1	Plunger Rod Pin	Mild Steel	6	3	9
1	1	Plunger Rod Spring	Spring Steel	2	2	2
1	1	Washers	Mild Steel	2	2	2
1	1	Nut/Bolt Washer	Mild Steel	4	4	4
1	1	Plunger Bush	BCP	8	8	8
1	1	Wash. Ring	Rubber	5	5	5
1	1	Foot Nut	C.I. Nut	19	20	20
1	1	Cylinder Pin Housing	Mild Steel	2	3	3
1	1	Cylinder Pin	Mild Steel	3	5	5
1	1	Foot Lever Pin	Mild Steel	4	10	10
1	1	Locking Hook	Mild Steel	1	1	1
1	1	Lever Spring Support Pin	Mild Steel	5	6	6
1	1	Spring Springs	Spring Steel	20	20	20
1	1	Plunger Bush	BCP	80	80	80
1	1	Pin/Bush/Plunger	BCP	25	25	25
1	2	Class. Bush 1/2" dia/Plunger	Mild Steel	1	2	2
1	1	Class. Adapter	Mild Steel	2	2	2
1	2	Class. Bush 1/2" dia/Plunger	Mild Steel	0.5	1	1
1	2	Class. Bush 1/2" dia/Plunger	Mild Steel	0.5	1	1
1	1	Pin	Mild Steel	0.5	0.5	0.5
1	1	Compressor Sucker	BCP	4.5	4.5	4.5

Next what I do? To elaborate the information phase further I put the bill of materials and cost of parts; if I do not put the cost of the parts it is just bill of materials if I put the cost of the parts this further elaborates our materials details here. We have the base plate is costing rupees 25; it is in one quantity here actually the total cost of the base plate is three rupees 32 of which rupees 25 is the material cost and rest rupees 7 is the operation cost that is being carried out to manufacture this base plate.

And in this case foot lever the cost of material is rupees 12 cost per piece comes to rupees 15 that is rupees 3 is the operation cost; that is  $32 - 25$  or  $15 - 12$ ; these are the operation cost. As you know the total cost of the product is material cost + operations cost; I have just put one element here that is operation cost this involves everything labour cost and over heads. So, that two components two quantities here; so  $15 \times 2$  total cost is 30; in this way we enlist all the materials.

(Refer Slide Time: 08:46)

**Function phase**

- In function phase, the functions of the components under study are defined.
- Function is which makes a product 'work or sell'.
- Functions are classified as 'Primary Functions' and 'Secondary Functions' at the part level as well as assembly level.

Next comes the function phase in function phase the functions of the components under study are defined just to recall function is which make the product work or sell functions are classified as primary functions and secondary functions at part level as well as assembly level will see how do we do this.

(Refer Slide Time: 09:12)

**Function phase**  
Defining the Functions:

- The functions of all the parts of the pump are defined
- **Rule 1.** The function should be accomplished in two words, a verb and a noun. E.g. in the Function 'Join Parts', Join is a verb, Part is a Noun.
- **Rule 2.** All functions should be divided into two levels of importance, primary and secondary.
- **A. Primary Function:** It expresses the primary purpose, which is only one for a part or for a product.
- **B. Secondary Function:** It expresses the purpose that support the primary function but does not directly accomplish it or it is resulted from a specific design approach.

Or defining the function there is certain rules here the functions of all the parts of the pump are defined rule 1 the function should be a accomplished in two words verb and a noun and active verb and measurable noun.



For example, the function join parts join is verb part is noun rule 2 all functions should be divided into two levels of importance it is primary and secondary. Primary function it expresses the primary purpose which is only one for the part of the product the product could be doing multiple function, could be doing may be 5 or 6 or 7; may be 10 functions ok, but there could be only one primary functions for which the product is made all other would be secondary.

Now, secondary function it expresses the purpose of that support the primary function, but does not directly accomplish it or it is resulted from specific design approach.

(Refer Slide Time: 10:13)

Part of assembly  
Pump  
(Product)

S. No.	Part Name	Existing functions		Functional purpose			
		Verb	Noun	Part		Assembly	
				Primary	Secondary	Primary	Secondary
1	Base Plate	Provide	Support	✓			
		Provide	Location		✓		✓
		Withstand	Impact		✓		✓
		Provide	Clearance		✓		✓
		Provide	Support		✓		✓
2	Foot Lever	Provide	Support	✓			✓
		Provide	Location		✓		✓
		Facilitate	Movement		✓		✓
		Join	Parts		✓		✓
		Withstand	Impact		✓		✓
		Transmit	Motion	✓			✓
3	Cylinder	Provide	Alignment		✓		✓
		Provide	Sealness		✓		✓
		<u>Generate</u>	<u>Pressure</u>	✓			✓
		Facilitate	Movement		✓		✓
		Provide	Alignment		✓		✓
		Join	Parts		✓		✓
		Provide	Location		✓		✓
		Transmit	Pressure		✓		✓
		Withstand	Impact		✓		✓
		Facilitate	Movement		✓		✓
4	Cylinder Cap	Join	Parts		✓		✓
		Provide	Location		✓		✓
		Retain	Fluid		✓		✓
		Provide	Alignment	✓			✓
		Facilitate	Lubrication		✓		✓

We will see this; so, this is dividing all the components into the function the base plate; the basic function of base plate is to provide support provide support to the cylinder it is the primary function.

Secondary functions are ‘provide location’ for the pin location for the cylinder, with stand impact when the pressure is applied it has weight and impact, provide clearance is between the levers between these levers and the base plate it has to provide some clearance here as well. Then foot lever; the primary function of foot lever is to transmit motion transmit motion to our cylinder to the cylinder piston mechanism here; this is the primary function. So, all other are provide location for the pins and other joining features here, facilitate the movement join parts with stand impact these are all secondary functions.



Now, we can see at assembly level the primary function that is identified is generate pressure; this is the primary function of my assembly that is of my pump; foot operated pump that is my product. And if the primary function of the product exists in our component here; it would be the primary function of the component here this is for sure. So, we cannot have 'generate pressure' here and that becomes the secondary function because generate pressure is the primary function of the product for which the product is being made. So, this would be an; this should be the primary function of our component which has this.

(Refer Slide Time: 12:15)

**Function phase**

S. No	Part Name	Common Definition		Common Location			
		Verb	Noun	Part		Assembly	
				Primary	Secondary	Primary	Secondary
3	Piston Rod	Join	Part		✓		✓
		Generate	Pressure		✓	✓	✓
		Withstand	Impact	✓			✓
		Support	Movement		✓		✓
6	Piston Rod Pivot	Join	Part		✓		✓
		Provide	Location	✓			✓
		Facilitate	Movement		✓		✓
		Withstand	Impact		✓		✓
		Facilitate	Fitment		✓		✓
7	Piston Rod Spring	Withstand	Impact		✓		✓
		Provide	Location		✓		✓
		Provide	Clearance	✓			✓
8	Bucket Washer	Facilitate	Fitment	✓			✓
		Permit	Retention		✓		✓
9	Metallic Bucket	Permit	Retention		✓		✓
		Permit	Flow		✓		✓
		Provide	Location	✓			✓
10	Plastic Bucket	Permit	Retention		✓		✓

Now, next is cylinder cap also you can we can see the various functions here. So, I have just selected ten components here the whole other component would divided to you in the notes. So, we have piston rod, piston rod also has this function primary function you consider there are certain components like piston rod pivot, piston rod spring, bucket washer metallic, bucket plastic bucket these all are the components that helps to fix and operate the piston in the proper way; here this movement of our piston is being carried out. So, these do not have the primary function of assembly in them, but in the present design they do exists we will see are they essential or just desirable.

