Process Integration
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Module - 5
Pinch Design Method for HEN synthesis
Lecture - 3
Application of PDM for MER HEN synthesis

Welcome to the lecture series on process integration. This is module 5 lecture 3. The topic of today's lecture is application of PDM for MER HEN synthesis meaning that will apply the pinch design method or pinch design rule, which we have in the last lecturers to design a maximum energy recovery heat exchange. To apply the PDM for the MER HEN design, I have selected a stream table given here.

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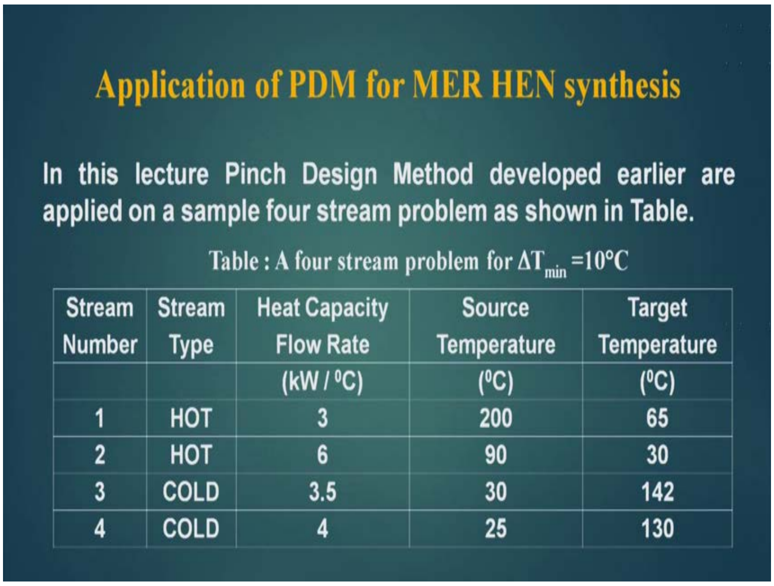

Stream Number	Stream Type	Heat Capacity Flow Rate (kW / °C)	Source Temperature (°C)	Target Temperature (°C)
1	HOT	3	200	65
2	HOT	6	90	30
3	COLD	3.5	30	142
4	COLD	4	25	130

There are 2 hot streams and 2 cold streams for which the heat capacity flow rate, source temperature and target temperatures are given. The hen is has to be designed for delta T minimum equal to 10 degree centigrade.

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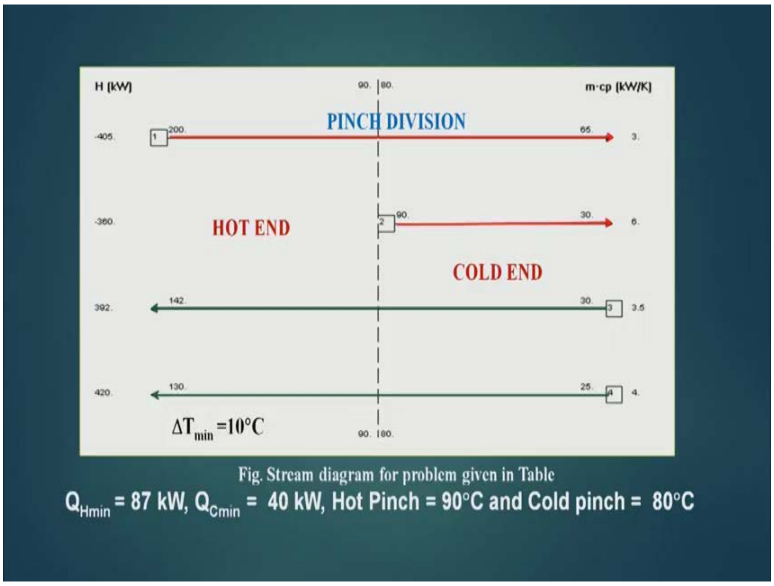

Now, this is the stream diagram or the grid diagram for the problem. The pinch temperature is hot pinch temperature is 90 degree centigrade and the cold pinch temperature is 80 degree centigrade. Q H minimum is 87 kilo watt. Q C minimum is 40 kilo watt. This has been observed. This result has been observed from PTA. That means we have already done the utility targeting and from the utility targeting, this result has come that is Q H minimum is 87 kilo watt. Q C minimum is 40 kilo watt.

Now, if I am going for a MER design maximum energy recovery design, then my developed HEN will show a heater having 87 kilo watt and a cooler having 40 kilo watt. The design will confirm these targeting results here will see that a number of alternative designs can be developed using pinch design rules or pinch design method. In this problem, I have developed 2 hot end designs. In fact, 3 hot end designs and 3 cold end designs as hot end and cold end are thermally disconnected. The hot end is separately thermally balanced and the cold end is separately thermally balanced. So, the designs, which we have developed for hot end and the designs which we have developed of cold end can make different combinations. We can have many designs of the HEN. This will see. To start with, in the upper part, we see the design one.

