Advanced Green Manufacturing Systems
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Lecture - 14
Value Engineering Green Plan: paired comparison technique

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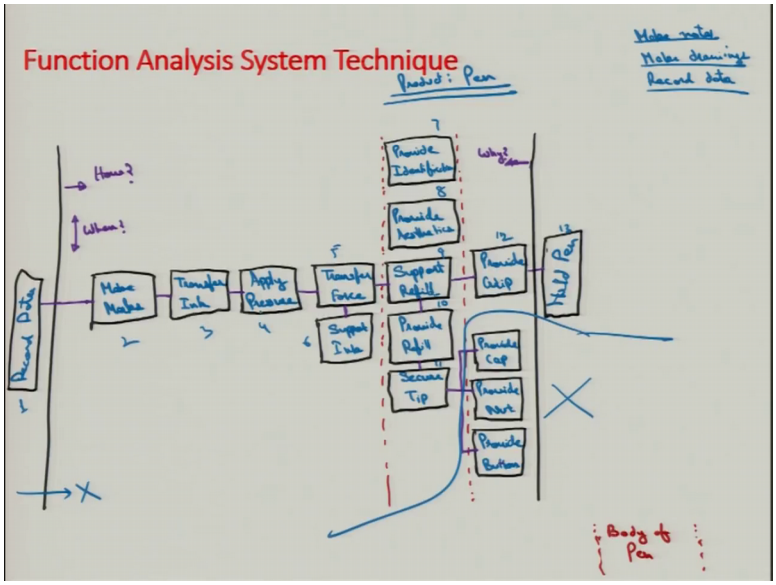

Good morning. Welcome back to the course on Advanced Green Manufacturing Systems. And we are discussing value engineering green plan in this week. So, we developed fast diagram on a pen that we selected, we did it simple pen, and also we did it for multi-objective or multi-purpose pen, but this is a simple fast diagram that we developed as the starting point.

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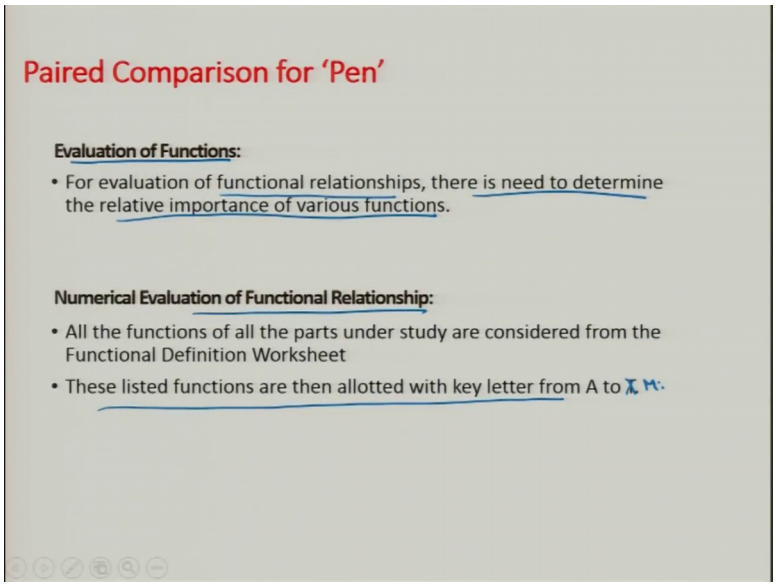

So, now I will try to develop the paired comparison in this lecture. So, just to recall, so paired comparison is for evaluation of the functions, for evaluation of the functional relationships, there is need to determine the relative importance of various functions for which paired comparison analysis can be used. So, paired comparison analysis is an activity for evaluating a small range of options, by comparing then against each other as we have discussed. So, this we have discussed this in the previous lecture.

So, I am just recalling that in many situations, there is a need to determine which alternative is most appropriate many time peoples, get stuck by the idea or they cannot make a decision, and then they end up in making no decision at all. So, what we can do here, we can use the paired comparison method to evaluate the relative importance of the functions that I will do for the functions that we did for the pen.

