1 High Pressure Steam Turbine

In this chapter examples of different types of high-pressure steam turbines are given in order to help the user with the modelling of steam turbines in Cycle-Tempo. The high-pressure turbines are modelled for a design situation and for part-load situations with 80% and 40% of the power at design situation. First the situation without a governing stage is described. The part-load conditions are obtained by either sliding pressure in the boiler or by throttling control. Then a steam turbine with a governing stage will be modelled. The conditions in the design situation are the same for the different turbine control situations: a steam turbine is used to extract steam with a mass flow of 100 kg/s from 90 bars and 450º Celsius to 30 bars.
All calculations are made with Cycle-Tempo beta release 4.14.

1.1 Sliding Pressure Control

When sliding pressure control is being used, the pressure in the boiler is reduced in order to get a lower power output. The efficiency of the turbine is hardly influenced by the part-load conditions. The boiler efficiency however decreases rapidly.

1.1.1 Input for the design load calculation

First the type of turbine has to be specified by the turbine code. This code can be found in table 2.2 on page 2-19 of the manual. For a high-pressure section without a governing stage *TUCODE* =10000 is used. The corresponding *GDCODE* =1, which means no governing stage is being used. The mechanical efficiency of the turbine is set to 0.99 and the efficiency of the generator is set to 0.98. Table 1 shows the input parameters for this example. The user is free to give a value for the isentropic efficiency for the turbine. When no value for *ETHAI* is given, Cycle-Tempo will calculate the turbine efficiency by the method of General Electric (see appendix A of the manual).

Table 1: input parameters for sliding pressure control

Input parameters	
Turbine (Nr.1)	
TUCODE	10000
GDCODE	1
ETHAM	0.99
PIN	90
Sink/source (Nr.2)	
TOUT	450
DELM	-100
Sink/source (Nr.3)	
PIN	30
Generator	
ETAGEN	0.98

With these input parameters, Cycle-Tempo can start the calculations.

1.1.2 Results of the design load calculation

The plot of the result of the calculation with the input parameters of Table 1 is given in Figure 1:

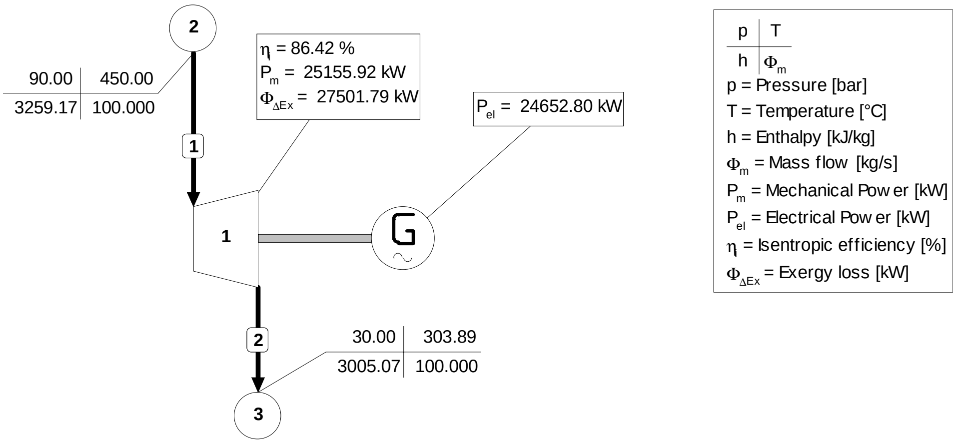

Figure 1 Results of the design load calculation

1.1.3 h-s diagram

We can view the expansion trajectory by making an *h-s* diagram, with the "new graph"-function in the "view" menu of Cycle-Tempo. The user can choose for different types of graphs to be made by Cycle-Tempo.

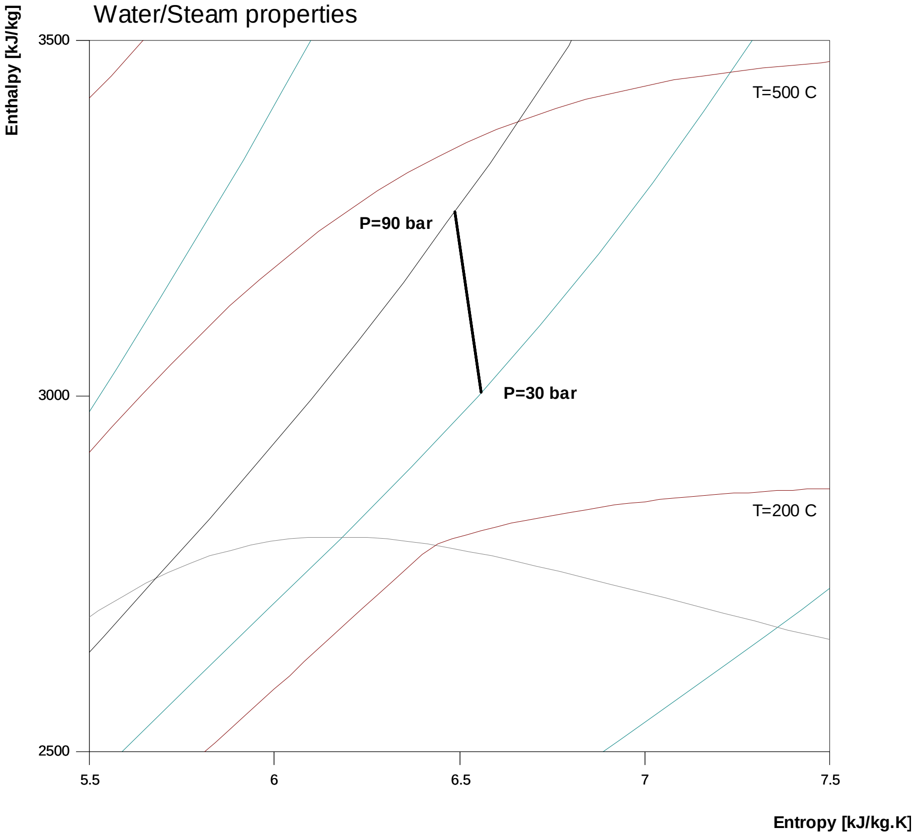

Figure 2 *h-s* diagram for the design situation

1.1.4 Input for the off-design calculation

Now two off-design situations are considered. In the first situation the turbine delivers 80% of the power that it supplied in the design situation. In the second example a power delivery of only 40% is considered.
This means for the delivered power:

$$P_{80\%} = 0.8 \times P_{design} = 0.8 \times 24652.8 = 19722.2 \quad \text{kW}$$

$$P_{40\%} = 0.4 \times P_{design} = 0.4 \times 24652.8 = 9861.1 \quad \text{kW}$$

To impose this power upon the system a "Production Function" is been made in the "General data" menu. Apparatus 1 (the turbine) is being given a production function of 19.722 MW for the first off-design situation and a production function of 9.8611 MW for the second situation.
Cycle-Tempo needs to know the design mass flows in order to calculate the size of the turbine. This means that the off-design input data has to be specified. Cycle-Tempo has already calculated that data, it only needs to be pasted from the design situation. The data is specified in a file with a ".pld" extension.
The output pressure is being held constant at 30 bars, as is the inlet steam temperature of 450º Celsius.

Table 2: Input parameters for the off-design situations

	Off-design 80%	**Off-Design 40%**
Production Function apparatus Nr.1	19.722 MW	9.8611
Turbine (Nr.1) *TUCODE* *GDCODE* *ETHAM* *Off design input data*	 10000 1 0.99 pasted from design load situation	 1000 1 0.99 pasted from design load situation
Sink/source (Nr.2) *TOUT*	 450	 450
Sink/source (Nr.3) *PIN*	 30	 30
Generator *ETAGEN*	 0.98	 0.98

With this data Cycle-Tempo can calculate the off-design pressures, temperatures and efficiencies.

1.1.5 Results of the off-design calculation

Figure 3 and Figure 4 show plots of the results for the 80% and 40% off-design situations.