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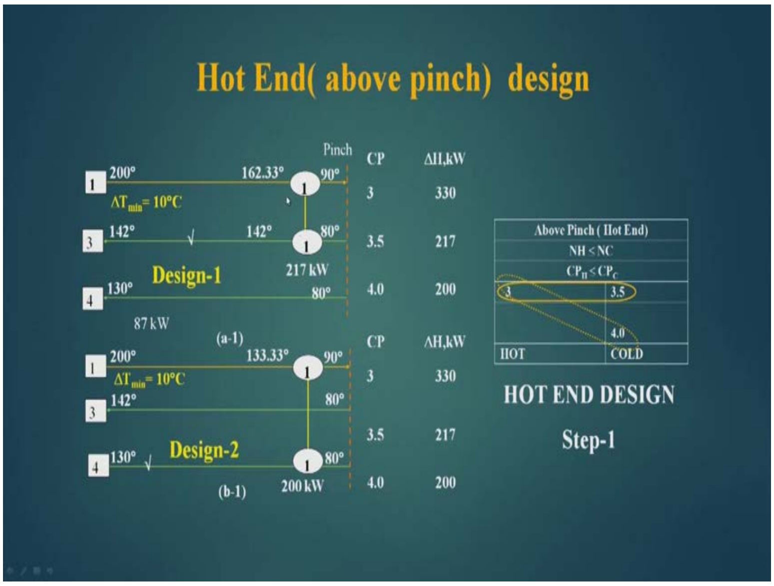

The design one is shown here and the lower part of the design two is shown here. Both are for the hot end of the problem given in the stream table. This is the CP table, which we have already talked during the pinch design rule. Now, if we see the CP table, it right here above pinch hot end design that means, this CP table is for hot end and above pinch area design the rules, which we have to follow are 2 rules. NH should be less or equal to NC. That means number of hot streams should be less or equal to the number of cold stream. This is the first rule.

The second rule is CP H that is CP of the hot stream should be less than or equal to CP of the cold stream, when we are putting off a match. Here, it shows that only 1 hot stream is present. It’s CP 3 and 2 cold streams are present to CP 3 point 5 and 4. So, there are 2 cold stream is here CP are 3.5 and 4 and 1 hot stream. The CP is 3. Same is repeated here, 4, 3.5 and 3.

Now, let us take a first rule, which says NH should be less than or equal to the NC. Here, there are 2 cold streams and 1 hot stream. So, this condition NH should be less than or equal to CP is satisfied for this hot end. So, I do not want to bother for this now. Now, the second rule, which is CP H is less than or equal to CP C is to be followed whenever we put a match.

Now, I can put a match from 3.5 to 3 or 4.0 to 3 that is these 2 matches are permissible. So, in the design one, let us take this match 3 and 3.5 because 3.5 years C P C and this is more than C P H, which is 3. So, this is permissible. Similarly, this match and this match is permissible. So, here let us put a match here 3 to 3. The question is what should be size of the match. Now, here we see that this stream, stream number 1, which starts from 200 degree C and comes to the pinch and at the pinch, it has 90 degree C, this is the pinch line.

Similarly, the hot stream 3 at 140 degree centigrade when comes to the pinch cold stream, it starts from the pinch at 80 degree centigrade and reaches to 142 degree centigrade. This is a cold stream and the difference here. The temperature difference is 90, 80, meaning 10 degree centigrade. There is another cold stream, which start at 80 degree centigrade from the pinch goes up to 130 degree centigrade.

Now, if you see the delta H of the streams, this is 330. This hot stream, this is 217, this cold stream and 200 this cold stream. Now, this is in a position to give heat to both of this 2. Now, as we are matching 3 and 3.5 for design one, so let us put match between the hot stream 1 and a cold stream 3 as it can give 217 kilo watt of it directly.

So, I put the match between this, this is heat exchanger number 1 and will keep the capacity of the heat exchanger as 217 kilo watt based on that means maximum heat transfer at 1 go has to be done. So, this is possible. So, we have put a match of 217 kilo watt because this cold stream can take 217 kilo watt. So, why not to give heat from this 330 kilo watt, hot stream directly to cold stream having a capacity of 217 kilo watt?

So, once we transferred this, the stream is ticked off. The stream is ticked off and due to this match; the exit temperature of this heat exchanger 1 is 162.33 degree centigrade. This temperature is 142, 142 degree centigrade. This is basically in let temperature 162.33 degree centigrade, outlet is 90. Here the inlet is 80 and the outlet is 142 degree centigrade. Similarly, it is the designed to behave gone for this matching 3 to 4 matching, which is perfectly alright based on this C P rule.

So, here we have put a match and we call the heat exchanger number 1. Now, what should be the capacity? The heat exchanger here, this has got a capacity to give 330 kilo watt of energy. It demands 2100 kilo watt of energy. So, it is within the reach of the hot stream to completely satisfy this cold stream. So, we have passed 200 kilo watt of heat through this link. This is heat exchanger number 1 based on the ticked up criteria. So, once we pass this heat, the stream which is a cold stream is ticked up that means this much of heat will be capable to raise its temperature from 80 degree centigrade to 130 degree centigrade. This can be seen here very easily 200 divided by 4.0, 200 divided by 4.0 comes after the 50 that means delta T will be 50. So, 50 plus 80, it gives 130 degree centigrade. So, that means this 200 kilo watt of energy enough to raise its temperature from 80 degree centigrade to 330 degree centigrade. So, this is step one. So, we are able to put 1 heat exchanger and we are developing 2 designs, simultaneously here for the hot end.