So, numerical evaluation of functional relationship can be developed. All the functions of all the parts under study are considered from functional definition worksheet. These listed functions are then allotted with a key letter from A to we will this T is I have picked it from the case study, keep with this functions (Refer Time: 02:10) function 1, 2, 3, 4, 5, 6. I am not picking these one, these are not picking 5, 6, 7, 8, 9, 10, 11, 12 and 13; 13 means, I will have J, K, L, M letter from A to M, I will allotted the numbers to the functions.

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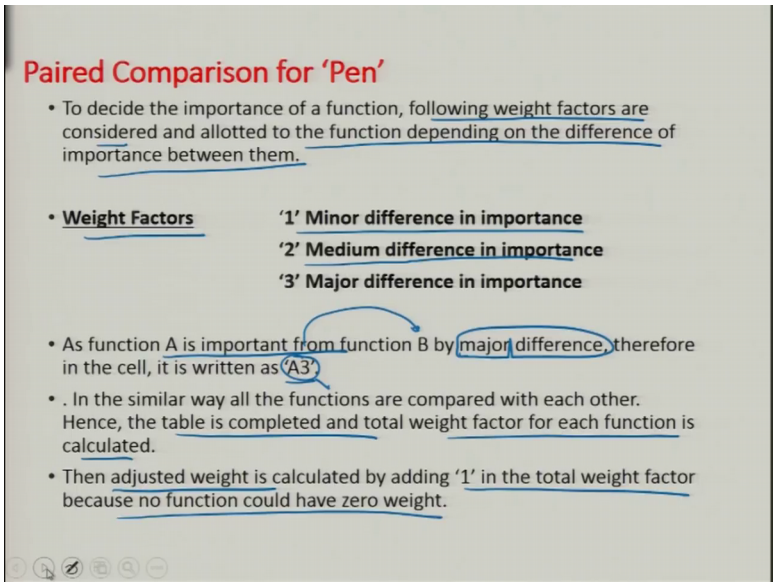

So, then we have start about paired comparison for that we will use this scale weighted factor scale, to decide the importance of a function, following weights are considered and allotted to the function depending upon the difference of importance between them. So, the weight factors are considered as one is for minor difference in the importance, two is for medium difference in importance, three is for major difference in importance.

So, let is certain example again as a function A is more important from function B major difference, therefore in the cell, so let written as A 3 that means, A is important than function B by a major difference ok, 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 we get the adjusted weight factor. It is calculated by adding 1 in the total weight factor, because no function could have zero weight.

Let us try to start making the weight of this functions, these are functions that record data make marks. I have would not put the function in this order, I will just pick the functions in randomly, and put terminal list. Hence turns this function is transfer ink, I can put transfer ink than make marks and something let me keep writing the functions.

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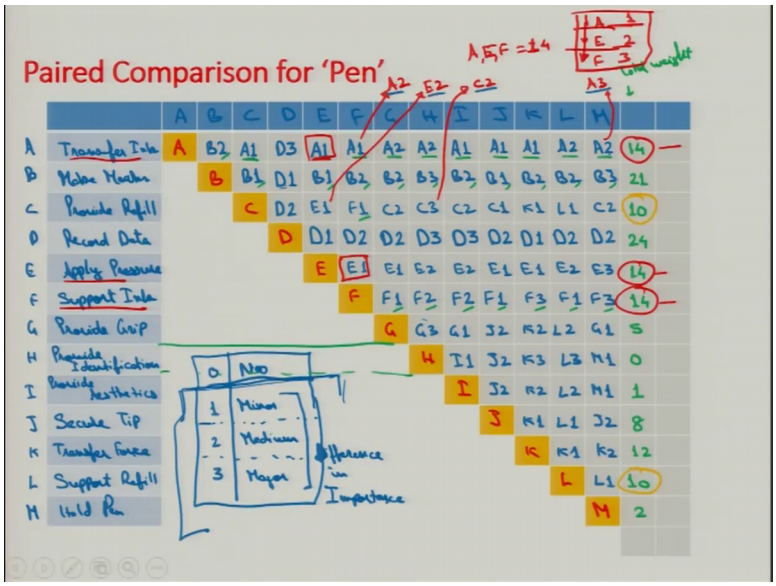

And so the first function, I can put here is transfer ink ok. Second function, I can put randomly I will pick the function, because I know I would like to have the rank, I would not put in this order, because this is generally as I said in fast diagram the highest order function should be the top rank functions. And the lower order function should be the low rank functions in generally. Yes in the beginning in the highest order functions, they would not have big difference. But, in the lower order functions, the difference would or might come, when we do numerical evaluation of paired comparison.