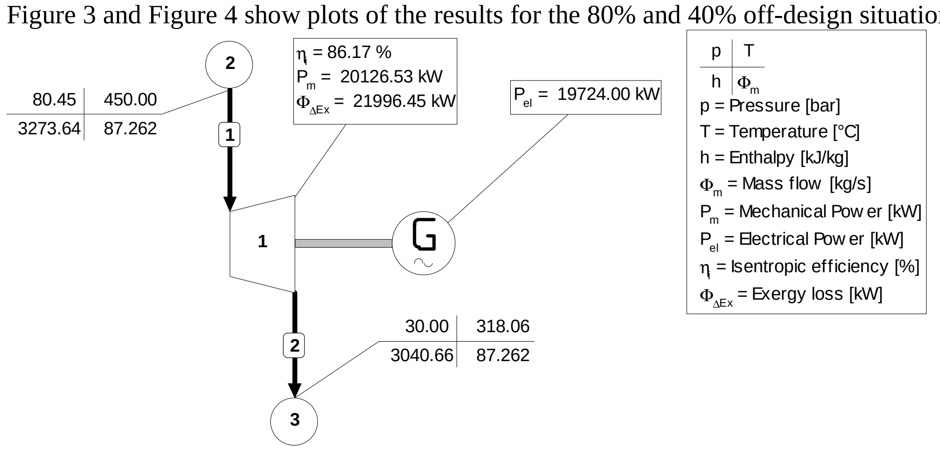

Figure 3 Results of the 80% off-design calculation

The user should note that there is a difference between the imposed electricity production of 19.772 MW and the calculated value of 19.724 MW. This is due to the fact that Cycle-Tempo uses a default relative accuracy of 1.0e-4. The user can change this accuracy by changing the “settings” in the “calculation” menu. For the next calculations an accuracy of 1.0e-6 is used.

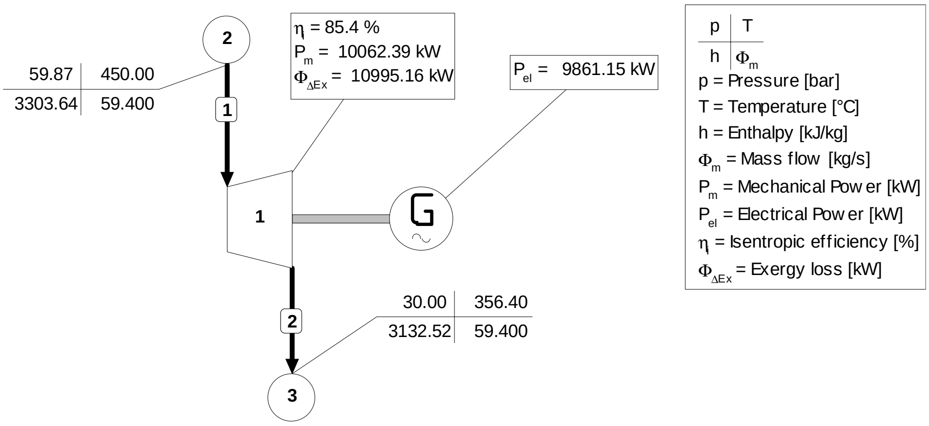

Figure 4 Results of the 40% off-design calculation

The turbine efficiency is hardly influenced by the part-load conditions. The boiler however (which is not modelled here) will have a lower efficiency because of the lower steam pressure.

1.1.6 Steam turbine without a generator

In the previous examples steam turbines were used in combination with generators which supply electricity. Steam turbines however are not always used to produce electricity. They are also used to deliver mechanical power for compressors or pumps. Cycle-Tempo can make calculations for these situations by just leaving out the generator. The input (and output) will be exactly the same as for the configurations with a generator, so this situation will not be discussed here.

1.2 Throttling control

The second way to control the power delivered by the steam turbine is by using throttling control. When an off-design condition is required a valve in the inlet steam pipe is used to reduce the inlet pressure of the steam. This configuration has the advantage that the boiler pressure (and therefore also the boiler efficiency) stays the same and the turbine will only have a slightly lesser isentropic efficiency in comparison with the design load case. However the steam will expand in the valve without delivering work.
To model a system where the part-load conditions are required by throttling control, the user should use the same turbine as in the gliding pressure controlled example but add a source/sink at the inlet steam pipe which can be used as an expansion valve.

1.2.1 Input for the design load calculation

The input for the design situation is similar to that of the sliding pressure control example. An extra source/sink (Apparatus Nr.4) is added to model the expansion valve, see Figure 5.
The input parameters for the other components are the same as in the sliding pressure control example and the input parameters for the newly added source/sink are given in Table 3:

Table 3: Input parameters for the expansion valve

Source/sink (Nr.4)	
DELP	0
DELH	0

1.2.2 Results of the design load calculation

As the pressure loss and the enthalpy loss are set to zero, the expansion valve doesn't affect the solution in the design load situation. The results are shown in Figure 5 and are equal to the results of the first example.

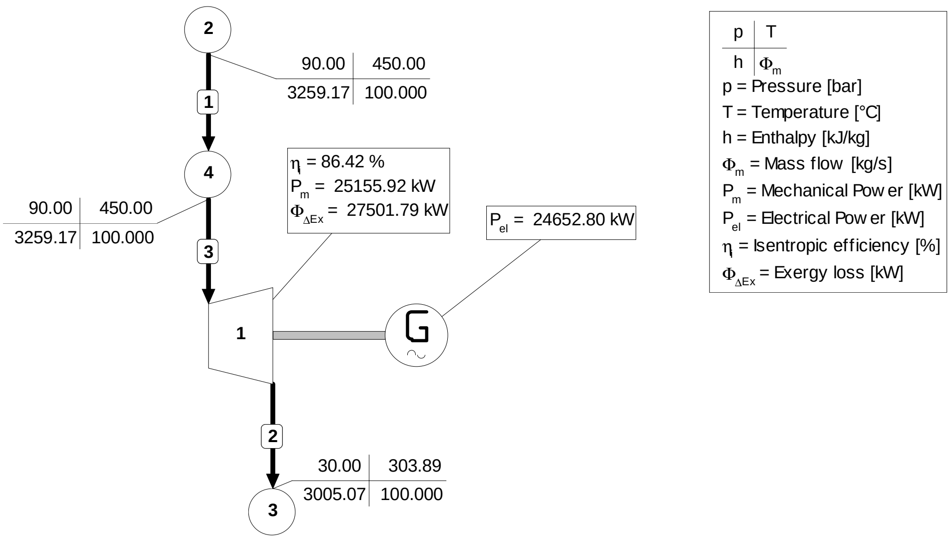

Figure 5 Results of the design load situation

1.2.3 Input for the off-design calculation

In the off-design situation the boiler pressure will be the same as in the design situation. The newly introduced valve will be used as a pressure reducer to decrease the amount of power supplied by the steam turbine. The off-design input data is the same as the off-design input for the sliding pressure control example except for the fixed (inlet) pressure in apparatus 2. By not giving a pressure difference in apparatus 3, Cycle-Tempo will calculate this difference. Table 4 gives all the input parameters for the off-design situation.

Table 4: Input parameters for the off-design calculation

11.2.3.1 Input parameters	**80% off-design**	**40% off-design**
Production Function apparatus Nr.1	19.722 MW	9.8611
Turbine (Nr.1)		
TUCODE	10000	10000
GDCODE	1	1
ETHAM	0.99	0.99
Off design input data	pasted from design load calculation	pasted from design load calculation
Sink/source (Nr.2)		
TOUT	450	450
POUT	90	90
Sink/source (Nr.3)		
PIN	30	30
Sink/source (Nr.4)		
DELH	0	0
Generator		
ETAGEN	0.98	0.98

1.2.4 Results of the off-design calculation

Figure 6 and Figure 7 show the results of these off-design calculations.