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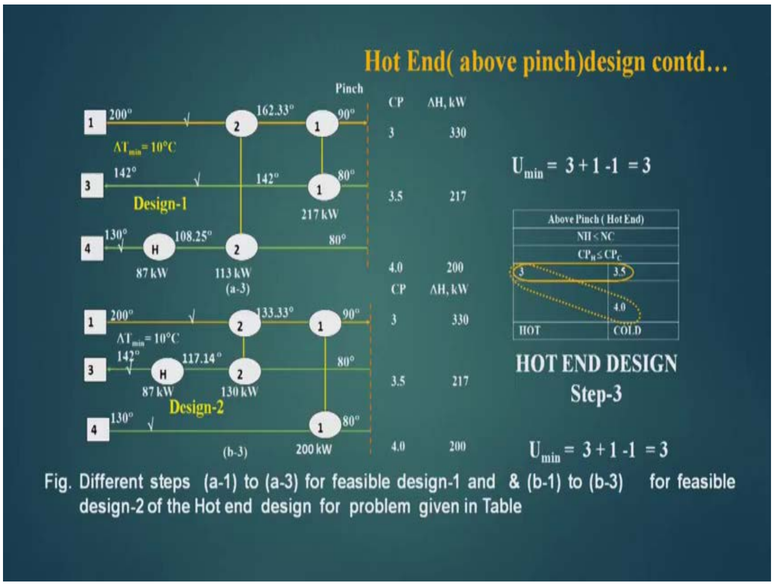

Fig. Different steps (a-1) to (a-3) for feasible design-1 and & (b-1) to (b-3) for feasible design-2 of the Hot end design for problem given in Table

Now, let us see the second step. Now, it is step 2. Here, we have already put 1 on heat exchanger. Now, we will put second heat exchanger. Now, second heat exchanger can be put from hot stream to the fourth number cold stream and the hot stream to the third number hot stream to the third number cold stream. This is perfectly permissible because C P H should be less than or equal to C P C.

So, here I use this connection that is 3 to 4.0, this pairing. For this, I am going for this pairing and the steps 2. Now, once this step is, this is put, this is 113 kilo watt. This is 113 kilo watt. Now, from where this 113 kilo watt comes here, it has given 217 kilo watt to this stream. So, remaining case 330 minus 217 comes out to be 113 that means this stream, stream number 1, which is a hot stream has got has 113 kilo watt of energy with it.

So, it can only transfer 113 kilo watt energy in a cold stream. Once it transfers this amount of energy, it is ticked up that means all energy has been consumed this 217 plus 113 kilo watt is 330 kilo watt. So, it is transferred from here to here, 113 kilo watt and the stream is now picked up.

Now, once it transferred this energy to here, obviously we reached to this 200 degree centigrade that means if input is 200 degree centigrade from here, the output is 162.33 degree centigrade. This is 90 degree centigrade. So, it is 10 degree centigrade. Here, it is around 20 degree centigrade here and this difference is also more than 10 degree centigrade.

So, for the design one, successfully put the second heat exchanger for the hot end design. Now, let us see for the design, we are matching 3 and 3.5, this is perfectly alright because C P H is 3 and C P C is 3.5. So, this is satisfied. So, this is match between this and this. We call it, number 2 heat exchanger. Now, this has 130 kilo watt. This 130 kilo watt comes because this 330 kilo watt, we have already put much of 200.

So, 130 kilo watt is left with. So, we have transferred the 130 kilo watt from the stream number 1 to stream number 3 using a heat exchanger 2. Once this much amount of heat is transferred, then this stream is ticked up. This stream is ticked up.

So, here in this design two, the stream is ticked up and the stream is ticked up. Here, the stream is ticked up and the stream is ticked up. Now, this stream for the design one, this stream is 200 kilo watt. So, 113 kilo watt has passed. So, it needs 87 kilo watt for the design one. Similarly, in the designed to for the stream, it is 217 kilo watt, I have passed 113 kilo watt. So, it is 217 minus 113 is 87. Now, we will remember that for the hot end, the heating requirement is 87.

So, in the third step, we will put heater here. I am putting heater in design one having the capacity of 87 kilo watt. Once I put the 87 kilo watt, this is able to hit from 108.25 degree centigrade to 130 degree centigrade. How do I check it, 87 divided by 4 plus this, so 87 kilowatts divided by 4 is 21.75 plus 108.25 comes out to be 113. So, the heat balance is and this is ticked up. Now, all the 3 streams are ticked up for the design one. Once the streams are ticked up, it means that the hot end design in the pinch rule or the heat exchanger network is complete. So, hot end is complete for design one. Now, for design to have seen that this was the stream, which was not ticked up, so you put a heater of 87 kilo watt. Here, it raises the temperature from 117.14 to 142. This can be calculated and checked.

So, this stream is ticked up because 87 plus 113, 87 plus 113 is 217. So, the heat balance is over here. Now, here we see the number 1 stream is picked up, number 3 stream is ticked up and number 4 stream is ticked up. So, the hot end design that is designed to is also over. Service has successfully designed the hot end and we have developed 2 designs, design one and design two in this last part of the design. We also see that for hot end, we will also design developer design, which we will call it design one minus design two minus for cold end will develop this designs.

Now, after finishing the hot end design, which is separately thermally balanced and developed, a cold end design should be noted that, which is separately thermally balanced will develop the cold end design. It should be noted that during the hot end design, we are able to meet the energy target that means hot utility requirement. During the targeting process, we have seen that the hot utility requirement was 87 kilo watt. Through this design, we have achieved 87 kilo watts.