If they are found to be essential components will keep them if they are just desirable that that is the product could operate, product could do it its main function without these components we can eliminate them that as well we can find some other alternative.

(Refer Slide Time: 13:21)

### Function phase

**Evaluation of Functions:**

- For evaluation of functional relationships, there is need to determine the relative importance of various functions.

**Numerical Evaluation of Functional Relationship:**

- All the functions of all the parts under study are considered from the Functional Definition Worksheet
- These listed functions are then allotted with key letter from A to T.

So, next we will evaluate the functions for evaluate of the functions for evaluation of functional relationship there is need to determine the relative importance of various functions. The numerical evaluation of functional relationship is carried out here all the functions of the parts under study are considered from the functional definition worksheet; these listed functions are then allotted with the key from A to T; there are number of functions like join parts generate pressure with stand impact; we enlist these functions and denote them with some letter some notations from A to T; there are these many number of functions here.

(Refer Slide Time: 14:04)

### Function phase

**Time of Expect**  
**Based upon the customer requirements**

Function	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Weight	Sub	
A	1																					1.042	
B	1.01	1																				1.019	
C	1.01	1.01	1																			1.047	
D	1.01	1.01	1.01	1																		1.142	
E	1.01	1.01	1.01	1.01	1																	1.062	
F	1.01	1.01	1.01	1.01	1.01	1																1.039	
G	1.01	1.01	1.01	1.01	1.01	1.01	1															1.019	
H	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1														1.019	
I	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1													1.019	
J	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1												1.019	
K	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1											1.019	
L	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1										1.019	
M	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1									1.019	
N	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1								1.019	
O	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1							1.019	
P	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1						1.019	
Q	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1					1.019	
R	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1				1.019	
S	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1			1.019	
T	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1		1.019	

Then what we do we make this numerical evaluation chart here how do we do that? I will just let you know.

(Refer Slide Time: 14:15)

**Function phase**

- To decide the importance of a function, following weight factors are considered and allotted to the function depending on the difference of importance between them.
- **Weight Factors**
  - '1' Minor difference in importance
  - '2' Medium difference in importance
  - '3' Major difference in importance
- As function B is important from function A by minor difference, therefore in the cell, it is written as 'B1'.
- In the similar way all the functions are compared with each other. Hence, the table is completed and total weight factor for each function is calculated.
- Then adjusted weight is calculated by adding '1' in the total weight factor because no function could have zero weight as in case of function S.

To decide the importance of a function following weight factors are considered and allotted to the function depending on the difference of importance between them. What is happening here we have given these weight factors 1, 2 and 3 for minor medium and major difference in the importance of function. In this case if I have put B 1 here; B 1 means function B is important than function A with a minor difference 1 is for minor, 2 is for medium, 3 is for major.

Let me take an example of medium difference function G is important than function H with a medium difference function G that is transmit motion is important than provide alignment with medium difference of importance let us pick some other here function F is important than function M; function F here is join part that is important than function M function has F from this side, M from this side. It is important function M with a major difference of importance that is my join parts is much important than provide reservoir; provide reservoir that is provide space for the piston. So these ratings are done by the experts; experts or team of experts; experts means they do it based on based upon the customer requirements.

So, a customer would like to have the parts joint that is the function than he would think of to provide a reservoir. So, function F is much important than function M here. So, let

us see two functions which are close here let me see this H 1; this function H is important because function H is important letter H is put in; what is the difference as potted? It is minor difference importance H 1 function H that is provide alignment is important than function K that is restrict movement by minor difference important that is the importance of this functions are very close.

Then the similar way we put the letter whichever is important function for example, this O 2 again I will take one more example here O 2; this O means O is important function than this matrix O and I; O is important than I and the difference of importance is medium. So, what we do? We have this rate as function B is important from function A by minor difference therefore, in the cell it is written B 1 function B is important than A by minor difference.

So, in this way this rating factor is used to evaluate the function numerically. Now what happens? We calculate the weight of the functions; now this is the weight of the function A, wherever we have A that is  $A\ 1 + 2 + 2 + 1 + 1 + 3 + 2$  that comes up to 12. Similarly, I will take some other example this is function M;  $M\ 1 + 2 + 2 + 2 + 2 +$  on this side  $M\ 1 + 1 + 1 + 2 + 2$ . Now this is all added for M; these numbers and these numbers where ever M exists so, how it is happening is  $M\ 2 + 2$  is equal to  $4 + 1; 5 + 1\ 6 + 2; 8 + 1; 9 + 1; 10 + 2; 12 + 2; 14 + 2\ 16 + 2$  total 18.

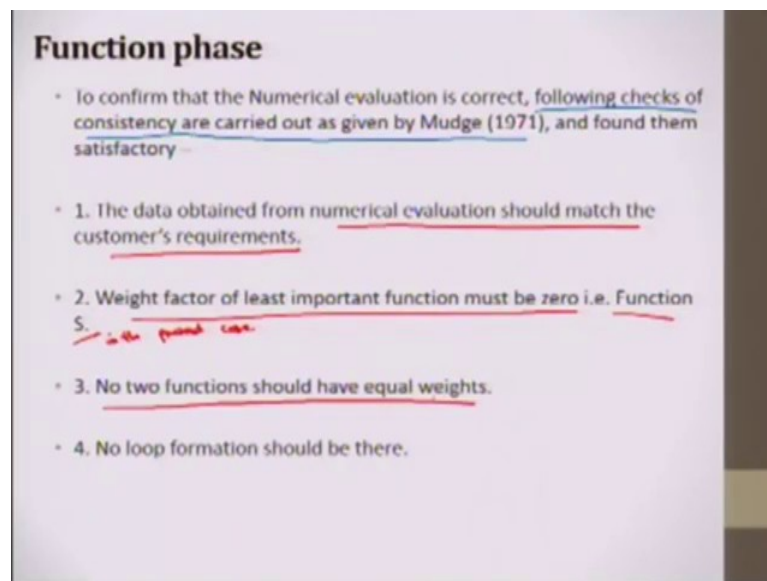
Similarly, for each function for O this where ever we have O in the column for the O and in the row for the O these weights could be added. Now because the generate pressure is our basic function L that would have maximum weight we have the function L the here weight here is 45. And one function you always find the way to be 0 that is least important function that is function S that is provide identification provide identification is nothing here they have put the sticker the logo of the company here.

That customer does not care at all because we are talking about the customer requirements or customer needs or customer view point here. So, what we do we add 1 to all the function  $12 + 1; 13, 11 + 1; 12, 27 + 1; 28$  so, on we add 1 to get its adjusted weight factor here.

Then total of the adjusted weights is made here 361; this is normalized with respect to 100; so this comes out to be percentage adjusted weight that is  $13 / 367$  what is the percentage contribution? 3.5 percent;  $12 / 367$ , the percentage is 3.2 the maximum would

be for 45 this L function; that is  $46 / 367$  that is 12 percent contribution. So, this is the weight of the function that is the customer are trying to look for function L first they want something to generate pressure something to inflate their objects, then the second weight we can see here is 9.8; they want function N function N is transmit; they want to transmit the pressure from the pump to their tyres, this is function N; the second highest level of weight. This is the weight of the function based on the customer requirement.