So, I am just putting the functions, they random way here. So, transfer ink, let next I can put some functions, so I am here make marks, then apply pressure may be make marks. Next function I can put here is provide refill ok, then maybe record data. Also I need to put numbers here, as well number was letters to donates some name or some coach to the function A, B, C, D, E, F, G, H, I, J, K, L, M. So, I have made this specifically 13 functions with come here.

Similarly, I will put the letters here A, B, C, D, E, F, G, H, I, J, K, L, M, then function E, I can pick here from many function, it not put before maybe apply pressure, then I can put support ink. Then one of the function is was provide grip, I will put provide grip here. Then provide identification, I will see into provide identification, there was provide aesthetics than the function network secure tip provide grip provide grip hold pen, secure tip transfer force support refill hold pen. So, I suppose all the function this is.

What essentially I am doing, I am putting a functions in a random order. So, not in the order or from the highest to the lowest level that the fast diagram has predicted, because we need to find out, what we have identified in the fast diagram the order that we have identified here is that also justified by the numerical comparison or not ok. So, let us see, so these are the functions.

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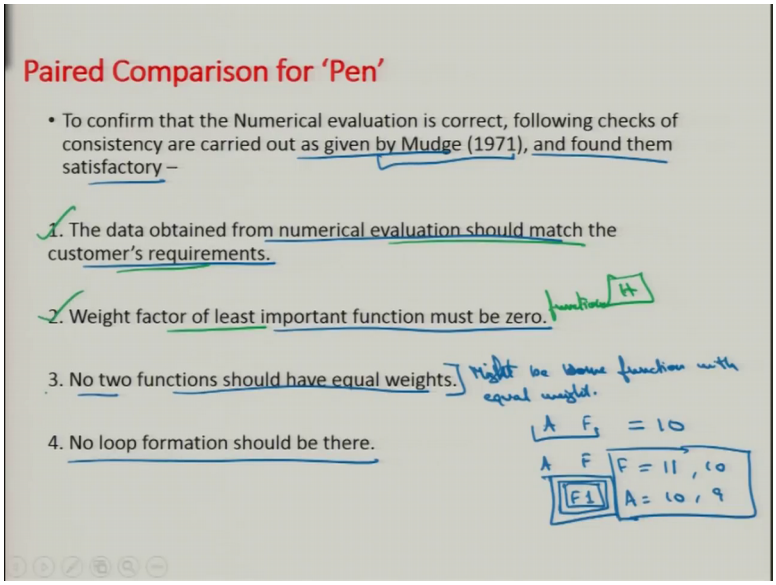

So, now I can have paired comparison between them, there are certain rules for this. To confirm that numerical evaluation is kept following checks of consistency are to be carried out as given by Mudge, and found them you have to find them you have to find that whether these are satisfactory or not.

The data obtained for numerical evaluation should match the customer's requirements. So, we need to think from the customers view point, but I as a manufacturer because I know what are the work function, what are the cell function the cell, I would have a mixed of customers and manufacturers viewpoint, while designing my paired comparison chart here.

But, yes for customer comparison what I can do, I can use this chart or put the same order, I can just print out this chart and give it to one of my students or maybe one of few colleagues with me ok. I what I will do, I will get the chart field, and get you the copy of that chart also, we will see what exactly the customer is feeling about, what different customers feel about the different functions of the pen.

First I have to make them understand, what is the function, what is transfer ink, what is apply pressure, what do I mean with this, I have to sit with them, they will field that they will do that. So, first let us fill in our (Refer Time: 09:15). So, weight factor of least important functions must be zero, least important function is one of the functions would be least important.

No two functions should have equal weight, there might be some function, this is what suggested by Mudge suggested by Mudge in 1971, but there might be some functions with equal weight ok. Then how to cater this problem? We need to then identify the relative rank between these two functions. So, instance if the function A and F are having weight is equal to 10. Suppose, if their having weight 10, then we need to see which one is important is A important or is F important.