So, we have met the target in hot end design here. Also, we will see that the U minimum here is 3 because we have 3 streams and 1 hot utility. So, then at next, the plus 1 this is m minus 1, so 3. So, here we have based on the unit target, we have calculated U minimum equal to 3 here.

We have 3 heat exchangers here, here 2 heat exchangers, here 1 heat exchanger. So, as far as the unit target is considered, also we have met the units target here in this design. Also, we have 3 heat exchangers out of which 1 are a heat exchanger. So, it has also met the heat unit target. So, we have met units target as well as the hot utility target both for this hot end design.

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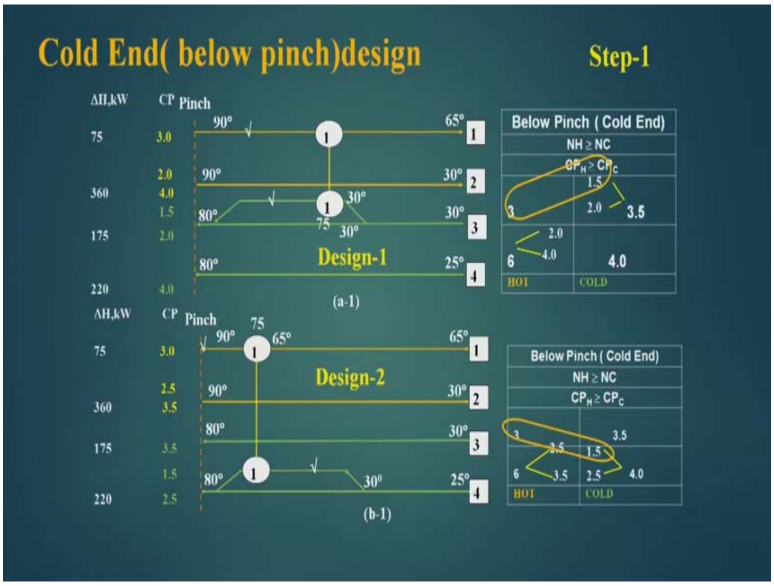

Now, we will go for the cold end design. Now, in cold end design, if you see the rules are then reversed here, the number of hot streams should be more or equal to number of cold streams. C P H should be greater than or equal to C P C. These are the 2 rules, which have to be obeyed for the cold end design. If 1 role is violated, then we have to split this stream to remove the violation or we can restrict to cyclic matching.

So, we will see that what is the problem, which is arising for the cold end design? So, here also, we have developed 2 designs, design one and design two for the cold end design. Now, first we see what is the number of streams rule, N H should be greater or equal to N C. Here, there are 2 hot streams and 2 cold streams. So, this rule is perfectly valid.

Now, C P H should be greater than C P C. Now, due to this rule, this stream can be matched with this and this stream can be match with this, but this stream cannot be matched with this and this. So, this rule provides me to match this stream with this and this stream with this. So, there is some sort of problem here. That problem can be eliminated by splitting these streams. We also see in the last in the design one dash and design two dash that without splitting if I move, then what can be done? So, here let us to solve of this let us divide this stream, this 3.5 stream into 2 parts, 1.5 and 2.0. So, here this 3.5 has been split into 2 parts.

This is 2.0 and this is 1.0. Now, why we have done? So, this is done with a little bit aim because this stream has got 75 kilo watt of heat, which is to be transferred to the cold stream. Now, this 75 kilo watt of heat if I calculate, if this C P is 1.5, then this stream transforms 80 degree to 30 degree. So, 80 minus 30 is equal to 50 into 1.5 that gives me 75. So, if I split it in such a way that delta of this stream is 75, I can directly match this stream with this stream at once. I can tick off this. Now, if it is 1.5 and the other part has to be 2.0, other point has to be 2.0, so I split the streams and then we have matched this 3.0 and 1.5. Now, this is the match, 3.0 and 1.5. So, it satisfies this C P criterion. Then, this C P H should be greater or equal to C P C. Here, C P H is 3 and C P C is 1.5.

So, it is greater. This is greater than this. So, this matches perfectly alright and according to the rules. Similarly, in this C P table, I can break this for into 2 parts 1.5 and 2.5. So, this is 2, this part C P is 4, but for this part, this is 1.5. For this point, this is 2.5. Now, this 1.5 has come with the same argument that because I have to tick off this stream, if I got a delta H of 74, if I break it at 1.5, then this from 30 degree to 80 degree centigrade, so it will take 75 kilo watt of heat. Once I take 75 kilo watt of heat of this, from 30 degree centigrade, it will rise up to 80 degree centigrade.

So, here something has to be done, so that this temperature is 75 degree centigrade at temperature rises up to 30 degree centigrade and we have not put anything here. Let us see so by doing so, if I put this, this temperature becomes 65 because this has got a 75. What that delta is 75. So, if I put as 75 load here, so immediately it will reach to the target temperatures. So, the outlet of this heat exchanger 1 is 65 degree centigrade because consider the range to be target temperature, so this is 3 to 1.5.

This is step one. Now, let us see step two. Now, 1 thing I would like to tell that when I split a cold stream here, the value of N C becomes 3. So, this rule is violated. This rule is violated because now N C is greater than N H. So, to satisfy this rule, we have to split a hot stream. Also, if I split a hot stream, then again the N H becomes, so N H becomes N C. So, if I split 1 cold stream, then 1 hot stream has to split to satisfy this equation 10; that is why this hot stream splits. Similarly, even I am splitting this hot stream also.