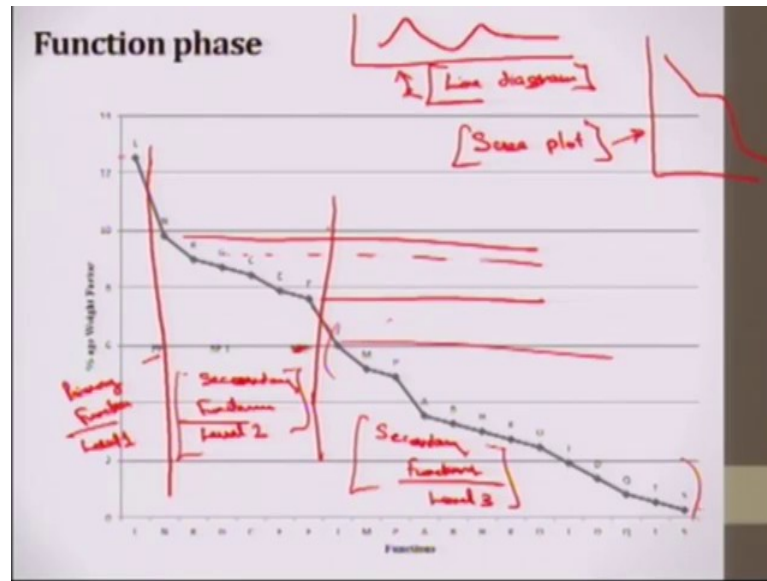
(Refer Slide Time: 21:26)



Now, next what we do? We confirm that the numerical evaluation is correct; following checks of consistency are carried out as given by Mudge. He says that the data obtained from numerical evaluation should match the customer requirements; this is based on that only. Weight factor for least important function must be 0 that is the function S in this case; in the present case. No two functions should have equal weights; that means, no these weight factors should be equal.

Then no loop formation should be there loop formation is if we have for in case if we have 2; 2; I am talking about this P 2 here 2 here and if it is 2 here and 2 here this makes a closed loop had a 2 here and 2 here 2, 2, 2, 2. So, there is no closed loop formation; so, these are certain checks for our correct numerical evaluation. Actually, we added 1 here because we will use this as a factor somewhere and if we use 0; 0 by that total would be 0 contribution, it has least contribution this function S has least contribution that is 1 by 367 and we do not want any function to have 0 contribution.

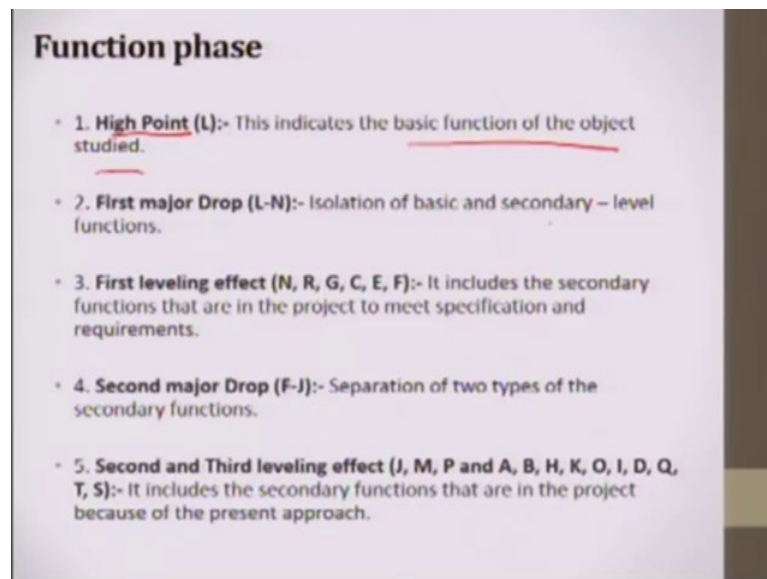
(Refer Slide Time: 22:58)



Now, this says the line diagram the plot for the functions line diagram or data visualization is used also this is known as screw plot.

Line diagram could be any line like this in the plot; when the plot is like this it is flowing down like this kind of plot is known as screw plot this is line diagram. So, what is happening here is.

(Refer Slide Time: 23:30)

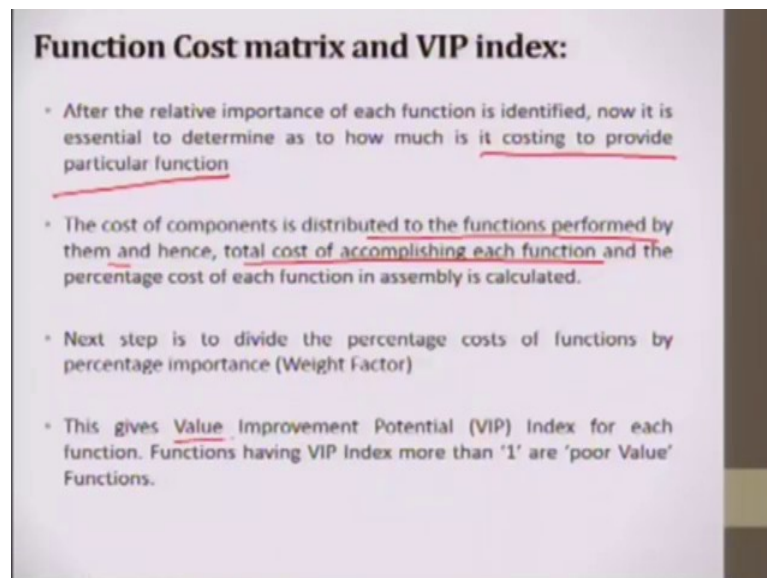


We have high point L that indicates the basic function of the object studied the AC function is generate pressure that is the point L. Next what we have? First major drop

that is L to N that is isolation of basic and secondary functions secondary level functions; that is from L to N that is the first drop, this becomes our primary functions P of here is primary function.

Second drop is here at N; this is secondary function functions level 2; this is actually level 1, then the rest of the functions after function F are secondary functions level 3; level 3. This is a kind of illustration that identifies the top function that is the highest order function L and shows that how the functions since in the one level that is the level 2 and in the other level 3 three are closed to each other. So, this is the difference in weightage here from N to F this difference is here; for j to S this difference is there this is all this levelling or drops are mentioned here.

(Refer Slide Time: 25:09)



**Function Cost matrix and VIP index:**

- After the relative importance of each function is identified, now it is essential to determine as to how much is it costing to provide particular function
- The cost of components is distributed to the functions performed by them and hence, total cost of accomplishing each function and the percentage cost of each function in assembly is calculated.
- Next step is to divide the percentage costs of functions by percentage importance (Weight Factor)
- This gives Value Improvement Potential (VIP) Index for each function. Functions having VIP Index more than '1' are 'poor Value' Functions.

Next is function cost matrix and value improvement potential. After the relative importance of each function is identified, now it is essential to determine as how much is it costing to provide particular function we have given the weights to the functions. Now we need to identify the cost of the function, as I said before value is utility per unit cost if we know weight we know utility. And if we know the cost of that we can take that ratio to find the value the cost of components is distributed to the function performed by them and hence total cost of accomplishing each function and percentage is taken here. So, will come up with value improvement potential here.



