3. Flows must be compatible at system interfaces

Common problems

Problems, typically indicating that condition no 3 is not met:
- The installed power is not transmittable when required, especially at high load
- The design supply temperature is too low (heating) or too high (cooling)
- Long time before all rooms reach correct temperature at start-up after each setback

In many systems, the installed power exceeds the maximum required by 50 % and the distribution circuits still do not receive enough power. The power boilers and chillers produce simply does not reach the heating or cooling circuits. This problem can be particularly in systems with several chillers or boiler working in sequence. The reason is usually a lack of compatibility at the interfaces between production and distribution.
With a heat exchanger between production and distribution, as in district heating for example, water flows may, of course, be different without any problems. But in most systems, production and distribution circuits are in direct contact with each other and this can cause serious and often mysterious disturbances, unless one takes adequate measures to avoid them.

Hydraulic interactivity

Hydraulic interactivity between different units takes place when several units in parallel share a common resistance, which means that any variation of flow through one circuit affects the flow in the other circuits. The larger this common resistance is the larger is the interactivity between the circuits.

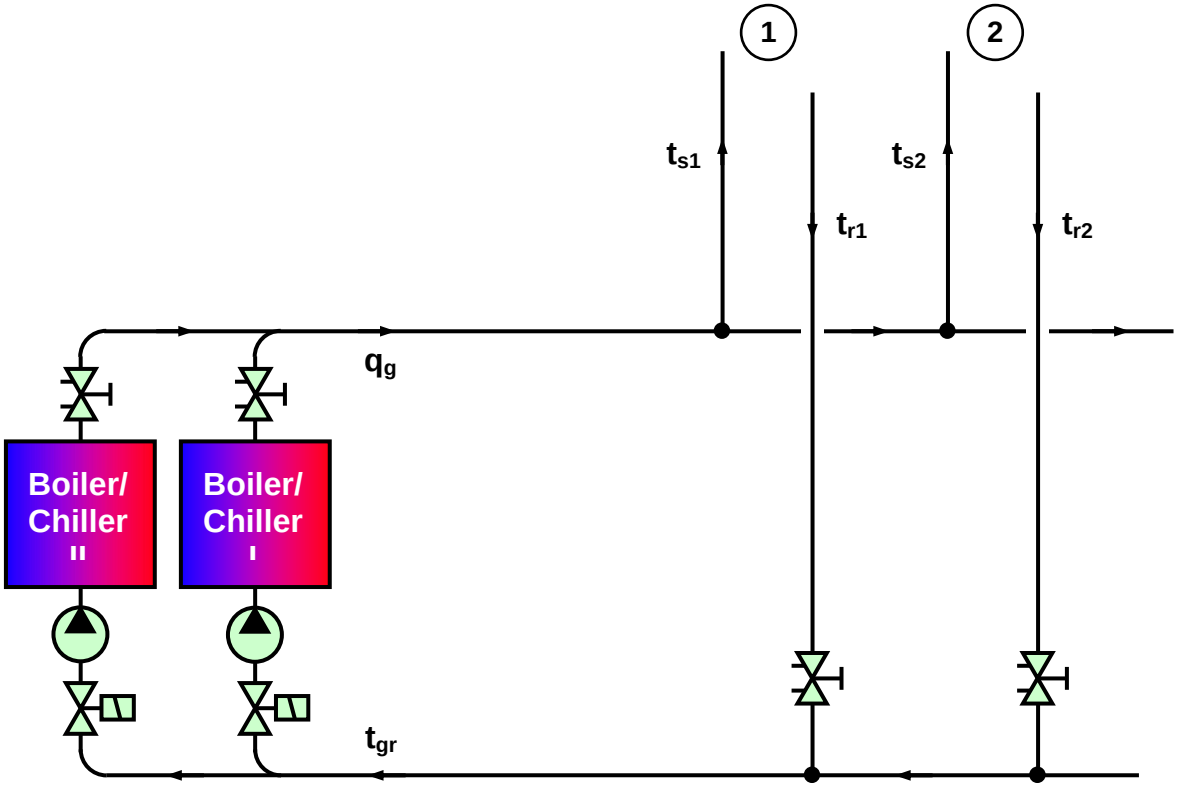

Fig 1
Two boilers/chillers in parallel

The two boilers/chillers create a common resistance for the distribution circuits and thus any change in flow for one circuit will affect the flow in the other. Furthermore, the boilers will be supplied at variable flow, which is not acceptable for standard boilers. In the chiller case, when the second chiller is switched on, the total flow will not change so much since most of the pressure drop is in the distribution. Then suddenly, the flow in the first chiller drops and as the chiller power does not drop in the same time, the temperature in the evaporator can reach the freezing point.