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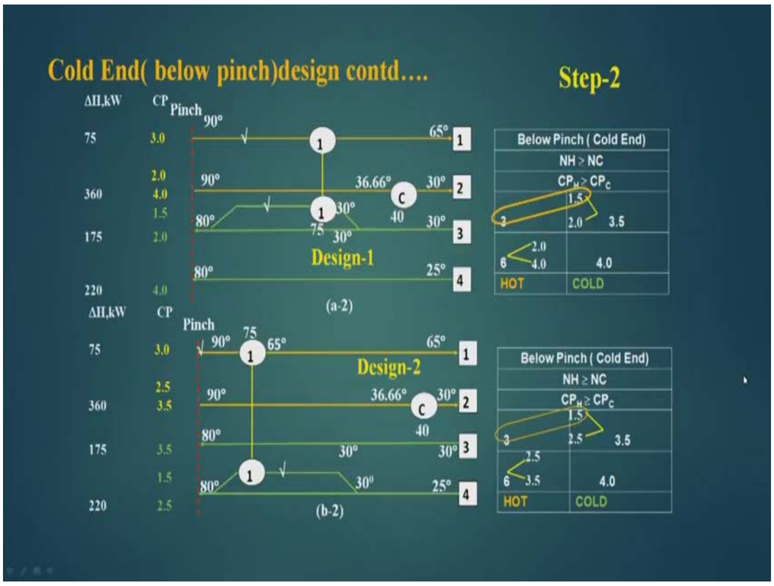

Now, we will go to step two. Now, in the step two, this is satisfied. This part is satisfied. This part is not satisfied. This is not satisfied. So, 1 complete hot stream has to be satisfied. So, there is another hot stream here. Now, it is obvious from this design that a cooler has to be put into this because there is no position left to put a cooler and at the cold end of the design, the cooler has to be put on a hot stream.

So, we have put a cooler here of 40 unit because from the PTA, we have seen that the cold utility requirement is 40. Similar arguments are valid here because this is only this is the hot stream. So, I have to put a cooler of 40units heat capacity. Here, the coolers are always put at the end. So, we have put it at the end.

So, when the temperature is 36.66 is the entry temperature to this cooler, if the cooler takes 40 kilo watt of heat; this will comes to 30 degree centigrade, which is the target temperature of this stream number 2. Here, also the same thing, I have put a cooler of 40 kilo watt. The antic temperature is 36.66 degree centigrade. It moves to 30 degree centigrade that means it is acting as the target temperature of this stream number 2. So, from 90 degree to 36.66, I have to cool this pi exchanging in this heat with this 2 cold streams. Similarly, here 90 to 36.66 have to be cooled down by exchanging it between this and this. So, we go the step number 3 and I too finish up the design. We have already put 1 heat exchanger here and this cooler.

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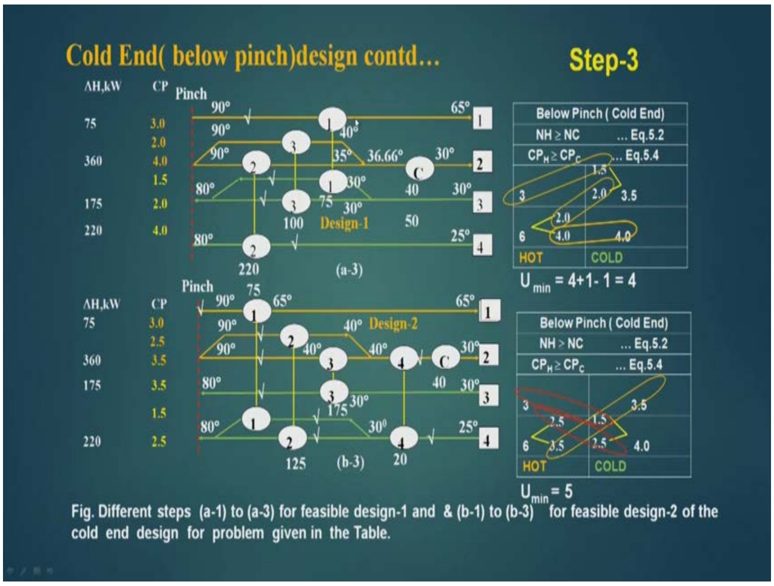

So, this part has been put into step number 2, this part has been put and this has been put in design two in step number 2. Now, let us do the design. Now, if it is moves from 36.66 degree centigrade to 90 degree centigrade this or I say that I have already put a match, 75 kilo watt, the remaining this 100 kilo watt here, the remaining is 100 kilo watt here. If I split this stream in such a way that this 100 kilo watt can be directly transferred to here, then it will tick off this stream completely.

So, this part will be ticked off. So, if I take here 100, then 100 divided by and this is the temperature difference. So, if I do it 90 to 40 degree centigrade, if the value is 2, if I calculate it 90 minus 40, 90 minus 40 into 2, it becomes 100. So, if I split this stream into 2 parts, 4 and 2, this is the stream, which has been split into 4 and 2. Then, this part will have 100 kilo watt energy. When I transfer, this stream ticked off that is stream number 3 ticked off. This temperature has been brought down to 90 degrees centigrade temperature is brought down to 40 degree centigrade.