(Refer Slide Time: 26:00)

The image shows a 'Function Cost matrix and VIP index' table. The table has columns for various functions (A through L) and rows for different components. Red arrows and lines are drawn on the table to highlight specific data points and groupings. The table is divided into sections for different components, with red arrows pointing to specific rows and columns. The table includes a total cost row at the bottom, which is highlighted in red and shows a total cost of 32 rupees. The table also includes a 'VIP Index' column on the right side.

I will show you with this chart; so, this base plate has these functions. So, this plate has functions A, B, C, D, E in it that is provide support provide location it is an impact and so, on and foot lever as these functions function A, B, C, E, F, G and H; what we are doing here is this was the total cost of the base plate we have divided this cost into the functions rupees 32 is divided into these components out of 32 rupees 12 is for function a rupees 10 for function B, 5 for C, 4 for d and so, on rupees 30 is again divided into these components here.

What happens here each of the components is divided into functions at the cost of the components is divided into its functions. This is again done by the experts who are manufacturing experts; they know what is the cost of this specific function. For example, to provide support there has to be some material that can withstand load there is a to withstand impact they have has to be some material cost of the material is there, the cost of the operation is there; considering all these points these components are divided into functions there their cost element is divided into its functions.

So, with this what we get? We get cost of these functions, cost of getting function B is the total cost of column B here. This is the total cost of function B; similarly, if I say cost of function L that is my primary function is this much rupees 43 this is rupees 36.

Again, I take the total of this cost what I do? I take the total of this cost 14 plus 36 + 41 + 6; this would come out to be see 351 and this would also be the total cost of my pump 32

+ 30 + 17 + 22 component wise and function wise; this total cost would be rupees 351 now fourteen by 351 is my cost contribution; 36 / 351 is my cost contribution for function B. For function L it is 43 / 351; the cost contribution is 12 percent. Now what I do? I take my VIP Value Improvement Potential; VIP, your Value Improvement Potential is exact opposite of value what we defined.

In this case I take various the percentage cost over percentage weight. So, VIP is equal to percentage cost over percentage weight; we actually want to reduce the cost here if the cost is high this VIP would be greater than 1, VIP greater than 1 implies poor value function and we will work on that.

(Refer Slide Time: 29:40)

**Function phase**

**Indifference chart:**

For the foot operated air pump, following are the poor value functions:-

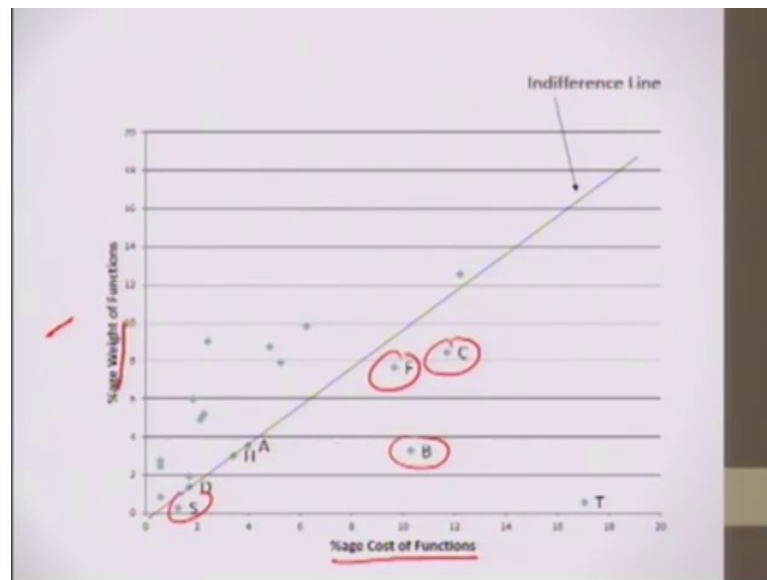
1. A-Provide Support
2. B-Provide Location
3. C-Withstand Impact
4. D-Provide Clearance
5. F-Join Parts
6. H-Provide Alignment
7. S-Provide Identification
8. T Measure Pressure

• Now the foundation had been laid for application of various techniques to generate every possible solution to the problem.

So, let us see in foot operated pump following on the poor value functions A, B, C, D, F, S, H and T. Now foundation had being laid for application of various techniques to generate every possible solution to the problem. These are the functions on which we will work on till this point we identified the poor value functions. So, the value and analysis part is over.

So, now will go to value engineering in which we will work on these functions.

(Refer Slide Time: 30:09)



This is an indifference line; indifference line indifference line is the plot between weight of the function and the cost of the function. That is the functions which fall below this line that is their cost is higher than their weight are the poor value functions.

(Refer Slide Time: 30:28)

### Creativity Phase

Creative Worksheet No.1

**Parts:** Base Plate, Piston Rod Pivot, Lever Spring Support Pin, Foot Lever Pivot, Lever Spring

**Functions:** Provide Support, Provide Location, Withstand Impact, Provide Clearance, Join

**Ideas:**

1. Use 25.4 mm square for base plate, round bar for piston rod pivot, cotter pins in the foot lever pivot, search new suppliers for lever spring.
2. Use round bar for piston rod pivot, cotter pins in the foot lever pivot and rectangular pipe 50.8 x 25.4 x 2 mm<sup>3</sup> for base plate.
3. Use Ms Angle 25.4 x 25.4 x 3.175 mm<sup>3</sup> for base plate, cotter pins in the foot lever pivot and round bar for piston rod pivot.

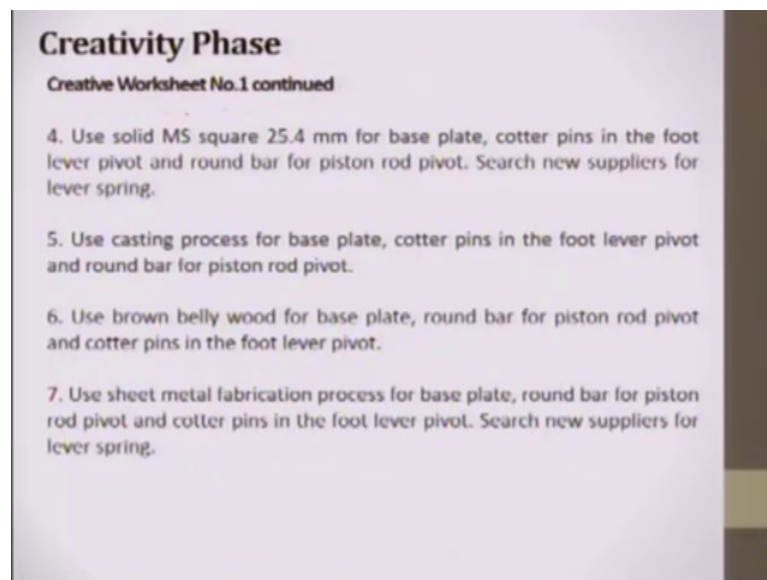
*Practically Feasible / Performance Feasible*

Now, next comes the creativity phase; in creativity phase we create creative worksheet. First, we group the functions which can be worked on; these are the parts I have selected base plate, piston rod pivot, lever spring support pin, foot lever pivot, lever spring these

are the parts and the functions provide support provide location withstand impact provide clearance and joint parts.