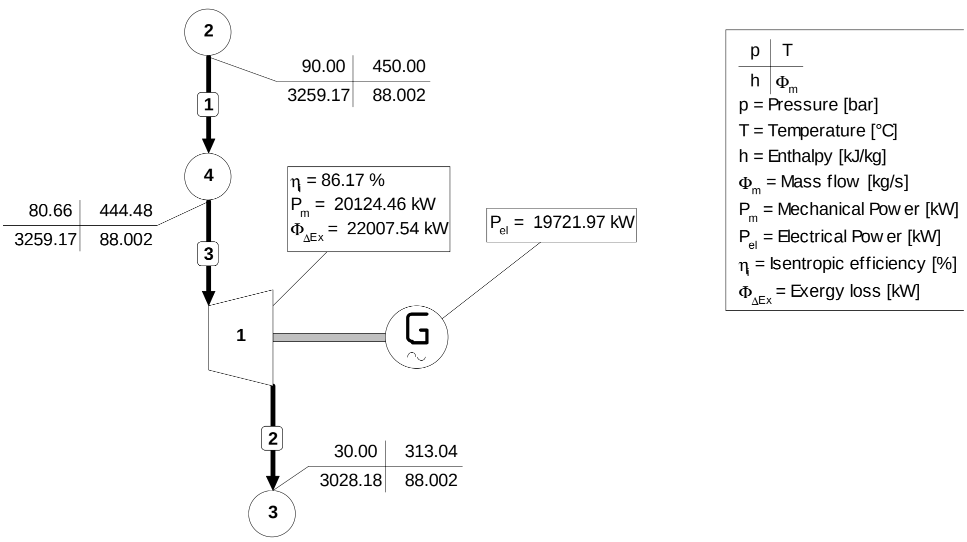

Figure 6 Results of the 80% off-design calculation, throttling control

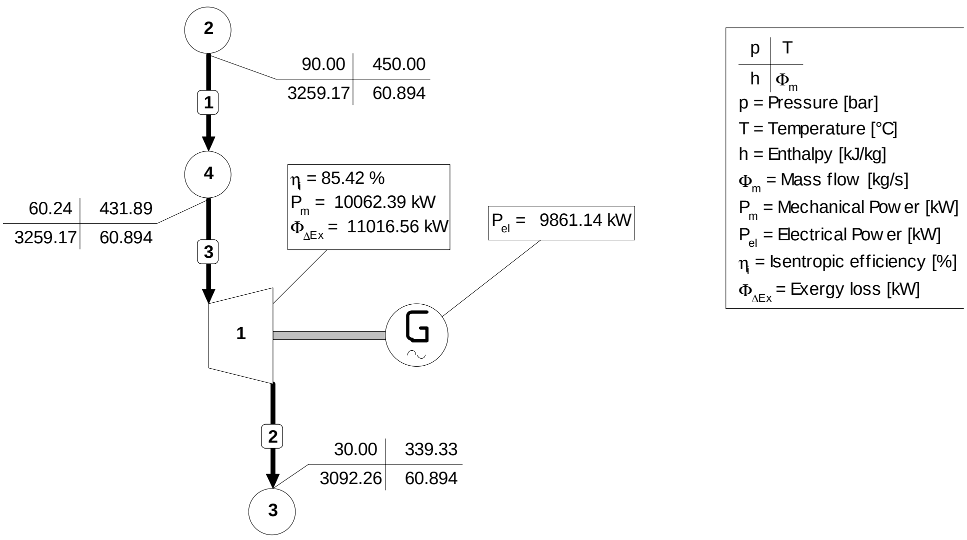

Figure 7 Results of the 40% off-design calculation, throttling control

The user should notice the different inlet and outlet conditions for the steam. The turbine efficiency is almost the same for the design and off-design calculations as was expected when throttling control is being used.
By making an *h-s* diagram the expansion first in the valve and after that in the turbine can be made clear.

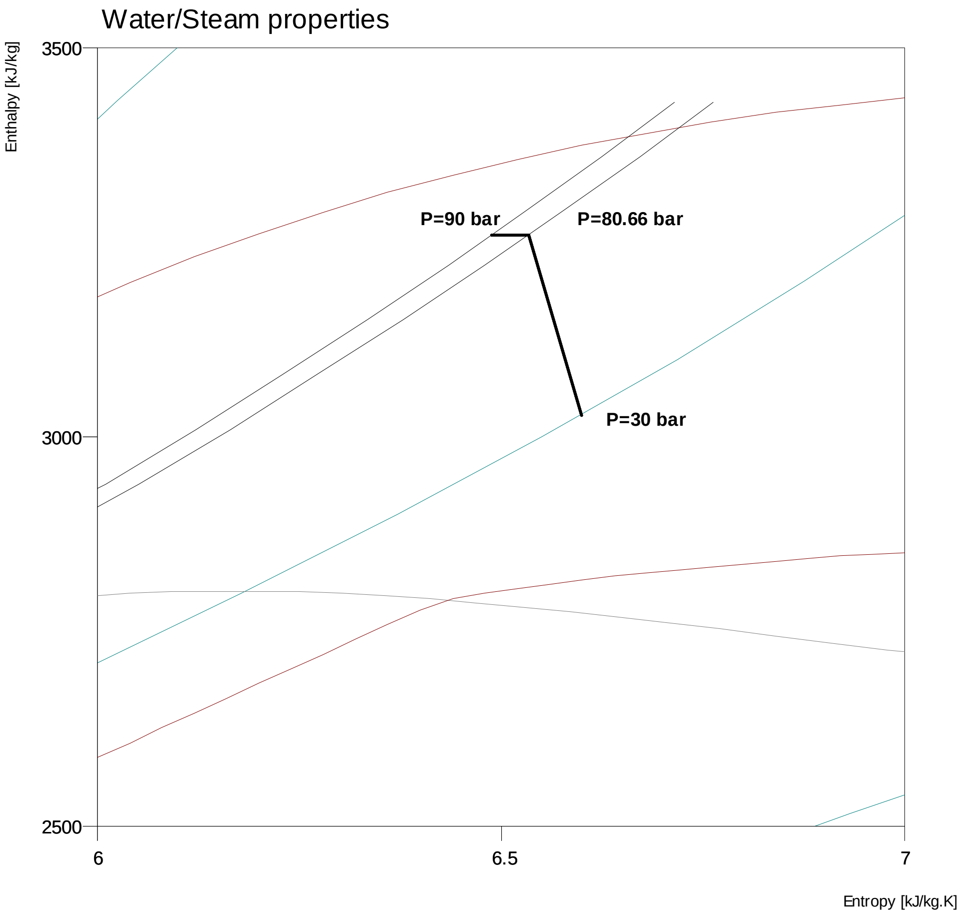

Figure 8 *h-s* diagram of the 80% off-design calculation, throttling control

1.3 Governing stage control

This example shows the calculation for a turbine with a governing stage. The advantage of a governing stage is that for a part-load condition the boiler pressure can be kept at design pressure and no pressure reduction by expansion valve is necessary. The disadvantage is a lower isentropic efficiency in design as well as part-load conditions.

1.3.1 Input for the design load calculation

In this example a turbine with a 1 row governing stage and a turbine with a 2 row governing stage are treated. One parallel flow is assumed, as are 4 inlet valves. With table 2-2 in the manual we find a *TUCODE*=21004 for the turbine with the 1 row governing stage and a *TUCODE*=31004 for the turbine with the 2 row governing stage. The *GDCODE*=2, because there is a governing stage. In order to let Cycle-Tempo make the calculations the user has to specify the so-called "pitch diameter" of the governing stage, *DIAIN*. This means the diameter of the governing wheel at half blade height. The value for *DIAIN* is chosen to be 0.3 meters. The input parameters for this example are shown in Table 5.

Table 5: input parameters for the design situation

Input parameters	**1-row governing stage**	**2-row governing stage**
Turbine (Nr.1)		
TUCODE	21004	31004
GDCODE	2	2
ETHAM	0.99	0.99
PIN	90	90
DIAIN	0.3	0.3
Sink/source (Nr.2)		
TOUT	450	450
DELM	-100	-100
Sink/source (Nr.3)		
PIN	30	30
Generator		
ETAGEN	0.98	0.98

1.3.2 Results of the design load calculation, 1 row governing stage

Figure 9 shows the results for the calculation of the turbine with a 1 row governing stage with the input of Table 5.

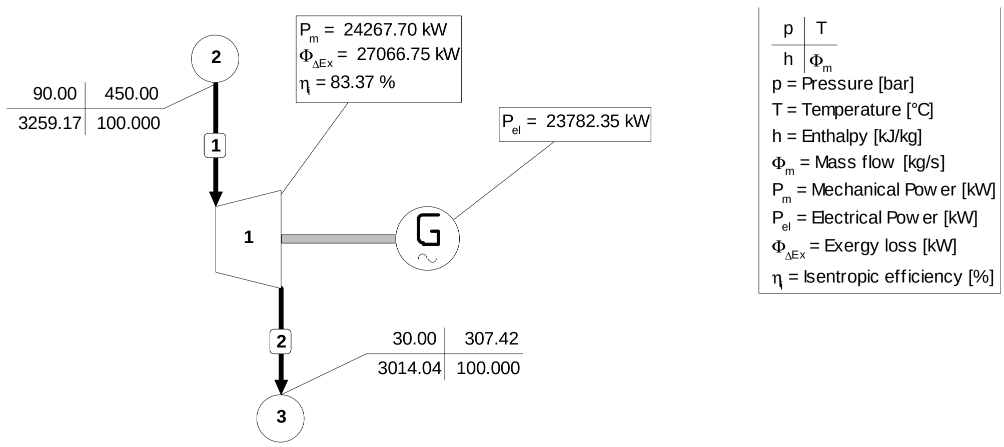

Figure 9 Results of the design load calculation, turbine with 1 row governing stage

The user should note that the isentropic efficiency of a turbine with a governing stage is less then the efficiency for a turbine without governing stage.

1.3.3 Results of the design load calculation, 2 row governing stage

Figure 10 shows the results for the design calculation of a turbine with a 2 row governing stage with the input of Table 5.

