Steam Power Engineering
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Lecture - 27
Reheat Factor

The topic of discussion here is about reheat factor. Actually, we are working on steam turbine power plant and in the steam turbine power plant, we know that the reality would have expansion in the turbine but the end or exhaust of the turbine would have temperature more than the ideal temperature. So, there is some heat, some energy, which is residue in the turbine exhaust which has not got converted into work.

That residue energy that energy difference between the ideal exhaust and the real exhaust is called as reheat and we are going to use this reheat concept to get some more expressions which are used for the getting idea or performance of the turbine. So, we will first understand what do we mean by reheat.

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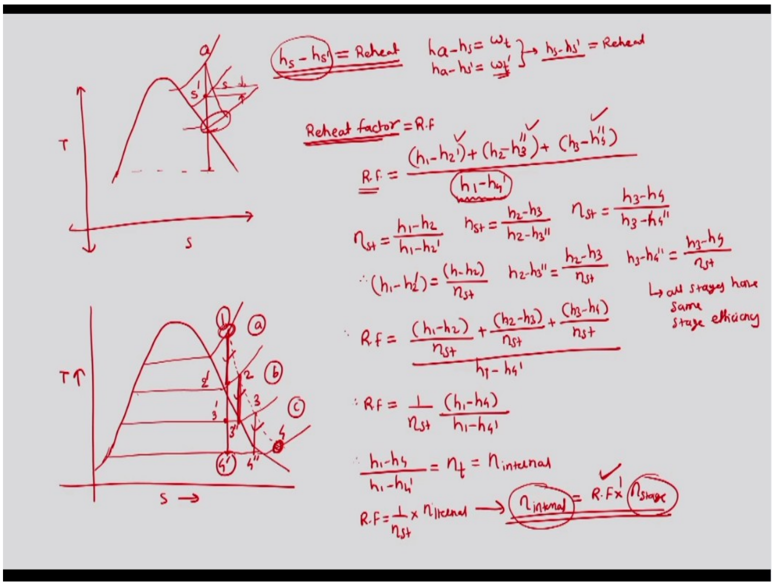

In the T-S diagram, we can better understand that this is turbine and then in this turbine we know that this is expansion from the state or entry to the turbine to the state at the exhaust to the turbine. Now, in this in reality this would follow this line. Now, if we are here, then the fact is the constant pressure line is like this though so this is suppose S' as ideal exhaust but this is S which is real exhaust.

So, the difference in enthalpy in these 2 states, so $h_s - h_s'$ is called as reheat. So, this is the enthalpy which is there in the flow which has not got converted into work. So, if a is the state at the inlet, then $h_a - h_s$ is turbine work but $h_a - h_s'$ is turbine work in ideal state w_t'. So, in both the cases, if we consider then $h_s - h_s'$ is called as reheat. There is one more fact which we should understand for reheat.

So, there is this as one pressure line, so the constant pressure lines diverge from each other at higher entropy sides. So, if we take the pressure ratio same then this line is more diverged, this line is less diverged. So, the point s will be more further and amount of reheat would be high. So, knowing this we should consider a reheat factor also called as RF. Let us draw a T-S diagram for better understanding where we are expressing the turbine work in multiple pressures.

So, this is one, this is other, this is third and this is fourth. So, this we will take like this. This is state 1 and then this is state $2s$ or we will say it as $2'$. So, the corresponding state is 2, corresponding real state is 2 but if we would have expanded from 2 to 3 then we would have come over here. So, this we will represent here as $3'$ and here we would represent as $3''$ and from 3 to 4 but reality would be here as 3.

So, we would have further point 4 here and point $4'$ here sorry point $4''$ here and 4 here. So, the line which is joining $1, 2, 3, 4$ is the real line also called as condition line and here we can say this point as $4'$. So, this is the expansion, ideal expansion of the steam from state 1 to $4'$ and if we would decompose it into 3 pressure ratios, one is a, b and c. So, if we would have expanded from for this 1 to 2 then we would have got 2' as ideal and 2 as real.

And then if we would have expanded from 2 to 3 then $3''$ would have been ideal and $4''$ practically would be ideal for third case. Then, reheat factor would be defined as the summation of enthalpies of small vertical lines divided by the big vertical lines which is isentropic. So, we will see that this is $h_1 - h_2'$.

So, this is small vertical line plus the next vertical line which is $\frac{h_2 - h_3'' + h_3 - h_4''}{h_1 - h_4'}$, this is ideal enthalpy drop if we consider complete all stages and this is enthalpy drop in ideal case in each stage. So, this is the ratio which we are calling it as reheat factor. Now, we will say that there is some stage efficiency and each stage has its efficiency.

So, knowing that we know stage efficiencies, turbine efficiency for that stage, so stage number 1 we have real enthalpy drop $\eta_{st}=\frac{h_1-h_2}{h_1-h_2{}'}$. Similarly, stage efficiency is equal to $\eta_{st}=\frac{h_2-h_3}{h_2-h_3{}''}$. So, similarly stage efficiency is equal to $\eta_{st}=\frac{h_3-h_4}{h_3-h_4{}''}$. So, we can express $h_1-h_2^{''}=\frac{(h_1-h_2)}{\eta_{st}}$.

Similarly, $h_2-h_3^{''}=\frac{h_2-h_3}{\eta_{st}}$ and $h_3-h_4^{''}=\frac{h_3-h_4}{\eta_{st}}$. So, we can write down reheat factor is equal to $RF=\frac{\frac{h_1-h_2}{\eta_{st}}+\frac{h_2-h_3}{\eta_{st}}+\frac{h_3-h_4}{\eta_{st}}}{h_1-h_4^{'}}$. Here, our assumption is all stages have same stage efficiency.

So, we get reheat factor as 1 upon stage efficiency and we get $h_1-h_2+h_2-h_3+h_3-h_4$so this $h_2 h_2$ and $h_3 h_3$would cancel and we get h_1-h_4, so h_1 is the inlet enthalpy for the turbine, h_4 is outlet enthalpy for the turbine divided by $h_1-h_4{}'$. So, we can write down here that h_1 but we know one thing that $\frac{h_1-h_4}{h_1-h_4{}'}$ is turbine efficiency or also called as internal efficiency.

So, we know now RF is equal to 1 upon stage efficiency into internal efficiency and hence internal efficiency is equal to RF into stage efficiency. So, since RF is more than 1 if stage efficiency is known, then we can find out internal efficiency or turbine efficiency and it leads to us and it is understood to us from here that since RF is more than 1 we will have internal efficiency more than stage efficiency.

So, this is how we can make use of the fact that there is a reheat factor and that can be used for understanding the turbine better from the stage to the complete integration of all stages. Thank you.