So, working on this group of parts and functions we will generate the idea. So, this is one idea use 25.4 millimetre square for base plate, round bar for piston rod pivot, cotter pins for foot lever, search new suppliers for lever spring. So, these are all mechanical engineers thing because now we are into manufacturing then second idea we have. And these are all ideas which are practically feasible; practically feasible or preliminary, it seems to be feasible. Some ideas might not be selected or might not be feasible in that technical or in the cost evaluation phase other.

(Refer Slide Time: 31:46)



So, this is creative worksheet one continued we have seven ideas actually; they are not only seven ideas when we work on the creativity phase, multiple ideas number of ideas comes down. So, out of those only seven ideas are listed which are practically feasible.

(Refer Slide Time: 32:05)

**Creativity Phase**  
**Creative Worksheet No.2**  
**Parts:** Foot Pedal, Foot Lever, Gauge Adapter, Cylinder Pivot  
**Functions:** Withstand Impact, Provide Location, Provide Support, Provide Alignment, Join Part  
**Ideas:**  
1. Use solid MS square 25.4 mm for foot lever and foot pedal, two pipe pieces for cylinder pivot.  
2. Use MS Angle 25.4 x 25.4 x 3.175 mm<sup>3</sup> for foot lever and foot pedal, two pipe pieces as cylinder pivot.

So, similarly creative worksheet two the; this are the parts, these are the functions they are grouped together. In the similar way in this study about 7 to 8 worksheets were made and actually 12 worksheets were made out of which it was found that 4 worksheets, 4 creative ideas or 4 groups of the parts and functions did not work and they worked on the 8 creative worksheets and changes were made.

So, I have listed only 2 worksheets here just to have the overview of how this conducted.

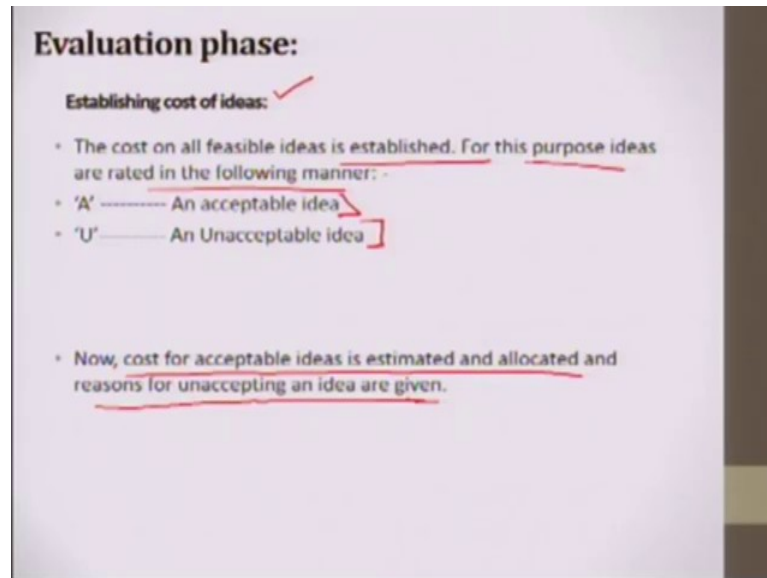
(Refer Slide Time: 32:37)

**Evaluation phase:**

- The objective of the evaluation phase of the Value engineering Job Plan is to analyze the results of the creative phase
- The skillful application is triggered at, for the prevention of unnecessary cost and development of value alternatives
- In order to guard these possibilities, this phase employs following techniques.
  1. Establish cost on all ideas
  2. Evaluate by comparison

Next, I will go to evaluation phase; the objective of the valuation phase of value engineering job plan is to analyse the result of creative phases; skilful applications is triggered at for the prevention of unnecessary cost and development of value alternative in order to guard these possibilities this phase implies following techniques, establish cost on all ideas number 1, number 2; evaluation by comparison.

(Refer Slide Time: 33:04)



How is this carried out let us see establishing cost; cost of the ideas that is cost on all feasible ideas is established for this purpose ideas are rated into the following manner. Acceptable idea and an unacceptable idea; now the cost for acceptable ideas is estimated and allocated and reasons for unaccepting an idea if we do is mentioned.

So, in evaluation phase a thorough review of various alternative to select the best idea of cost reduction is done. it is kept in mind or made sure that the product is not cheapen or degraded making sure that there is no reduction in durability or ease of operation or other aspects.

(Refer Slide Time: 33:53)

**Evaluation phase:**  
**Function Evaluation Worksheet No.1**

Parts: Base Plate, Piston Rod Pivot, Lever Spring Support Pin, Foot Lever Pivot, Lever Spring  
 Functions: Provide Support, Provide Location, Withstand Impact, Provide Clearance, Join Part

Present Design Cost—Rs12 (Base Plate) + Rs3 (Piston Rod Pivot) + Rs6 (Lever Spring Support Pin) + Rs10 (Foot Lever Pivot) + Rs10 (Lever Spring) = Rs 41

S. No.	Idea	Status of Idea 'A' or 'U'	Cost if 'A' Reason if 'U'
1	Use 25.4 mm square for base plate, round bar for piston rod pivot, cotter pins in the foot lever pivot, search new suppliers for lever spring.	'A'	Rs 60 (Base Plate) + Rs8 (Piston Rod Pivot) + Rs1 (Cotter Pins) + Rs8 (Lever Spring) = <del>Rs77</del> X
2	Use round bar for piston rod pivot, cotter pins in the foot lever pivot and rectangular pipe 50.8 x 25.4 x 2 mm <sup>2</sup> for base plate. Alternate suppliers for lever spring.	'A'	Rs (Piston Rod Pivot) + Rs1 (Cotter Pins) + Rs90 (Base Plate) + Rs8 (Lever Spring) = <del>Rs107</del> X
3	Use Ms angle 25.4 x 25.4 x 3.175 mm <sup>2</sup> for base plate, cotter pins in the foot lever pivot and round bar for piston rod pivot. Search new suppliers for lever spring.	'A'	Rs50 (Base Plate) + Rs1 (Cotter Pins) + Rs8 (Piston Rod Pivot) + Rs8 (Lever Spring) = <del>Rs67</del> ~ Rejected

Below the requirement of so, this is function evaluation worksheet 1; in this is the idea same idea which we had in the creative phase. And this is the cost of the present design, this is the idea this is status of idea is acceptable. Then we put the cost of this idea. Total cost of this idea for these components this group of components is rupees 77; the previous cost was rupees 67 because this was in creativity phase, we did not think about the cost much. So, this is greater cost idea.

Similarly, second idea is rupees 1 or 7; third idea is rupees 67 if cost is the criteria these idea would be rejected. This is equally important to the present design that is rupees 67.