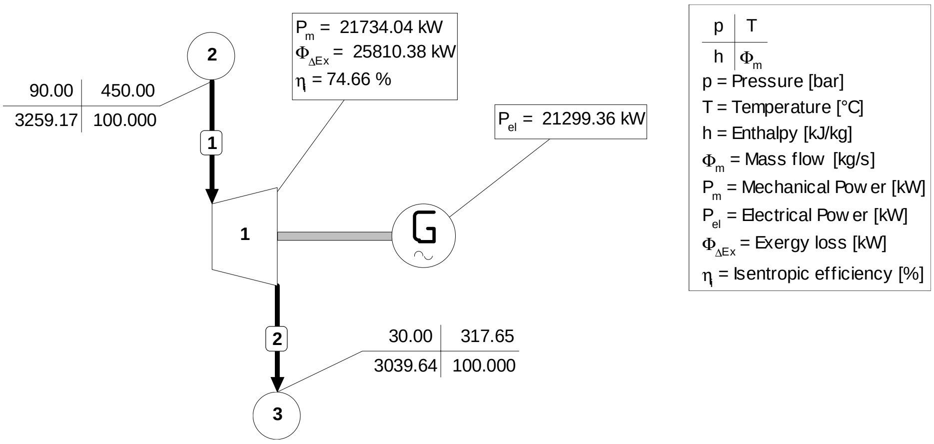

Figure 10 Results of the design load calculation, turbine with 2 row governing stage

Note that the efficiency of the turbine with the two row governing stage is lower than the efficiency of the turbine with the one row governing stage. This is due to the fact that a governing stage is less efficient then a normal expansion stage.

1.3.4 Input for the off-design calculation

For the off-design calculations a power delivery of 80% and 40% of the power delivered by the generator in the design load situation is looked at. Table 6 gives the input parameters for these calculations. Note that *TUCODE*=2104 is for the turbine with a one row governing stage and *TUCODE*=3104 is for the turbine with a 2 row governing stage.

Table 6: Input parameters for the off-design calculations, 1 and 2 row governing stage

Input parameters	**Off-design 80%**		**Off-Design 40%**	
Production Function apparatus Nr.1	19.026 MW	17.039 MW	9.513 MW	8.520 MW
Turbine (Nr.1)				
TUCODE	2104	3104	2104	3104
GDCODE	2	2	2	2
ETHAM	0.99	0.99	0.99	0.99
PIN	90	90	90	90
DIAIN	0.3	0.3	0.3	0.3
Off design input data	pasted	pasted	pasted	pasted
Sink/source (Nr.2)				
TOUT	450		450	
Sink/source (Nr.3)				
PIN	30		30	
Generator				
ETAGEN	0.98		0.98	

1.3.5 Results of the off-design calculations, 1 row governing stage

Figure 11 shows the results for the 80% off-design calculation.

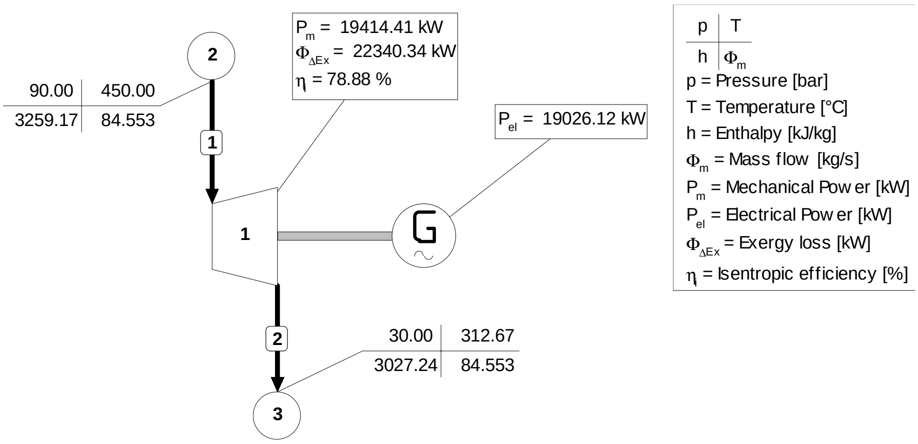

Figure 11 Results of the 80% off-design calculation, turbine with 1 row governing stage

Figure 12 shows the results for the 40% off-design calculation.

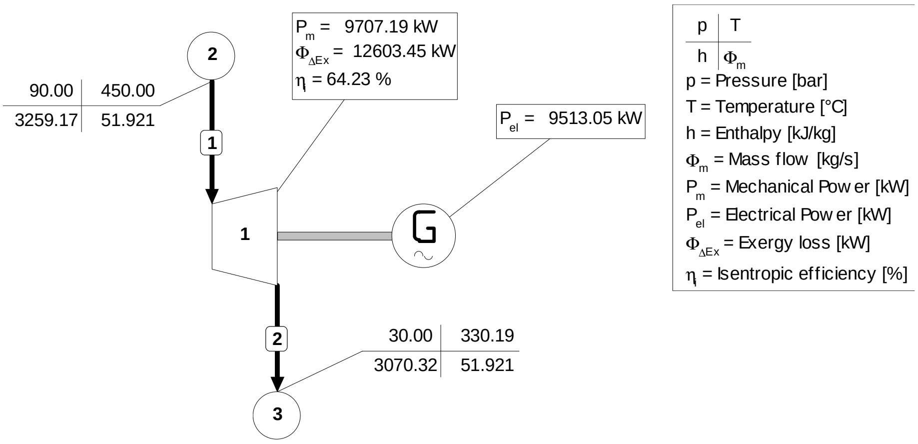

Figure 12 Results of the 40% off-design calculation, turbine with 1 row governing stage

1.3.6 Results of the off-design calculations, 2 row governing stage

Figure 13 shows the results for the 80% off-design calculation.

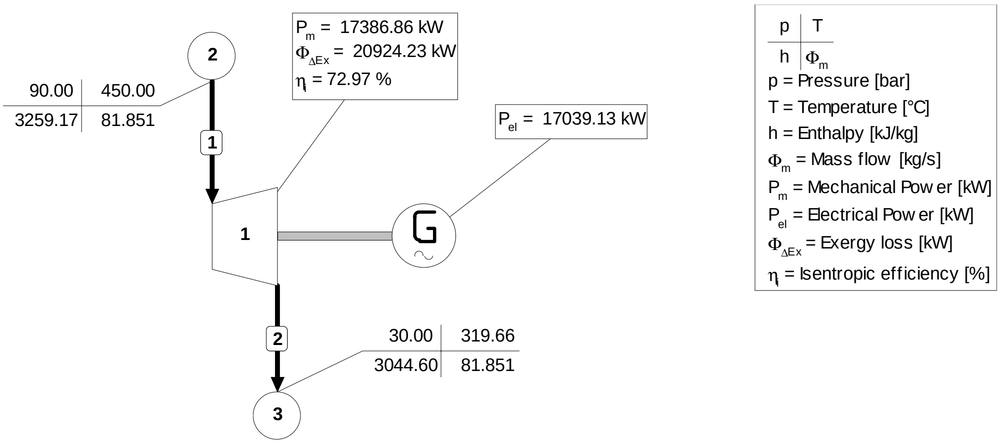

Figure 13 Results of the 80% off-design calculation, turbine with 2 row governing stage

Figure 14 shows the results of the 40% off-design calculation.

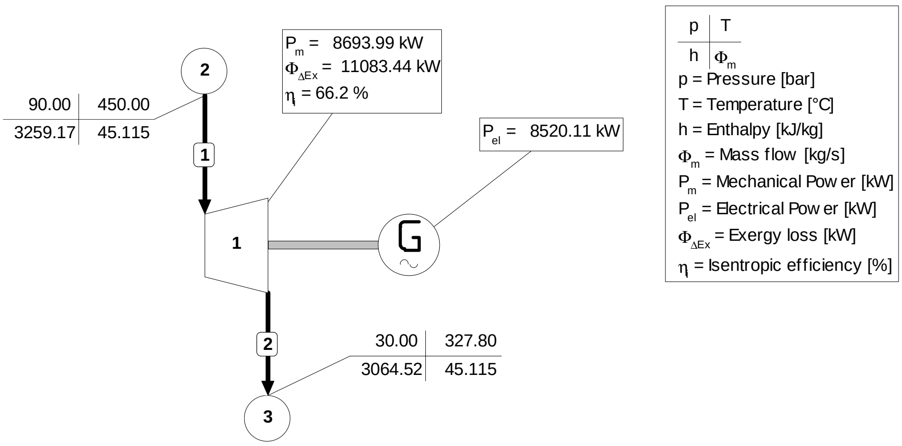

Figure 14 Results of the 40% off-design calculation, turbine with 2 row governing stage

2 Condensing turbine sections

In the previous chapter different types of high-pressure steam turbines were described. In this chapter the modelling of condensing sections will be treated. Again a closer look will be taken towards design and off-design situations for different types of turbines. The part-load conditions will be obtained by lowering the mass flows, while inlet and outlet pressures will be kept constant. All calculations are made by Cycle-Tempo version 4.14 with an accuracy of 1.0e-6. The environmental conditions are set to be like Baehr at 25º Celsius.