So, we can change this weight of F to maybe 11, if suppose F is important in the box with A and F, should intersect. For instance, if it is written F 1 that is F is important than A, then F should might be having might should have value 11 for F should be 11. And for a it could be 10 or this could be 10 and 9, and so on accordingly we can change some of the importance factors or we can just put the ranks accordingly, because we know that F is important than A, this matrix this box determines that this box determines that, so we will see that.

No loop formation should be there loop formation, I will tell you, when I will make the chart. So, now this is A, B, C, D, E, F, G, H, I, J, K, L, M in the point where B is there, here we have B value for B would come either in this column or in this row ok. Value of E would come either in this column, corresponding to E or in this row ok.

Now, this element, this element I am going to put the value, what is the difference of importance between A and B in which one is higher. So, I will put value 1, 2, 3; 1 for minor, 2 for medium, and 3 for major. This is difference in importance ok A and B what do you believe, which function is more important transfer ink or make marks.

According to the customer I do not think so, he is concerned of transferring ink over making marks, he is more concerned about making marks on a paper ok. So, make marks would definitely be important than transfer ink according to the customer, but according to manufacture transfer ink is also some important.

So, I am considering you know, this chart is actually made by a team as I told you before, a team in which customers are there, production manager is there, marketing people are there people purchase department is there, who could tell what is what is available. And people from different teams sit, and the value engineering team that they sit, and make this paired comparison chart for value engineering function analysis.

So, I can put here value make marks is more important than transfer ink with a medium difference B 2. Similarly, transfer ink and provide refill this column provide, in this case I believe transfer ink is more important than provide refill with a minor difference. Now, comes transfer ink and record data, record data we know that this is the highest order function in the fast diagram, but customer does not know this. But, customer my consider is what customer would be told, when I will give the charts record data is the final goal that we need to achieve that is the function for which the customer is going to pay for which the customer is going to spend his money to purchase the pen.

So, record data is of most important function here. So, it is obviously an important function. So, wherever record data would come, it would be or more importance, I can put it here D ok. Record data would be of more importance, then any of the functions. So, it is more important than transfer ink, record data, I can put is a major difference.

And again working on the first row transfer ink, and apply pressure. Here I can put according to customer, it could be similar but transfer ink is more important than apply pressure, because apply pressure is something difference C my condition, and I could transferring ink from the pen to paper in important apply pressure is also and function, but transfer ink is preferred over there ok.

So, as I told you before, there is no correct fast diagram, there is a method to build a fast diagram. Similarly, there is no 100 percent correct paired comparison, but what we do? When the team sits together, they can have a discussion then they can come on a consensus ok, this could be the difference in importance, this function is important this can we one way.

Second way is we can develop certain charts of similar way in the on the similar product with this function with the same functions. And get the average value of them ok, this thing these things I have told you. Then is transfer ink, and function F is support ink in this case transfer ink, I am again putting more important with a minor difference. Then

for transfer ink and G, function G is provide grip, and transfer ink transfer ink is more important. So, it will take you while for building this diagram, because you have to think of, you have to you have to actually compare the two functions, then you have to think of what is that difference of importance.

So, let me try to make one or two rows, then I will make the whole diagram whole chart by myself, and then I will bring it in front of you. So, A and H, H is provide identification, obviously H is not important, A is more important in the medium difference I am putting. So, then A and I, I is provide aesthetics is it is more important. Transfer ink is more important, then provide aesthetics with this difference of importance A1 ok, A and J secure tip is more important than secure tip by again minor difference.

Then A and transfer force K is transfer force, so again is more important than transfer force again by they minor difference. Then A and L, A is more important than L with a medium difference. A is more important than M, I am considering were I believe this is by a medium difference, this is one way. Either we can work for single function A or as we know that the highest order function is D, because start from that as well.

So, D is the highest order function that is work for this. D function D with B function D with B in this box. D is more important than make marks. Make marks and record data, make marks would lead to recording of the data. So, there is a minor difference, then D with provide refill. I can put here this is a medium difference, then D with apply pressure. So, I recant this is minor difference here.