(Refer Slide Time: 34:48)

**Evaluation phase:**  
Function Evaluation Worksheet No.1

S. No.	Idea	Status of Idea 'W' or 'U'	Cost if 'W' Reason if 'U'
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.	W	Rs 200 (Base Plate) + Rs 1 (Cotter Pins) + Rs 8 (Piston Rod Pivot) + Rs 8 (Lever Spring) = Rs 217
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.	W	Rs 75 (Base Plate) + Rs 1 (Cotter Pins) + Rs 8 (Piston Rod Pivot) + Rs 8 (Lever Spring) = Rs 92
6	Use brown bully wood for base plate, round bar for piston rod pivot and cotter pins in the foot lever pivot. Alternate suppliers for lever spring.	W	Rs 100 (Base Plate) + Rs 8 (Piston Rod Pivot) + Rs 1 (Cotter Pins) + Rs 8 (Lever Spring) = Rs 117
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.	W	Rs 28 (Base Plate) + Rs 8 (Piston Rod Pivot) + Rs 1 (Cotter Pins) + Rs 8 (Lever Spring) = Rs 45

Similarly, we can see the idea 4, 5, 6, 7 had this cost rupees 217, 92, 117, 45 this is the only idea here that has the cost less than that existing cost of the group here.

(Refer Slide Time: 35:06)

**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) + 10(Foot Lever) + 2(Gauge Adapter) + 5(Cylinder Pivot) = Rs 57

S. No.	Idea	Status of Idea 'W' or 'U'	Cost if 'W' Reason if 'U'
1	Use solid Ms square 25.4 mm for foot lever and foot pedal, two Ms rod pieces for cylinder pivot.	W	160(Foot Lever) + 40(Foot Pedal) + 10(Cylinder Pivot) = Rs 210
2	Use Ms angle 25.4 x 25.4 x 3.175 mm <sup>2</sup> for foot lever and foot pedal, two rod pieces as cylinder pivot.	W	40(Foot Lever) + 9(Foot Pedal) + 10(Cylinder Pivot) = Rs 59
3	Use rectangular pipe 50.8 x 25.4 x 2 mm <sup>2</sup> for foot pedal and foot lever, two Ms rod pieces for cylinder pivot.	W	75(Foot Lever) + 9(Foot Pedal) + 10(Cylinder Pivot) = Rs 94
4	Use sheet metal fabrication process for foot lever and foot pedal and threaded cylinder pivot.	W	77(Foot Lever) + 4(Foot Pedal) + 9(Cylinder Pivot) = Rs 35
5	Use casting process for foot lever and foot pedal, cylinder pivot consisting of two Ms rod pieces.	W	47(Foot Lever) + 20(Foot Pedal) + 10(Cylinder Pivot) = Rs 77
6	Use 25.4 mm Ms square for foot lever and foot pedal, cylinder pivot consisting of two rod pieces.	W	55(Foot Lever) + 12(Foot Pedal) + 10(Cylinder Pivot) = Rs 77

Similarly, this is the function evaluation worksheet 2 in which these ideas 1, 2, 3, 4, 5 and 6 are put into the status all ideas acceptable that is they are feasible practically these can be done and cost of acceptable ideas are put, it can be seen that most of the ideas most of the ideas cost is high and, this rupees 35 is less than rupees 57.

(Refer Slide Time: 35:33)

### Evaluation phase:

**Evaluation by comparison:**

- After allocating the cost to the ideas, the ideas are evaluated by comparison by using appropriate criteria of evaluation, for selecting the final acceptable ideas.

**Criteria of evaluation:**

- The evaluation criteria suitable for this study are:
  - A – Cost Savings
  - B – Durability
  - C – Ease of implementation
  - D – Ease of operation

*Rank these criterion.*

So, evaluation by a comparison after allocating the cost to the ideas; the ideas are evaluated by comparison by using appropriate criteria of evaluation for selecting the final acceptable ideas. These all ideas are compared based on certain measures, as we discussed the criteria here selected is cost saving, durability, ease of implementation and ease of operation; first what we do we rank these criteria.

(Refer Slide Time: 36:13)

### Evaluation phase:

	A	B	C	D	T. Wt	Avg. Wt.
A		A2	A3	A4	6	7
B		B2	B3	B4	3	4
C			C3	C4	0	1
D				D4	2	3

**Decision matrix:**

- The decision matrix is made to finally selecting the suitable alternative by ranking.
- Ideas are ranked by finding value scores of ideas using weights from numerical evaluation of criteria and a five point scale mentioned as under.

Excellent = 5 point  
Very Good = 4 point  
Good = 3 point  
Fair = 2 point  
Poor = 1 point

How do we do that? The same method numerical evaluation is there we see that A is important than B that is cost is important than durability with a medium difference. Then

cost is important than C that is ease of implementation then with major difference. Similarly, we find the difference in weights and we take the total  $2 + 3 + 1$  is 6 for A, for B it is  $2 + 1 + 3$  for C it is 0; C is not at all in this triangle; for D it come down to 2. So, we add 1 and we add this adjusted weight.

So, for decision matrix we choose this criteria decision matrix is made finally, to select the suitable alternative by ranking, ideas are ranked by finding value scores of ideas using weights from numerical evaluation of criteria; these weights are used and a 5 point scale mentioned as under how do we put that in our decision matrix?

(Refer Slide Time: 37:34)

• The technique used to assign points to each idea for each criterion is consulting with the experts (experienced manufacturers, customers and workers engaged in manufacturing pumps).

<u>Cost Savings</u>	<u>Points</u>
• No Savings	- 0
• Less than 5%	- 1
• Between 5% to 10%	- 2
• Between 10% to 15%	- 3
• Between 15% to 20%	- 4
• More than 20%	- 5

We also use scale for cost savings that is not saving 0 more than 20 percent saving 5 we calculate the percentage of savings if it is there.

(Refer Slide Time: 37:35)

**Decision matrix 1:**

**Evaluation phase:**

Proposed (Idea No.)	Function	Weight	A=1 (Points) Score	B=2 (Points) Score	C=3 (Points) Score	D=4 (Points) Score	Total Score
Use 25.4 mm square for base plate, round bar for piston rod pin, collar pins in the best lower plate, search new suppliers for lower spring.	Cost	7	5	3	3	3	21
Use round bar for piston rod pin, collar pins in the best lower plate and rectangular pipe 50.8 x 25.4 x 2 mm for base plate. Alternative suppliers for lower spring.	Durability	7	3	4	4	3	21
Use the angle 25.4 x 25.4 x 3.175 mm for base plate, collar pins in the best lower plate and round bar for piston rod pin. Search new suppliers for lower spring.	Implementation	7	3	4	4	3	21
Use solid file square 25.4 mm for base plate, collar pins in the best lower plate and round bar for piston rod pin. Search new suppliers for lower spring.	Operation	7	3	4	4	3	21
Use casting process for base plate, collar pins in the best lower plate and round bar for piston rod pin. Alternative suppliers for lower spring.	Cost	7	5	3	3	3	21
Use brass body second for base plate, round bar for piston rod pin and collar pins in the best lower plate. Alternative suppliers for lower spring.	Durability	7	3	4	4	3	21
Use sheet metal fabrication process for base plate, round bar for piston rod pin and collar pins in the best lower plate. Search new suppliers for lower spring.	Implementation	7	3	4	4	3	21

Handwritten notes on the table include: "25% > 20%", "7 \* 5 = 35", "3 \* 4 = 12", "4 \* 4 = 16", and "7 \* 5 = 35".

So, what happens here is in decision matrix one we have put the parts and functions in the same way, we put the 5 point scale here. Now we see that the function that is cost; function B durability function B is implementation and function D is operation these are the weights of this function and we see that there is no cost saving only one alternative was there in which cost saving was there. And the cost saving was more than 20 percent more than 20 percent; that means, this rating 5 is given.