2.1 Condensing section MP + LP, 3000 rpm

The first type of turbine that is regarded is a 3000-rpm condensing section with an intermediate-pressure and a low-pressure section. The input pressure is 20 bar and the output pressure (condensing pressure) is 0.05 bar.

2.1.1 Input for the design load calculation

First the type of turbine needs to be specified by giving a value for the *TUCODE*. Table 2-2 on page 2-19 of the manual shows a *TUCODE*= 5mdLe, with:

m: number of parallel flows in the medium pressure part of the condensing section

d: outlet direction of the condensing section:

- d=1: downward at 3000/3600 rpm
- d=2: downward at 1500/1800 rpm
- d=3: axial, at 1500/1800 rpm

L: number of parallel flows in the low-pressure part of the condensing section

e: shape of the expansion line for condensing section

- e=0: straight expansion line in the *h-s* diagram
- e=1: curved expansion line

In this example a turbine is used with m=1, d=1, L=3 and e=0.

For the condensing turbine sections the sizes of the turbine are required for the calculations. This means that values have to be given for *DIAIN* and *SLENG*, where:

DIAOUT: pitch diameter of the last row of blades

SLENG: blade length of the last row of blades

In this example a turbine is used with *DIAOUT*= 72” (=1.8288 meter) and *SLENG*= 26” (=0.6604 meter).

Table 7 shows the input parameters for the design situation.

Table 7 Input parameters for the design calculation

Input parameters	
Turbine (Nr.1)	
TUCODE	51130
GDCODE	1
ETHAM	0.99
PIN	20 bar
DIAOUT	1.8288 m
SLENG	0.6604 m
Sink/Source (Nr.2)	
TOUT	530º C
DELM	-100 kg/s
Sink/Source (Nr.3)	
PIN	0.05 bar
Generator	
ETAGEN	0.98

With these input data Cycle-Tempo can start the calculation.

2.1.2 Results of the design load calculation

Figure 15 shows a plot with the results of the design calculation.

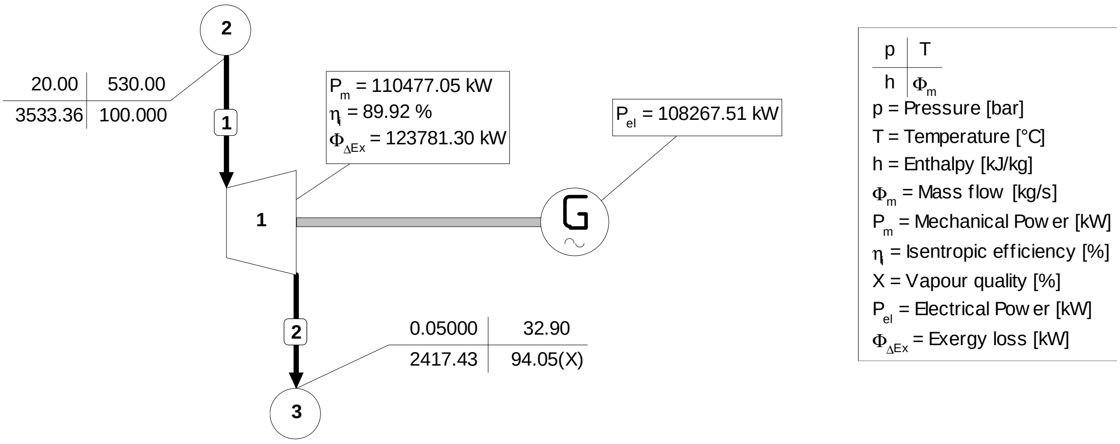

Figure 15 Results of the design load calculation

The plot of the results shows that Cycle-Tempo calculated an isentropic efficiency of 89.92% for the turbine. The steam quality at the outlet of the turbine is equal to 94.05%, which is acceptable for a condensing section.

2.1.3 Input for the off-design calculations

Two different ways of doing an off-design calculation will be discussed here in order to give the user a better understanding of the possibilities of doing such calculations with Cycle-Tempo. The first off-design situation is a situation where the mass flow is reduced to 80% of the mass flow in the design situation as discussed before to let Cycle-Tempo calculate the power and inlet pressure. This means that the mass flow has been set to $0.8 \times 100 = 80$ kg/s.
The second off-design situation is obtained by impose a power to the generator and let Cycle-Tempo calculate the mass flow and inlet pressure. The power that is imposed is equal to 80% of the power delivered in the design calculation: $0.8 \times 108.267 = 86.614$ MW.
In both situations the outlet pressure is being held constant at 0.5 bar and so is the inlet steam temperature of 530º C. Table 8 shows the input parameters for both situations.

Table 8 input for the off-design calculations

Input parameters	80% Mass-flow	80% Power
Production Function apparatus Nr.1	-	86.614 MW
Turbine (Nr.1)		
TUCODE	51130	51130
GDCODE	1	1
ETHAM	0.99	0.99
DIAOUT	1.8288 m	1.8288 m
SLENG	0.6604 m	0.6604 m
Off-design input data	pasted from design load model	pasted from design load model
Sink/Source (Nr.2)		
TOUT	530º C	530º C
DELM	-80 kg/s	-
Sink/Source (Nr.3)		
PIN	0.05 bar	0.05 bar
Generator		
ETAGEN	0.98	0.98

With these inputs Cycle-Tempo can start the calculations.

2.1.4 Results of the off-design calculations

Figure 16 shows the results for the off-design calculation with a mass flow of 80% of the mass flow in the design calculation.

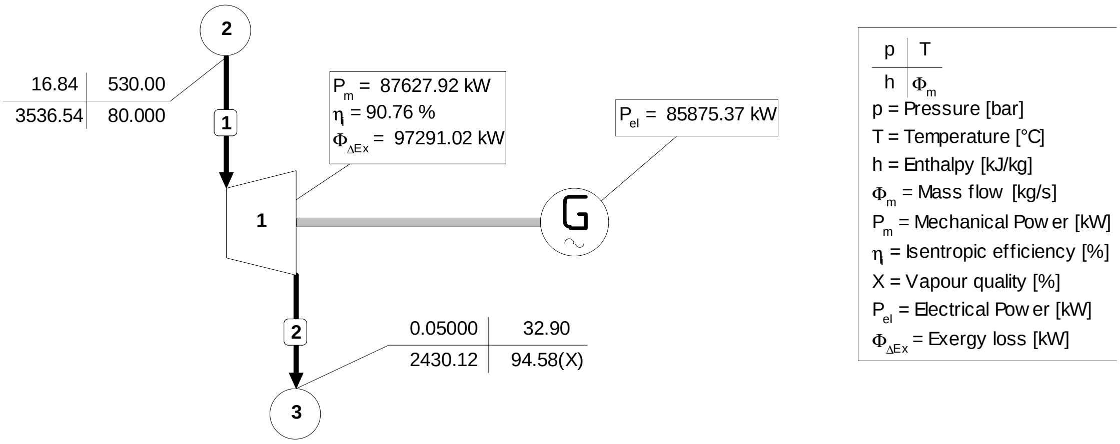

Figure 16 Results of the off-design calculation with 80% mass flow

In this example Cycle-Tempo has calculated the power delivery and inlet pressure, with a given mass flow.

Figure 17 shows the results for the off-design calculation with 80% of the power that was produced in the design calculation.

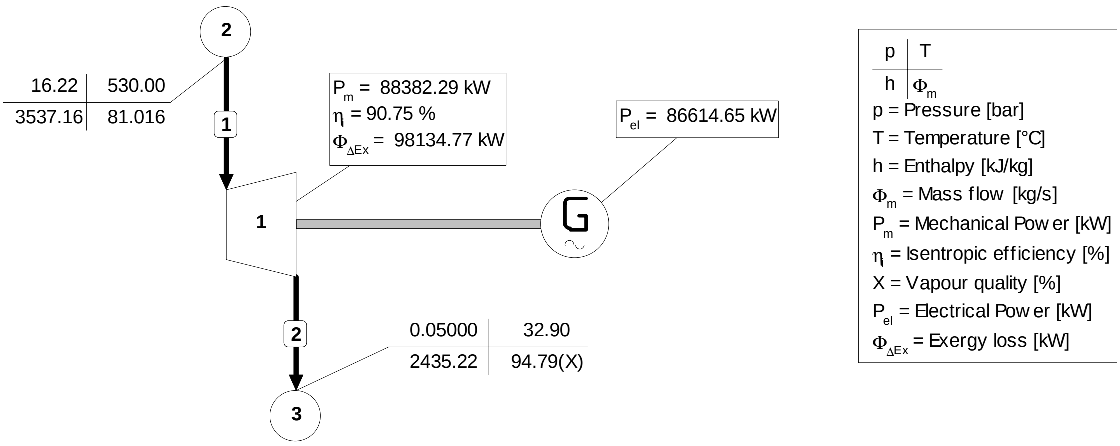

Figure 17 Results of the off-design calculation with 80% power delivery

In this example Cycle-Tempo has calculated the mass flow and inlet pressure, by using the power production that is specified by the user.