Now, this is transferring 100 kilo watt of heat. This is cooling 40 kilo watt. So, this is 140. So, this is 140, so 360 minus 140, 360 minus 140 comes out to be 220. That way this part has got 220 kilo watt of heat with it. So, if I pass the heat from this part to this heat exchanger from completely satisfied this stream and this is ticked off.

So, when I pass the heat 220 to this, the temperature of this stream becomes 35 here. This you can calculate 90 minus 35 into 4 is 220. So, this stream will be cooled down to

35 degree centigrade and this stream will be cooled down to 40 degree centigrade. When they mix here, they create 36.66 degree centigrade. So, they start with 90 degrees centigrade, the part goes here cooled down to 40 degree centigrade.

Another part starts with 90 degree centigrade, goes through this heat exchanger, cooled down to 35 degree centigrade. When these 2 cold streams meet here, it makes 36.66 degree centigrade. Then, they pass 40 kilo watt heat to the cooler and reach the target temperature of 30 degree centigrade.

So, the work of this second stream is slower that means the whole of the second stream is has been ticked off and the fourth stream is also ticked off. So, in this, all of my streams are ticked off here. So, the cold end design as per as design one is concerned has been finished. So, here we see we first put up magnitude 3, 1.5 and then split. We split 3.5 into 1.5 and 2. We put a magnitude 3 and 1.5, and then we split 6 to 2 and 4 and we put 2 to 2 match and then 4 to 4 match here. So, 3 heat exchangers are put here and 1 cooler has put here. When I apply my U minimum criteria here, there are 4 streams and 1 cold utility.

So, this is 4 plus 1 minus 1, this is 4. So, I am able to reach my units target as well as I am able to use my reach my energy target also because through PTA, I have calculated that my cold utility requirement will be 40 kilo watts. So, here I am consuming 40 kilo watt and here I am consuming 40 kilo watt and my units target is also net.

So, T cold end design, as far as design one is concerned, I have met my energy target as well as unit target. Now, if I see the design two, so we have passed the 75 watt and we have ticked off this. So, if I pass 75 kilo watt here, the remaining energy is 125 kilo watt, last 20 kilo watt because this is 75. So, 220 minus 75, 220 minus 75 is equal to 125.

So, this is 125 minus 20, so if I see here, this stream is split into 2 parts, 2.5 and 3.5. This is 2.5 and this is 3.5. Now, if I see this stream, this stream has a delta H of 175 kilo watt. So, here if I see this 3.5, so 90 minus 40 is 50 degree. 50 into 3.5 come out to be 175. So, if I break it by 3.5 and 2.5, and then transfer this heat from here to here, I will able to tick off this completely. So, this has been broken into 2 parts, 3.5 and 2.5. So, when I am fixing up, 3.5; obviously, the other part will be 2.5.

So, I split like that and then just transfer heat to this 175 here. So, the outlet temperature here will be 40 degree centigrade. So, 40 minus 30 is 10 degree centigrade. Now, the outlet from this is 33.6 degree centigrade. So, 36.55centigrade to 20 degree centigrade, I have to put a heat exchanger. So, this exchanger is 4 and this passes of 20 kilo watt of it. Now, this part now contains 90 minus 40 into 2.5, 90 minus 40 into 2.5 comes out to 125 kilo watt.

Now, this stream has now 125 kilo watt. So, using heat exchanger 2, I am transferring the total heat to this as 125 heat; so, this is the ticked off. This 2 are also ticked off and this is also ticked off that means my design is complete. So, what I have made? I have made the energy target, which is forty, but I am not able to meet the U minimum target, which is 4. Now, here I have 1, 2, 3, 4, 5 heat exchangers. I am putting; I am putting 5 heat exchangers and am not able to meet the U minimum target. So, we have completed 2 sets of design for the cold end. The first end will be called as design one and the second set will be called design two.

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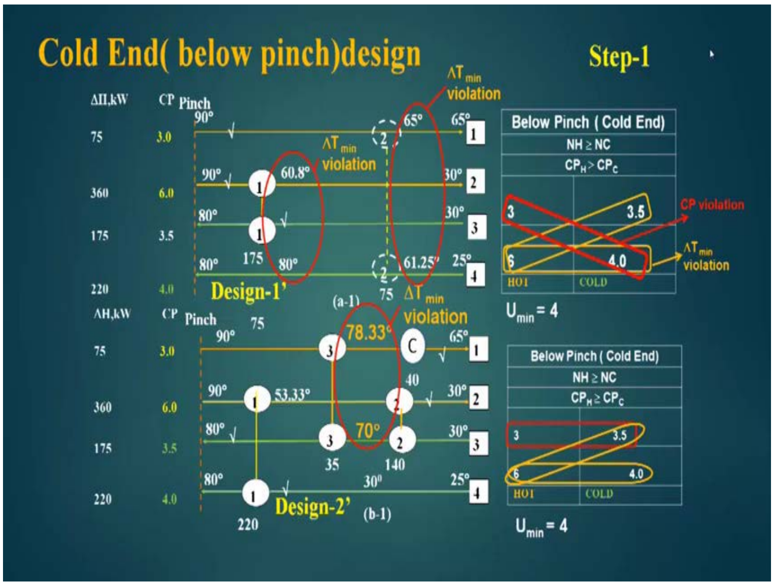

Let us check another alternative for the cold end design. Let us check whether this alternative is feasible or not. The design one end shows another alternative for the design of the cold end. Now, if we see this table, this is C P table, and we can match fix with 4.0. We can match 6 with 3.5 and both this matches are valid as in this case; C P H is greater than C P C. I see C here, and then this is the hot stream, which is stream number 2, which has got C P of 6. This is the cold stream, which is stream number 3, which has C P of 3.5.