So, this rating  $5 * \text{weight } 7$ ;  $7 * 5$  is equal to 35 similarly the points for durability are given, these are again the group of experts who give the opinion for that they say that if this idea is there durability would be rated 3, the durability would be good the implementation is also good, but the ease of operation would be fair. So, these are the numbers which are taken from this scale; all the numbers all the numbers in brackets are taken from of this scale these are the ratings which are given by experts and these are the numbers at the lower side this the number is  $3 * 4$ ;  $3 * 4$  is equal to 12. This is  $4 * 4$ ; this  $4 * 4 * 4$  equal to 16; this works similar to what we did in QFD; Quality Function Deployment.

So, in this way we have the total score for the ideas here this is the score finally, the weights are considered, the criteria are taken into consideration here. So, this is  $12 + 3 + 6$ ; 21,  $12 + 2 + 6$ ; 20; we see that the maximum score is of idea 1, 2, 3, 4, 5, 6; idea 7. So, this is the idea that is selected that can be implemented.

(Refer Slide Time: 39:55)

**Decision matrix 2:**

Parts: Foot Pedal, Foot Lever, Gauge Adapter, Cylinder Pivot  
 Functions: Withstand Impact, Provide Location, Provide Support, Provide Adjustment, Side Panel

5 Point Scale  
 Excellent = 5  
 Very Good = 4  
 Good = 3  
 Fair = 2  
 Poor = 1

**Evaluation phase:**

Proposal (Idea No.)	Weighted Criteria (with weight)	A=7 (Points) Score	B=4 (Points) Score	C=3 (Points) Score	D=2 (Points) Score	Total Score
Use solid Mx square 25.4 mm for foot lever and foot pedal, two Mx rod pieces for cylinder pivot.		00	(5)	(1)	(1)	26
Use Mx angle 25.4 x 25.4 x 3.175 mm for foot lever and foot pedal, two rod pieces as cylinder pivot.		00	(3)	(2)	(2)	18
Use rectangular pipe 30.8 x 25.4 x 2 mm for foot pedal and foot lever, two Mx rod pieces for cylinder pivot.		00	(4)	(1)	(2)	23
Use sheet metal fabrication process for foot lever and foot pedal and threaded cylinder pivot.		35	20	4	15	74*
Use casting process for foot lever and foot pedal, cylinder pivot consisting of two Mx rod pieces.		0	17	1	6	24
Use 25.4 mm Mx square for foot lever and foot pedal, cylinder pivot consisting of two rod pieces.		0	12	2	6	20

Similarly, we find the scores of various ideas for various groups for based on various worksheets from creative worksheets; we develop the functional development worksheet, then we have decision matrix.

So, in this case this is the maximum score this idea is selected.

(Refer Slide Time: 40:13)

**Implementation phase:**

- The proposals finalized after evaluation are brought forward to investigation phase for combining the changes made in some parts in the different groups of parts which has been made during creativity phase.
- It is observed that most of the final proposals involved different parts, except the foot pedal which is there in the final proposals in group 2 (decision matrix 2) and group 6 (decision matrix 6).

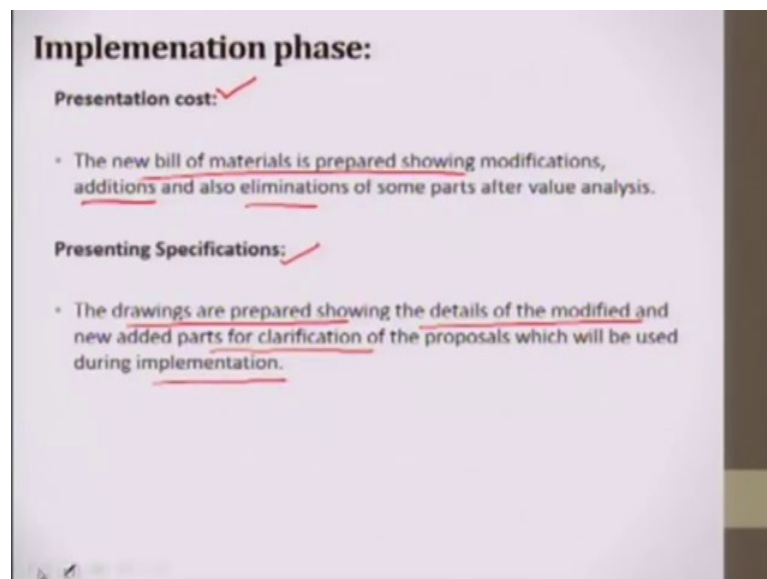
Now, comes the implementation phase; what we have done we have selected this idea use sheet metal fabrication process for foot lever and foot pedal and threaded are under pivot. We have selected this idea use sheet metal fabrication process for base plate and

so on. Now we need to see is there any idea which has contradiction with each other is; can we combine one or two ideas?

Because there are multiple worksheets; so, the combination of the ideas or if the ideas are contradicting those are taken care of. So, the proposal finalized after evaluation are brought forward to investigation phase; for combining the changes made in the same parts in different groups; please note combining the changes made in the same parts in the different groups.

For example, in base plate if the change is made in creative worksheet 1 and again in I would better say decision matrix one and in decision matrix 5; we will see is the change same or do we need to redo the things. It is observed the most of the final proposals involved different parts except for the foot pedal which is there in the final proposals decision matrix 2 and decision matrix 6; it was found that this foot pedal was there in both the matrix.

(Refer Slide Time: 41:36)



Next is presentation of cost; the new bill of material is made showing the changes modifications, additions, eliminations, presentation, specifications; new drawings are made the exploded view or the tear down way is again presented. So, this is our new cost of the parts with bill of materials.



(Refer Slide Time: 41:51)

Bill of Materials and Cost of Parts (after VA)						
Part No.	Qty.	Part Name	Material	Material Cost (Rs.)	Cost Price (Rs.)	Total Cost (Rs.)
1	2	Iron Plate Part	Mild Steel	15.2	12	24
2	2	Iron Plate Clamp	Mild Steel	2.3	2	4
3	2	Front Lever Part	Mild Steel	17	11	22
4	1	Cylinder	Mild Steel	28.2	42	42
5	1	Cylinder Cap	Mild Steel	4.75	7	7
6	1	Column Rod	St. Steel	7	12	12
7	1	Column Rod Pin (Modified)	Mild Steel	8	8	8
8	1	Column Rod Spring	Spring Steel		1	1
9	1	Bracket Washer (Eliminated)	Mild Steel			
10	1	Bracket Bracket	Mild Steel	3	4	4
11	1	Bracket Bracket (Modified)	Mild Steel	3	3	3
12	1	Bracket Pin	St. Steel	3	5	5
13	1	Fast Pin (Modified)	Mild Steel	3	4	4
14	1	Cylinder Head Nut (Eliminated)	Mild Steel	1.5	3.5	3.5
15	1	Cylinder Pin (Modified)	St. Steel (Pin)	2	0	0
16	1	Flange Lever Pin (Modified)	Mild Steel	3	4	4
17	1	Locking Stud	Mild Steel	1	1	1
18	1	Lever Spring Support Pin	Mild Steel	1	0	0
19	1	Lever Spring	Spring Steel	8	8	8
20	1	Pressure Gauge	Grip		44	44
21	1	Pressure Connection	Grip		18	18
22	2	Iron Plate (1/2 inch Thick) (Eliminated)	Mild Steel		0	0
23	1	Iron Plate (1/2 inch Thick)	Mild Steel		1	1
24	2	Iron Plate (1/2 inch Thick)	Mild Steel		1	1
25	2	Iron Plate (1/2 inch Thick) (Eliminated)	Mild Steel		0	0
26	1	Iron Plate (1/2 inch Thick) (Eliminated)	Mild Steel		0.5	0.5
27	1	Clampnut Bracket (Eliminated)	Grip		0	0
28	1	Cylinder Cap Stud (New Part)	Mild Steel	2	2	2
29	1	Clamp Adapter	Mild Steel	2	2	2
30	2	Column Pin (New Added)	Mild Steel		0.2	0.2
<b>Total Cost</b>						<b>252</b>

So, this total cost here is rupees 252; earlier the cost was more than rupees 300. So, in this case the certain modifications are made; these parts are eliminated parts and some parts are newly added new added parts are there and some parts are just modified.