2.2 Condensing section cross compound 3000/1500 rpm

A different turbine configuration is the so-called cross compound unit, where the high-pressure section is a 3000-rpm section and the low-pressure part is a 1500-rpm section. The speed of the low-pressure element of a cross compound unit affects efficiency because 1500-rpm sections are more efficient than 3000-rpm sections. In this paragraph such a cross compound unit is modelled for design- and part-load conditions.

2.2.1 Input for the design load calculation

As in the previous example the turbine code must be specified. Table 2-2 gives a *TUCODE*= 8mdLe. The same inputs will be used as in the previous example (except for d=2), which means that the *TUCODE*= 81230.
In order to let Cycle-Tempo calculate the efficiency of the 1500-rpm section the pressure after the intermediate pressure section has to be specified by the user. For this example *PINCND*= 5 bar is used. The size of the final expansion stage will be different from the sizes of the previous example. For this example we use a pitch diameter of 115" (= 2.921 m) and a blade length of 38" (= 0.965 m).
The input parameters are shown in Table 9.

Table 9 Input parameters for the design calculation

Input parameters	
Turbine (Nr.1)	
TUCODE	81230
GDCODE	1
ETHAM	0.99
PIN	20 bar
DIAOUT	2.921 m
SLENG	0.965 m
PINCND	5 bar
Sink/Source (Nr.2)	
TOUT	530º C
DELM	-100 kg/s
Sink/Source (Nr.3)	
PIN	0.05 bar
Generator	
ETAGEN	0.98

2.2.2 Results of the design load calculation

Figure 18 shows the results for the design situation.

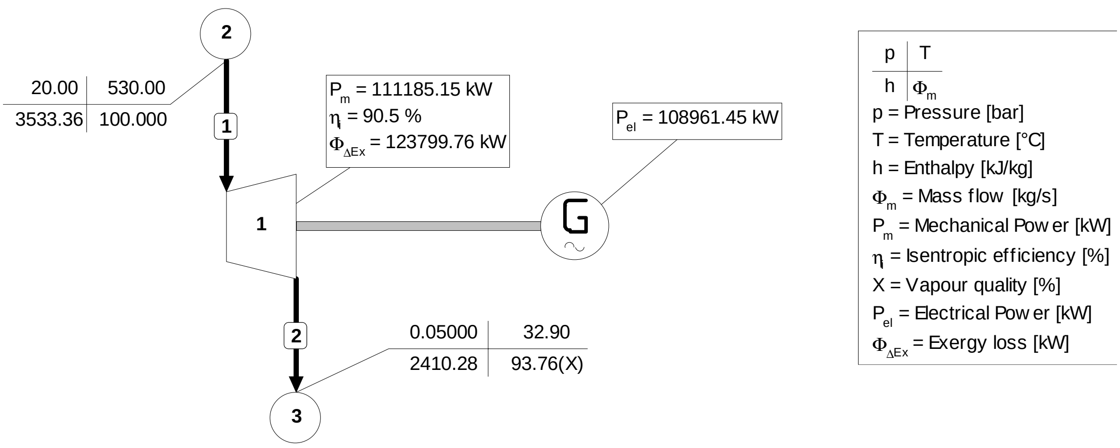

Figure 18 Results for the design situation

2.2.3 Input for the off-design calculation

In this paragraph an off-design situation will be considered that is obtained by introducing a production function for the turbine. This means that the turbine has to deliver the power that is defined by the user. Cycle-Tempo will calculate the accompanying mass-flow, inlet pressure and efficiency. For an off-design situation where the mass-flow is defined, we refer to paragraph 2.1.3. This situation will not be discussed here because of the similarity with the situation in the paragraph mentioned above.
A situation will be looked at where the turbine has to deliver 60% of the power that it delivers in the design situation. From the results for the design situation we see that this power is 108.961 MW.
This means that for the off-design calculation a production function is specified for apparatus nr.1 of $0.6 \times 108.961 = 65.377$ MW.
The input parameters for this off-design calculation are shown in Table 10.

Table 10 Input for the off-design calculation

Input parameters	**60% power**
Production Function apparatus Nr.1	65.377 MW
Turbine (Nr.1)	
TUCODE	81230
GDCODE	1
ETHAM	0.99
DIAOUT	2.921 m
SLENG	0.965 m
PINCND	5 bar
Off-design input data	pasted from design load model
Sink/Source (Nr.2)	
TOUT	530º C
Sink/Source (Nr.3)	
PIN	0.05 bar
Generator	
ETAGEN	0.98

With these data Cycle-Tempo can start the calculation.

2.2.4 Results for the off-design calculation

Figure 19 shows the results for the off-design situation.

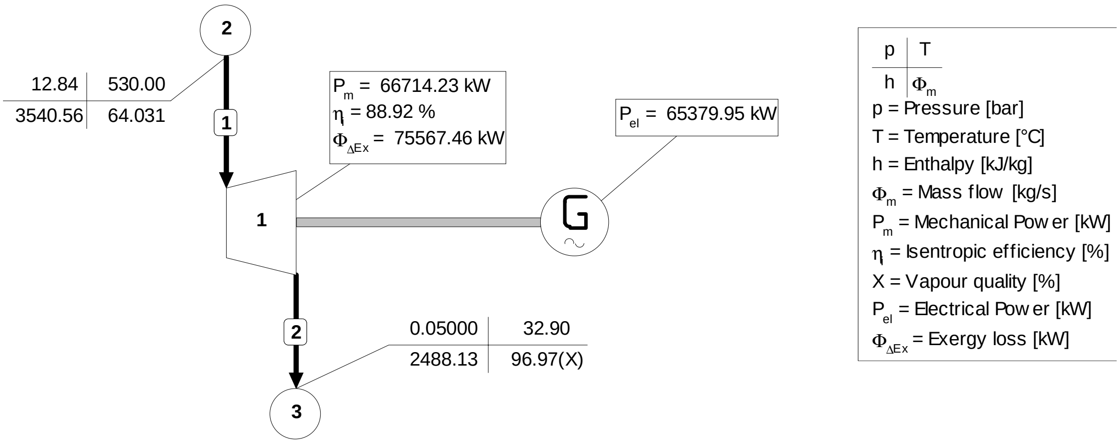

Figure 19 Results for the off-design situation

The user should note that there is a small difference between the imposed power by means of the production function and the power that is calculated by Cycle-Tempo. This is due to the accuracy that is used for this calculation. The user can define the accuracy of the calculation in the “calculation settings”-menu.

3 HP + condensing section steam turbine sets

In the last chapter different types of steam turbines were discussed. Here an example of a combination of the different types will be given as they can exist in power plants. The amount of combinations that can be modelled with Cycle-Tempo is almost endless. Only two examples will be given to give the user an idea of how a complete steam turbine set can be modelled with Cycle-Tempo. All calculations are executed with Cycle-Tempo version 4.14 with a relative accuracy of 1.0e-6.

3.1 Steam turbine set without reheat

In this configuration a high-pressure section with a 1 row governing stage (apparatus nr.1) is linked to an intermediate + condensing section (apparatus nr.2). Again a design load situation and a 60% part-load situation will be discussed. The scheme for this example is shown in Figure 20:

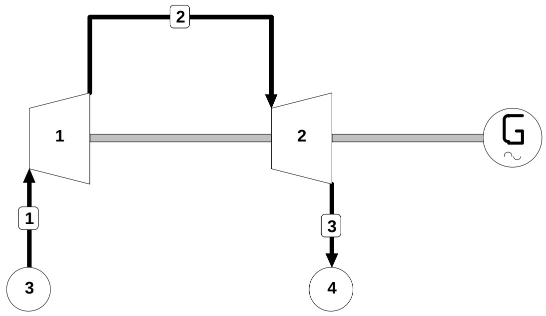

Figure 20 Scheme for the example without reheat

3.1.1 Input for the design load calculation

In this example a high-pressure steam turbine with a 1 row governing stage is used to expand steam with a pressure of 90 bar and a temperature of 530º Celsius to 20 bar. The steam is then expanded to 0.1 bar in an intermediate-/low-pressure turbine section. Table 11 shows the input parameters for this example.