Let us put a match between these 2 streams that is 2 and 3. So, when we put a match between these 2, which is termed as heat exchanger number 1, then the hot has a capacity to transfer 360 kilo watt that is number 2 stream can pass 360 kilo watt and number 3 stream can take 175 kilo watt. So, we can directly pass 175 kilowatt through this heat exchanger, which is exchanger number 1 and tick off this stream.

If you do so, then the temperature here becomes 60.8, where as this temperature exits temperature stream number 4 becomes 80. We try to put another match to this and this that is stream number 2 and stream number 4, which is valid as per as the rules is concerned. We see here there is delta T minimum violation because the hot stream required a temperature of 60.8 and the cold stream 80 degree centigrade. That means cold stream has got a higher temperature than the hot streams and hence the violation.

So, we cannot put a match between this 2 because 1 end has a temperature delta T violation. Now, let us see the other alternative available, which is 3, can be matched with 4. We can see here. This violates this rule here. The C P H is not greater than C P C. In fact, if I do this match 3 to 4, C P C is greater than C P H, but let us see what happens. If I put this match, so I put this match to that is exchanger number 2 for this match. When I put this match, which will the capacity of the match will be 75 because the hot stream has got 75 kilo watt to give the cold stream can take 220 kilo watt. So, I can directly put a match of 75 kilo watt.

If I do so, the temperature here becomes 65 degree centigrade and the temperature here becomes 61.25 degree centigrade. Hence, there is delta T minimum violation. So, remember that this is the pinch match and I am violating this rule. Hence, I can expect a delta T minimum violation, which I see here. So, 3 to 4 this match is not feasible and 2 to 4 also match is not feasible. Hence, I cannot create a heat exchanger network the cold end by matching this way. Another alternative can be checked for the cold end design and that alternative is called as design two dash.

Let me see whether this is feasible or not. Here, we cannot put a match between 6 and 4 and this is completely valid because C P H is greater than C P C. So, I put a match between stream number 2, which has got C P of 6.0 and stream number 4, which has got C P of 4. So, this match is called match 1. Now, as stream number 2, hot stream can be

360 kilo watts of energy and stream number 4 can take 220 kilo watt of energy, put this match to be equal to 220 kilo watt.

So, when I put this match, the outlet temperature of these heat exchangers is 53.33 centigrade. This stream that is stream number 4 is ticked off. Now, another match can be put between 6 and 3.56 is number 2 stream because its C P is 6 and number 3 stream C P is 3.5. So, I can put a heat exchanger, which is heat exchanger number 2 here between these 2 hot streams. Now, if I subtract 220 kilo watt from 360 kilo watt, this becomes 140 kilo watt.

So, I can put a match of 140 kilo watt here. I can tick off this stream number 2. Now, once I put this match, the exit temperature here becomes 70 degree centigrade. Now, here we will see that this is ticked off. If I deduct 140 from 175, so I get 35. So, this stream here 75 stream that is stream number 1, which is a capacity of 75 kilo watt than the 30 kilo watt to this stream, stream number 3, but when I go for matching between 1 and 3 that means 3 and 3.5, which is 3 and 3.5. This rule is violated by that is C P H is greater than or equal to C P C.

So, I can expect something to happen that in terms of delta T minimum violation. So, if I put this heat exchanger here that is heat exchanger number 3 between 1 and 3, so this temperature becomes 78.33 and this 70. So, there is a delta T violation here. So, obviously this design two dash is rejected because in this design, delta T minimum violation. So, we saw that both of these designs, design one dash and design two dash are not feasible designs.

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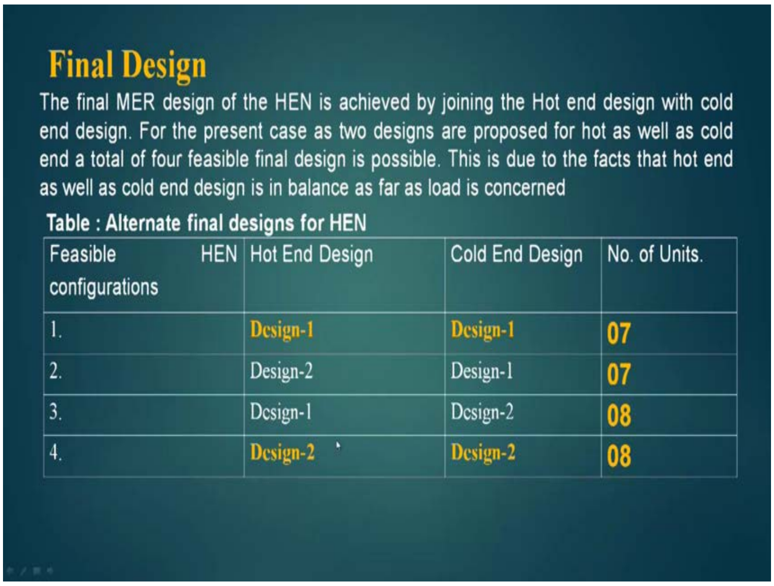

Now, the final design, we have seen that there are 2 designs for the hot end and there are also possible designs in the cold end. So, if I go for permutation and combinations, there will be 4 designs. These designs are 1 of the hot end design, 1 of the cold end design, 2 of the hot end design, 1 of the cold end design, 1 of the hot end design, 2 of the cold end and design two of the hot end and design two of the cold end. This is because if I take this, then I find that the number of units when I am taking hot end design one and cold end design one is 7.