(Refer Slide Time: 42:35)

**Implementation phase:**

**Cost Savings**

- Cost savings after VA = Cost before VA – Cost after VA  
 $= \text{Rs } 351 - \text{Rs } 252$   
 $= \text{Rs } 99 \text{ per pump}$
- Percentage savings =  $(\text{Rs } 99 / \text{Rs } 351) * 100$   
 $= 28.2\% \text{ per pump}$  *~ 30% of Savings*
- The company on an average has of sale of 200 pumps per month (2400 pumps per annum) which implies  
 Average annual savings =  $\text{Rs } 99 * 2400$   
 $= \text{Rs } 2, 37, 600$

*Handwritten notes at the bottom:*  
 $\text{Cost} = \frac{X}{C} \approx \frac{X}{(1-C)}$   
 $\frac{X}{(1-C)}$

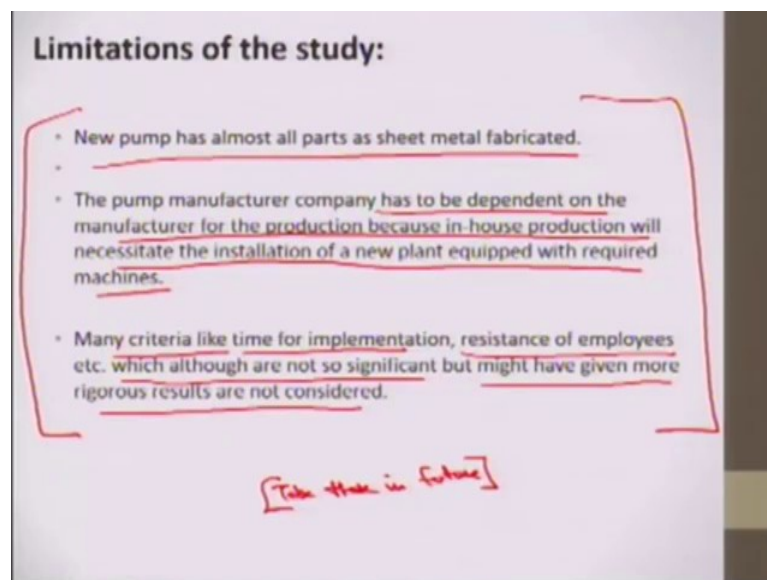
So, we present this to the decision maker and tell them that the cost savings is this much; the cost before value engineering is rupees 351 after value engineering is the this is the same rupees 99 per pump. And the company on which we worked manufactured 200



pumps per month that is it was total 2400 pumps per annum; total saving was this much it is rupees  $99 * 2400$ .

So, this is the potential of value engineering 28.2 percent about 30 percent of savings. So, we had this value is equal to  $x / \text{cost}$  new value is  $x / 0.7$  of the cost; 30 percent of the cost reduced; this 0.7 is actually this comes from  $x / 100 - 30 / 100$  into new cost.

(Refer Slide Time: 43:41)



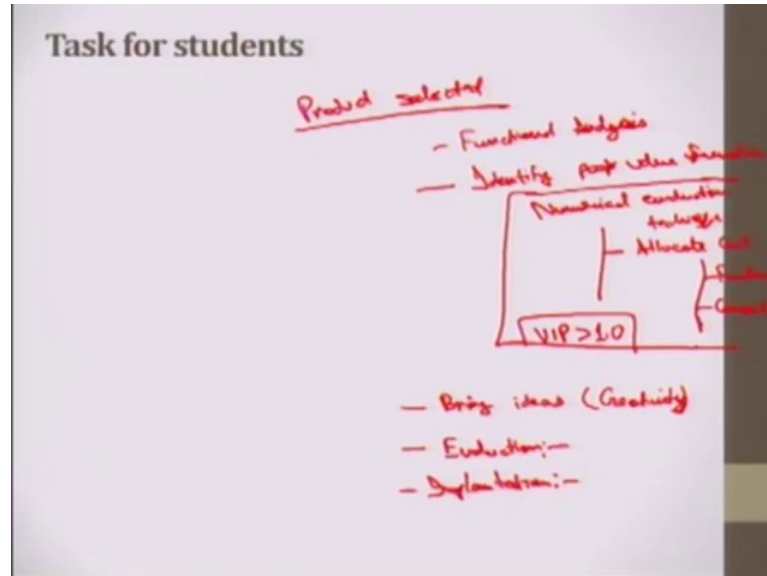
So, this is how do how we implement value engineering; also when we implement value engineering we would always find some limitations in our study.

Some drawbacks or something which we were not able to do or some things which we have observed, but we will do that in future so, those are always to be listed in this case new pump has almost all parts of sheet metal fabricated. So, the pump manufacturer company has to be dependent on the manufacturer for the production. Because in house production will necessitate the installation of new plant equipment with the machines this was for the specific case study.

Many criteria like time for implementation resistance of implementation employees to change which although are not so, significant, but might also have given more rigorous result are not considered. We will list the limitations and take them in future and the ideas which are not accepted in value engineering in the evaluation phase the creative ideas, those are also note just thrown away they are kept in record. In future also if we

conduct value engineering on the same kind of product or even if on the same product those help; so, this was all about value engineering.

(Refer Slide Time: 45:02)



So, I have a task for you people; the product you selected you did function analysis, now you need to identify poor value functions here; using this numerical evaluation. So, that you need to allocate cost, cost for function. cost for each component and that is for the component cost would be divided. You need to compare the functions according to their importance this whole exercise is to be carried out; identify the poor value functions then bring ideas that is creativity I think this you already did.

But now you will work on the poor value function that is use VIP; Value Improvement Potential is more than 1 you work on these functions. Then try to conduct the evaluation and implementation phase as well. So, you will have to apply lot of judgement here; a team is desirable thing here if possible this was all about value engineering.

Next, I will discuss, rapid proto typing in this course in which we will see what are the what is rapid prototyping; how rapid prototyping is related to additive manufacturing, rapid prototyping techniques; we will see the application. Then we will see what is plant layout; we will see various kinds of layout and I will take to smart systems and operations lab in IIT, Kanpur where we will see the plant simulation software, we will see how the plant layout factory design is being carried out and let us meet next in rapid prototype module.

Thank you.