So, D with F, F is support ink support ink and record data. Record data is more important than support ink with a medium difference. Then D with G again I will put a medium difference D with H, H is the low order function provided identification is not at all the desire of the customer is more concerned about recording the data. So, I will put a major difference. So, similarly provided identification, this can also be a major difference. So, D and J, J is secure tip, you can put medium difference. Then D and K for D and K, I can get minor difference. For D and L, L is support refill, I can put here medium difference, D and M I can put again medium difference.

So, let me fill the complete chart and get back to you. So, not to forget or either we can put zero here as no difference in important as well, but I do not recommend using this

one. Because, when you think of the ideas when you have to compare the two functions, if there is something no difference some at there is some point you have to be neutral.

So, this is generally sometime happens that the neutral part is when will people something provide aesthetics for identifications do not have any difference, they can you will I just this is just my experience that people have been using this value 0 for maximum number of the boxes. So, it is better to pick these one to three values ok.

No difference can also be there, but I am using the only the these three values, because no difference value is sometime people do prefer to use no difference for many of the box is because they say we do not have any decision on this, we cannot make the decision, let us put no difference. No decision means, no difference which is not a great idea. Sometimes, there is a difference of minor important. So, I will just use three hours, and I will just complete this chart, and I will get back to you.

So, this is the chart that I have obtained, I have put the differences of importance which I considered should be right your opinion or your depending upon your experience or a manufacturers experience or different customers these values might be different, but the difference would not be that high, because the functions or work and cell functions.

To work functions customer might not understand, but the major functions the performance functions or you can you can say the operational functions here he might understand, they can come up with some idea. For instance provide grip, provide grip is something this is function G, I have consider provide grip as an important function then H, I considered provide grip as an important function than H.

H is provided identification with a major difference, but in these in the column corresponding to this G in this column provide grip is not an important function, I did not considered it as a important function from the manufacturers view point, when I am thinking of manufacturing this. But, customers when they feel, then they feel this chart, they might consider that provide grip is an important function. So, there might be some difference in the importance here, so that might affect my ranking.

Now, how to produce ranking from this? I will just calculate the sum of the differences of importance for A. A would be only in this row ok, total sum would be A 1 plus 1, this is for A1 plus 1, 2, 3, 4, 5, 6, 7, 8, 10, 11,12, 13, 14, this is value for A, there is 14.

Similar, for B for B it is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 ok, this value is 21.

Similarly, I can put the values for C, C there is no C here 2, 3, 2, 1, 2 for C it is 10. For D, it has to be maximum, it is 3, 1, 2, 1, 2, 2, 2, 3, 2, 3, 2, 2 for D, it is 24. For E there is a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14. For F, it is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15; F is 14 ok. Let me put the values again quickly, G is it is 5. For H is provided identification, we do not have H.

So, while putting the differences of importance, I have found that this function provided identification is not important than any of the function, so that is why it has got this value 0. So, this also justifies our review, we said one function for the least important functions must be 0 that is function H here ok. So, for G for H, it is 0. For I, I is provide aesthetics as a manufacture, I did not considered aesthetic as a very important factor a very important function. So, this caught the value total weight as 1. So, this J this J 2 total weights for J is 8, total weight for K is 12. And for L, it is 10. For M, it is M is only here 2. This is the total weight total weight.

Now, let us see whether the rules step we saw or being followed or not. So, data should be in numerical, we should match the customer requirement ok, I consider the customers and as well as manufacturers requirements. Weight factors, so one for this must be zero, this is this is net this is net. No two functions we have equaling weights, let us see this one. No two functions we have equal weights 14; 14 is repeating here ok, yes we have this repetitions 14 is repeating here, here and here ok. Similarly, 10 is repeating C and L. Similarly, function this is repeating 10 and 10.

So, let us try to see whether we can change some values, one way to do the with this is we consider the differences have important for A, E and F ok, these are all the functions are equal dash. So, let me try to change some values. So, value for it is a A value, A and E are coming say which one so it what we have need to see A, E and F are equal A, E and F ok. Values for these is coming as 14 the equal weight, which one is important. A is important than E that can be identified from here ok. Then A is important than E, E and F E and F. E is important than F. A is important than F, obviously it has to be there. And E is important than F.