Table 11 Input parameters for the design situation

Input parameters	
Turbine (Nr.1)	
TUCODE	21004
GDCODE	2
PIN	90
ETHAM	0.99
DIAIN	0.96
Turbine (Nr.2)	
TUCODE	51120
GDCODE	1
PIN	20
ETHAM	0.99
DIAOUT	1.66
SLENG	0.58
Sink/source (Nr.3)	
TOUT	530
DELM	-100
Sink/source (Nr.4)	
PIN	0.1
Generator	
ETAGEN	0.98

3.1.2 Results of the design load calculation

Figure 21 shows the plot with the results for the design calculation.

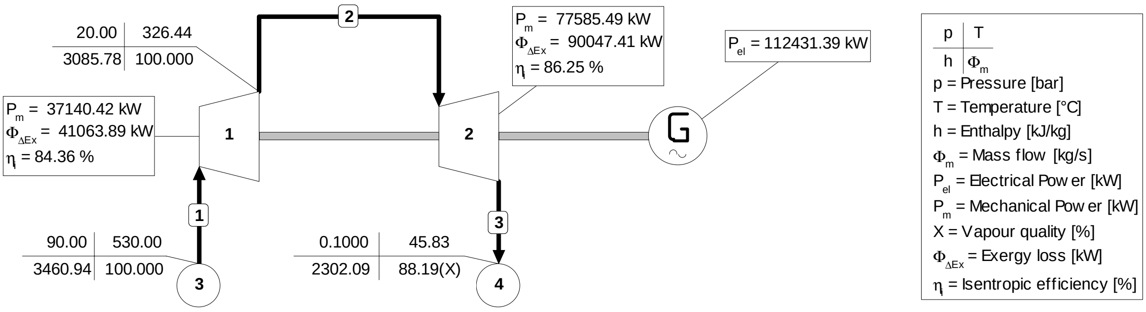

Figure 21 Results for the design calculation

Cycle-Tempo has calculated turbine efficiencies with the method of General Electric, which is explained in the user manual. The user can now see the delivered power and the steam quality after expansion in the condensing section.

Cycle-Tempo can also make an *h-s* diagram which shows the expansion in the two turbine sections, see Figure 22.

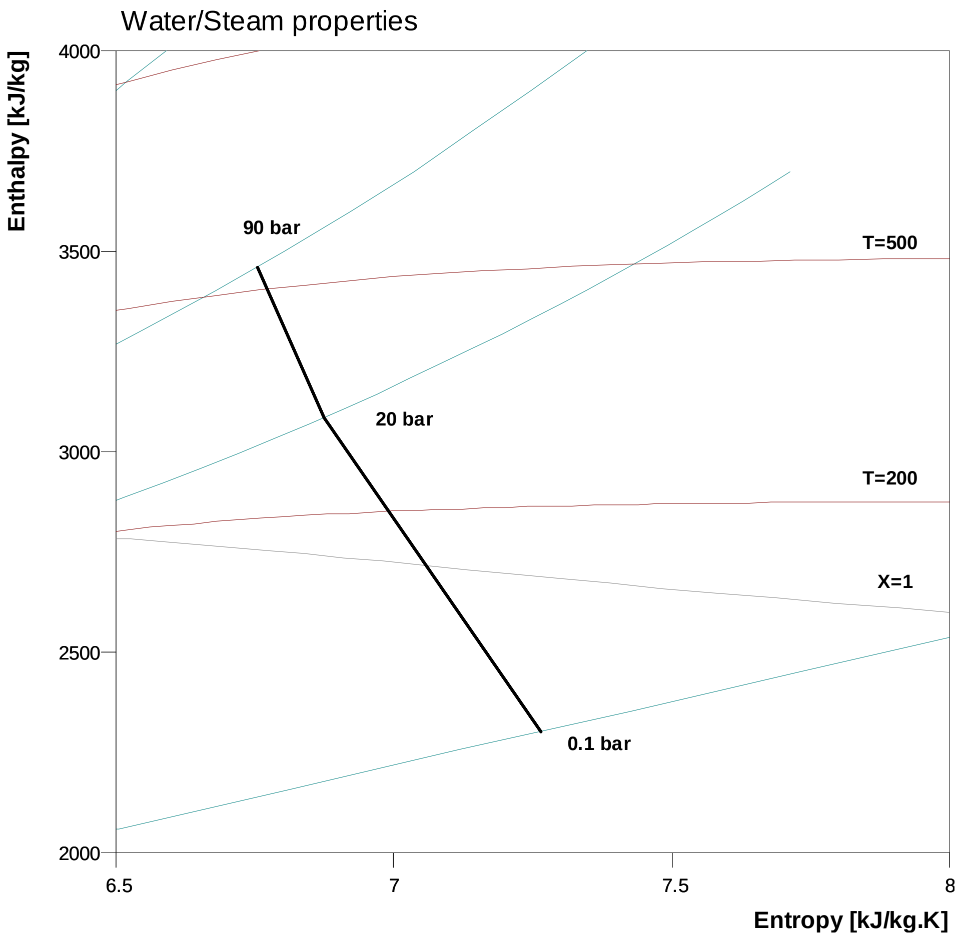

Figure 22 ***h-s diagram***

In the *h-s* diagram the expansion in two different turbine sections is made clear. The difference in the slopes of the expansion trajectories is caused by the different efficiencies of the sections.

3.1.3 Input for the off-design calculation

In this off-design calculation the turbine sections have to deliver a power that is 60% of the power delivered in the design situation. This means that a power has to be imposed of:

$0.6 \times 112431 = 67458.6$ kW.

This power is imposed by defining a production function for the turbines (apparatus 1 & 2).
The high-pressure turbine is a turbine with a 1-row governing stage, so the inlet steam pressure is kept constant, as is the temperature of the steam at the inlet. Cycle-Tempo will calculate the new mass-flow. The input parameters are shown in Table 12.

Table 12 Input parameters for the off-design calculation

Input parameters	
Production function apparatus 1,2	67.459 MW
Turbine (Nr.1)	
TUCODE	21004
GDCODE	2
PIN	90
ETHAM	0.99
DIAIN	0.96
Off-design input data	pasted from design load situation
Turbine (Nr.2)	
TUCODE	51120
GDCODE	1
ETHAM	0.99
DIAOUT	1.66
SLENG	0.58
Off-design input data	pasted from design load situation
Sink/source (Nr.3)	
TOUT	530
Sink/source (Nr.4)	
PIN	0.1
Generator	
ETAGEN	0.98

Cycle-Tempo can now calculate the desired properties.

3.1.4 Results of the off-design calculation

Figure 23 shows the output of the off-design calculation.

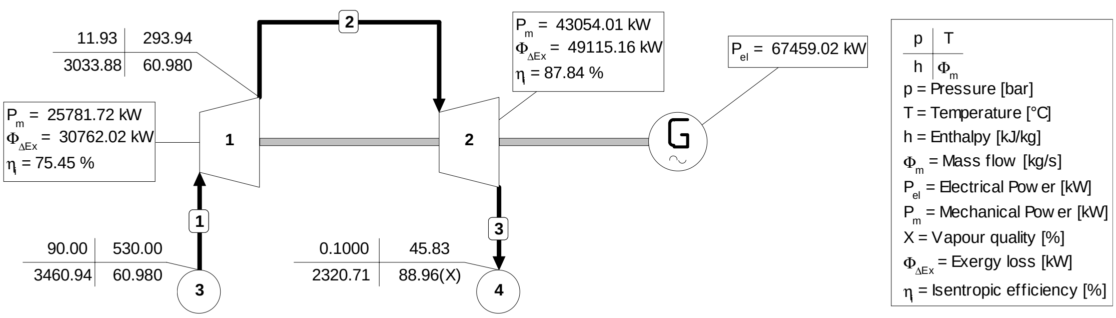

Figure 23 Output of the off-design calculation

Cycle-Tempo has calculated that a power of 67.459 MW is delivered by decreasing the mass-flow to 60.98 kg/s.

3.2 Steam turbine set with reheat

This configuration is similar to the configuration that was discussed in the last paragraph, except for the fact that a reheater (apparatus nr.5) is added that reheats the steam after expansion in the high-pressure turbine. The reheat temperature is similar to the temperature of the steam at the inlet of the high-pressure section. Furthermore the high-pressure turbine is not equipped with a governing stage and part-load conditions will be modelled by using sliding pressure control.
The scheme for this example is shown in Figure 24.

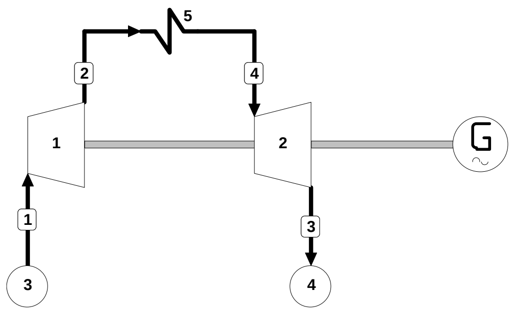

Figure 24 Scheme for the example with reheat

3.2.1 Input for the design load calculation

Steam with a mass-flow of 100 kg/s, a pressure of 90 bar and a temperature of 530º Celsius is expanded in a high-pressure turbine to 20 bar. Then the steam is reheated to 530º Celsius and expanded in an IP/LP turbine section to 0.1 bar. For simplicity the pressure loss over the reheater is set to zero.
The input parameters for this example are given in Table 13.