Similarly, when I am taking hot end design two and cold end design one, it is also 7. When I take hot end design one and cool end design two, the number of units is 8. When I take design two of the hot end and design one of the cold end, the number of units is 8. So, as far as number of units is concerned, these 2 designs is feasible, configuration 1 and 2, which gives 7 number of units or better.

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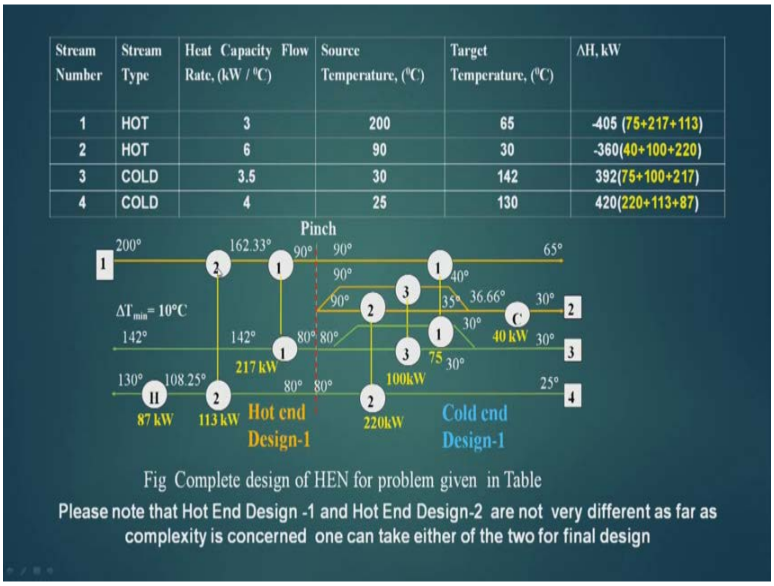

So, this is my complete design when I am mixing designs hot end design one and cold end design one. So, please note that hot end design one and hot end design two are not very different as far as complexity is concerned. One can take either of the 2 for the final design.

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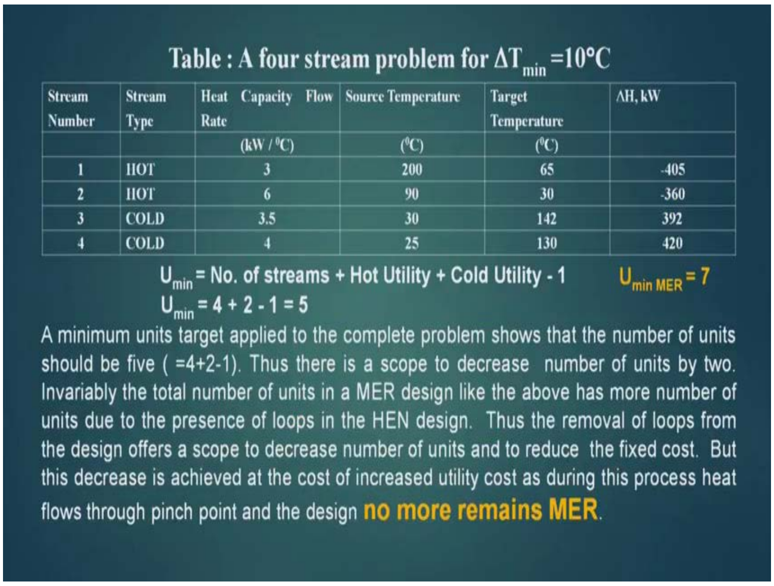

Now, there is something that needs discussion. Now, if I apply my U minimum criteria to this table considering that there is no division at pinch, which is a requirement for

MER design, then my U minimum comes out to be 5. This is for whole all the streams that is 4 streams and to utilities this 4 plus 2, 6, 6 minus 1 equal to 5.

So, it tells that if you ignore pinch division, then the whole heat exchanger network should be designed with 5 numbers of heat exchangers or units, but where as I apply my units target directly to the hot end and separate to the cold end, then I find that the U minimum heat exchangers requirement is 7. So, when I am going for a MER design, so U minimum MER is 7 when I am attiring my units target for hot end and cold end separately and then joining them.

So, to tell something, if I am not going for MER design, then I have scope to decrease the number of units by 2. That means there is a possibility that the heat exchanger network cost will be less if I am going for a non MER design, but in non MER, design will always consume more utilities than a MER design. Now, how to reach from a MER design to a non MER design? So, the unit target tells something about this that why this 2 heat exchangers more are required for a MER design.

Now, when we go for a MER design, we create some loops in the HEN and in this, we will detect that there are 2 loops, 7 minus 5 is equal to 2 loops. So, there will be 2 loops for MER design. These loops have been created because the hot end and cold end designs are separately designed without consulting each other. So, loops have been created. So, once we remove these loops, we can decrease the number of units. So, in both, the loops which are present in this MER design will be broken.

Then, the number of units will drop down to 5, but at the cost of higher utility. That means the utility will increase when I am decreasing the number of units. So, there is a trade off between the utility and the number of units. This trade off has to be checked, but when they break the rules, it is no more MER design. Now, it is a non MER design.

Thank you.