So, the order should be A should be at high level. After that comes E, after that comes F ok. I repeat try to understand this thing. We have got the equal values for A, E and F which are the functions transfer ink, apply pressure and support ink. From the individual elements, I found that A is important than E and L is also important than F. So, A got the rank 1 out of them ok.

Then I found that E is important than F, the E got the rank two underscore the rank, F got the rank 3. Accordingly, I can change or might change my value let me try to change this value, let me try to change this two value A 2, let me try to change in this two A2 between A and F, because A is important than E, but E is important than F. So, A is a little more important than F that E. So, I am changing this value to A2.

So, similarly for E and F, I can changes this value. So, let me try to change some other values so, as to get the chart at the similar level, then is the similarity between C and L with C is function provide refill. And l is support refill these are very similar functions, they have getting the same weight factor.

So, C and F comparison between C and F, F is more important than C. So, let me try to change some value, so that everything is fixed. So, if what if I change this value of E here E to E 2 is important than provide refill. And if I change some value, let me say C and C and L I have sticking. So, C and H this would not make much difference C and F, I can put this value as C 2. So, let me come up with the new chart, while changing this value. So, now I had needs these changes change in the boxes that I have put the box over here A2, E2, C2, and A3. So, these values are changed A2, E2, C2, and A3. Now, this gives me the weights which are not similar.

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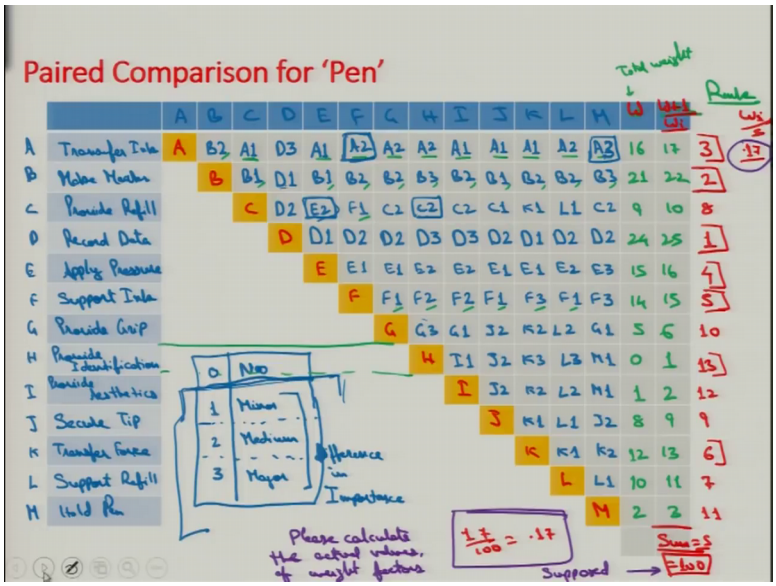

So, now let me have the new ranks. So, I have calculated the weights after this changes, so these weights comes out to be this is 16, 21, 9, 24, 15, 14, 5, 0, 1, 8, 12, 10 and 2 ok. As you said, let me say this is value some value weight ok. This is weight plus 1, while adding one is always come out to be 17, 22, 10, 25, 16, 15, 6, 1, 2, 9, 13, 11 and 3.

So, this gives me the rank, the highest value highest rank should be with the function with maximum weight. So, this gets the rank-1, I can put rank, so this gets rank-1. And second rank is for 22 or rank should be your 17, rank-3; 4, 5. Then this is rank-6 for transfer force after 13, we have 11 as rank 7 11 is support refill. Then 8 is this one provide refill and 9; 10, 11, 12 and 13.

In this way, we have got ranks for the functions. So, the top rank is for function record data, you can see also in the fast diagram record data is the highest order function. In this we have this provide grip as a maybe not 12th rank, but at this or I can say ok. So, it is at the lower level, but let us see what is provide grip here what is provide grip here for provide grip is rank-10.