Table 13 Input parameters for the design calculation

Input parameters	
Turbine (Nr.1)	
TUCODE	10000
GDCODE	1
PIN	90
ETHAM	0.99
Turbine (Nr.2)	
TUCODE	51120
GDCODE	1
PIN	20
ETHAM	0.99
DIAOUT	1.66
SLENG	0.58
Sink/source (Nr.3)	
TOUT	530
DELM	-100
Sink/source (Nr.4)	
PIN	0.1
Reheater (Nr.5)	
DELP	0
TOUT	530
Generator	
ETAGEN	0.98

The next paragraph discusses the results of this calculation.

3.2.2 Results of the design load calculation

Figure 25 shows the results of the design calculation.

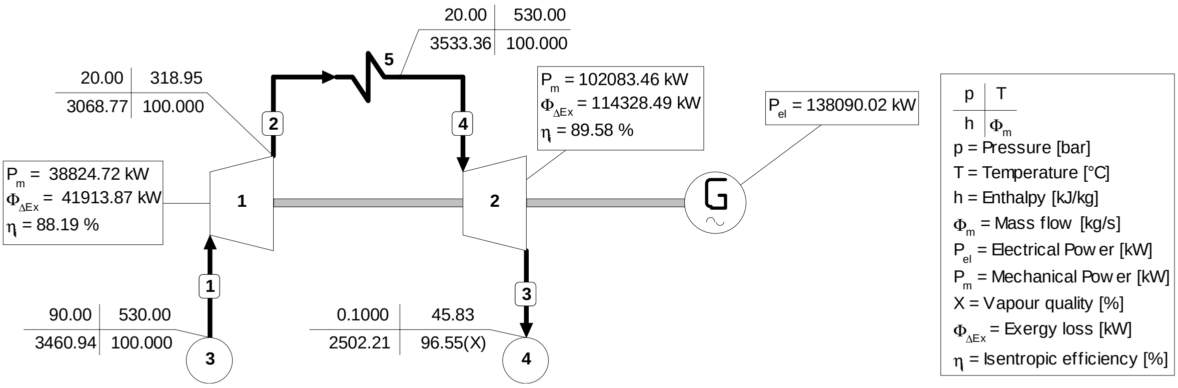

Figure 25 Results of the design situation

The user should note that the power delivered by the turbines is higher then in the situation without reheat. As is expected the steam quality at the outlet of the condensing section is higher then in the example without reheat.
An example of a *T-s* diagram is given to show the process of expansion, reheat and the second expansion.

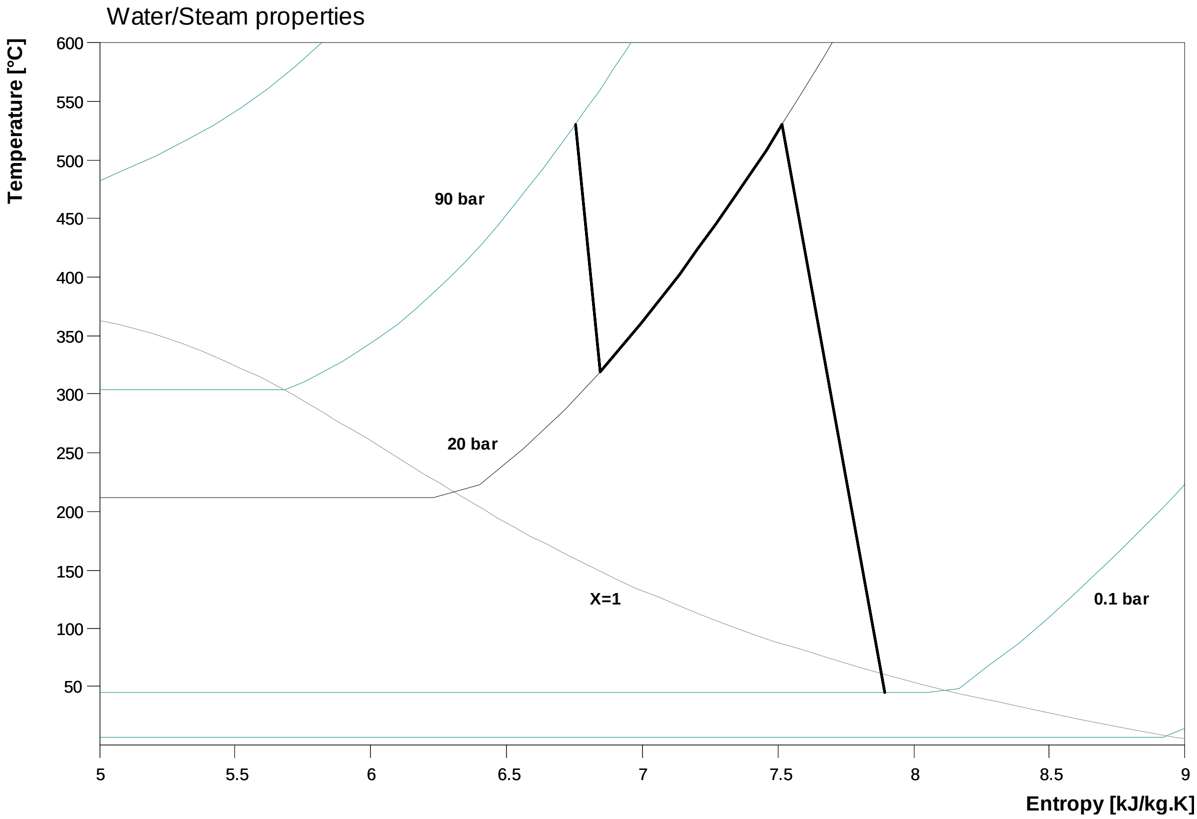

Figure 26 *T-s* diagram of the example with reheat

3.2.3 Input for the off-design calculation

Again the off-design situation will be looked at where the turbines deliver 60% of the full load power. In this case that means a power production of:

$$0.6 \times 138090 = 82854 \text{ kW}$$

The high-pressure turbine section has no governing stage and the part-load conditions are modelled by using sliding pressure control. The input parameters are shown in Table 14.

Table 14 Input parameters for the off-design situation

Input parameters	
Production function apparatus 1 & 2	82.845 MW
Turbine (Nr.1)	
TUCODE	10000
GDCODE	1
ETHAM	0.99
Off-design input data	pasted from design load situation
Turbine (Nr.2)	
TUCODE	51120
GDCODE	1
ETHAM	0.99
DIAOUT	1.66
SLENG	0.58
Off-design input data	pasted from design load situation
Sink/source (Nr.3)	
TOUT	530
Sink/source (Nr.4)	
PIN	0.1
Reheater (Nr.5)	
DELP	0
TOUT	530
Generator	
ETAGEN	0.98

3.2.4 Results of the off-design calculation

Figure 27 shows the results off the off-design calculation with the input parameters of Table 14.

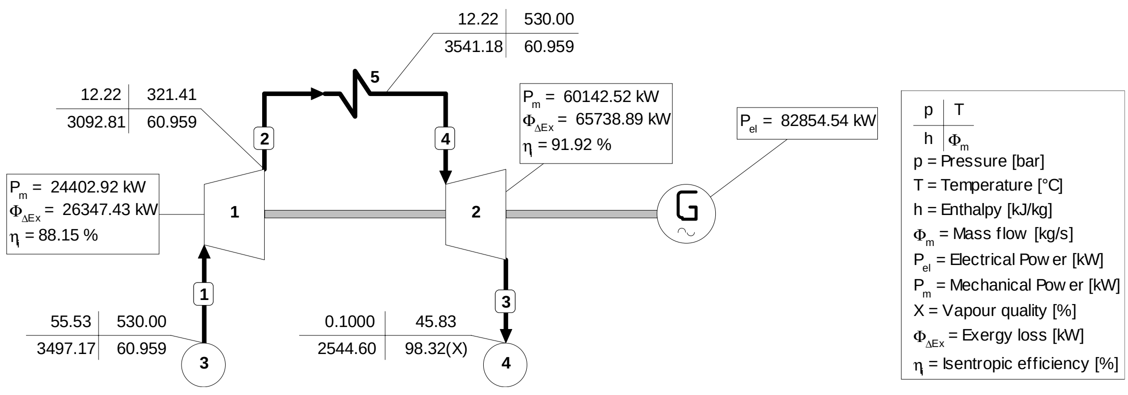

Figure 27 Results of the off-design calculation