So, this is the difference in ranks between the lowers lower order functions, but rank-1 has it is value, rank-2 has it is value, according to the fast diagram ok. This is 1, 2, 3, 4 is apply pressure. Let me say what is 4 is what is 4 here 1, 2, 3 is ok, 4 is apply yeah 4 is also apply pressure. Then 5 transfer 4 is support ink similar transfer force. Support ink is

5 very good, transfer force is 6 very good. These are force one, because we know I am making the chart, I have also made the fast diagram. So, I had one mind set.

So, by considering the customers view point, there I will say come in a similar, but in the later rank as said the ranks are not similar. This is rank-13 13 is for provided identification, which is which came here provide identification, it is not rank actually. It is just I have number the function, it has come as a support function for support refill. So, we get the body as I said this is the body of the pen, these two dotted vertical lines in maroon colour, I representing the body of the pen in a provided identification came here, so but in my ranking it has the last rank-13.

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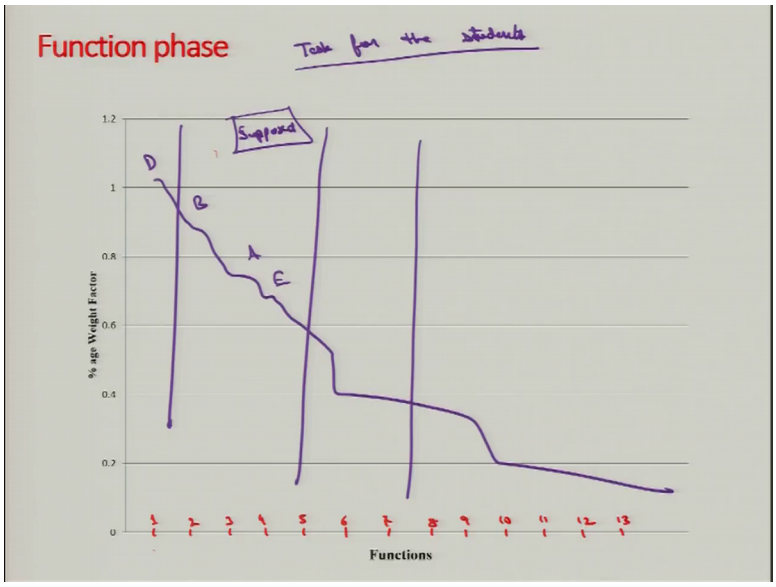

Also we can draw the scree plot for this, scree plot I am not making the scree plot, I will just tell you. What will do, we know the ranks of the functions you please make this scree plot may provide this to you in the notes, you just try to make this. Then in the next week, we will try to give it to you this is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13 ok.

So, what you need to do here is this is just task for you people now, you have got the rank. You will get the total sum values of this of this weights sum values of this weights 17 plus 22 plus 10 plus 25, you will get a total sum this is sum ok. Let me try this sum is S, I am just talking about the column W plus 1 ok. This is column W, column W plus 1, we will take the total sum that is sum S.

Now, these values let me say these S, I values are there, but S I have put this value has W i's. You will get the weight factor W i by S W i by S that means, suppose the sum is 100, it is not 100 let me say it is 100, you will calculated by yourself. So, we will get the values 17 by 100 is equal to 0.17 that value might come here, 0.17. This is we supposed please calculate the actual values of weight factors.

So, this I am leaving as a task for you people. So, we have met these requirement, no two functions you have equal weights, no loop formation should be there. No loop formation is these like instance D 1, D 2, we should not have the equal loop formation like 2, 2, 2 this loop formation is not allowed.

So, this is task for the students ok, you will get its scree plot something like the function highest order function is D, B, A and E, it would be something like this. D, B, then A, then E something like this some this kind of plot, you would have, you have to identify the primary function, the first order secondary function, and the third order secondary functions. This is again we have supposed D, B, A would be there, please try to find the difference of the elbow formation.

So, this is the case study that we developed in this course only. We try to what identify the functions for the pen, we try to make a fast diagram for that, then we try to do numerical evaluation. And found on that numerical evaluation, and the fast diagram showed the similar patterns or the similar results were observed in the rankings of the functions, but no those were not exactly same. So, try to plot the scree plot, then I will come up with in the next week I will might talk about quality function deployment, and creativity techniques. So, we will continue of green manufacturing systems. You are welcome to ask any questions in the forum, and I will try my best to cater your queries.

Thank you.