Decoupling with a by-pass

A by-pass line, with no or low pressure drop, between production and distribution solves these interactivity problems, but compatibility between the production and distribution flows has to be assured

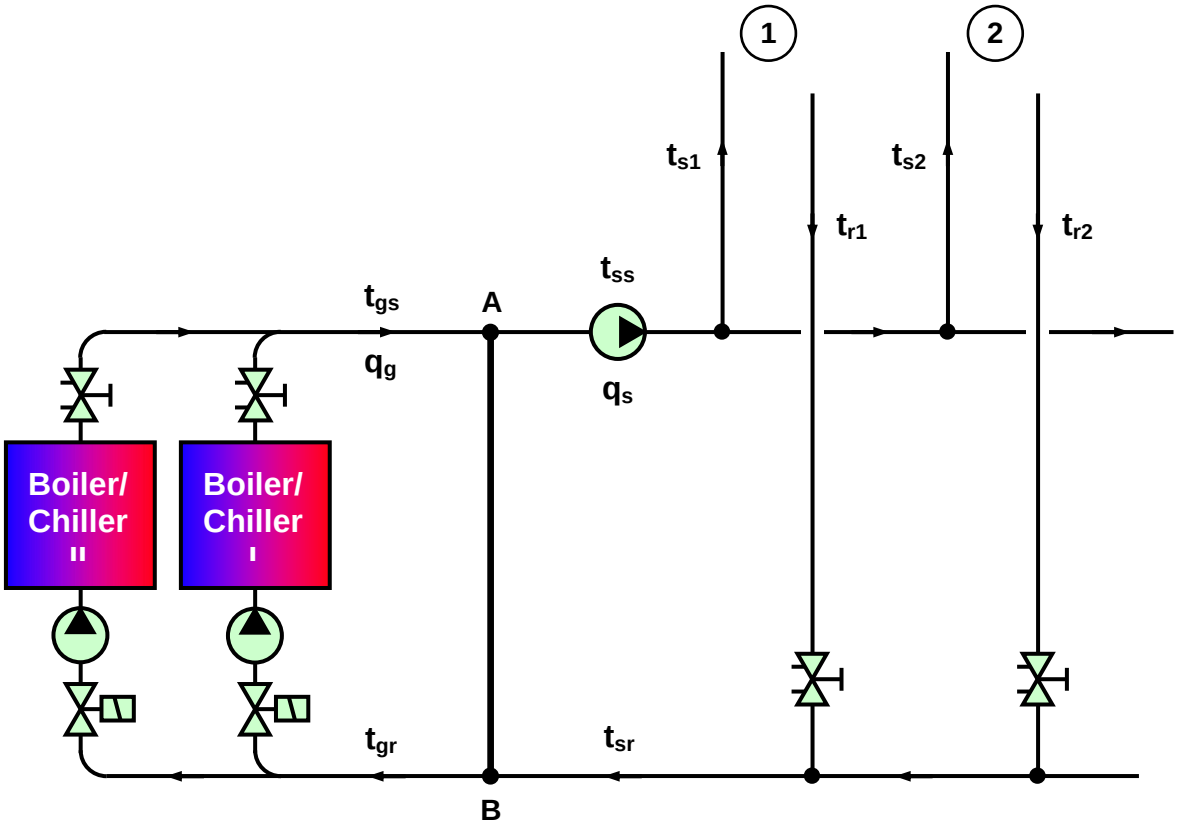

Fig 2
Decoupling with a by-pass

A by-pass between A and B keeps the differential pressure between these points close to zero and there will be no interactivity between the circuits, nor between the boilers/chillers. Furthermore, it will be a constant flow in each boiler and there is no risk of freezing in the chiller case. The by-pass avoids any interactivity, but since there is no (or very little) pressure drop between A and B, a secondary pump is required. However, solving interactivity problems with a by-pass creates compatibility problems unless correct measures are taken

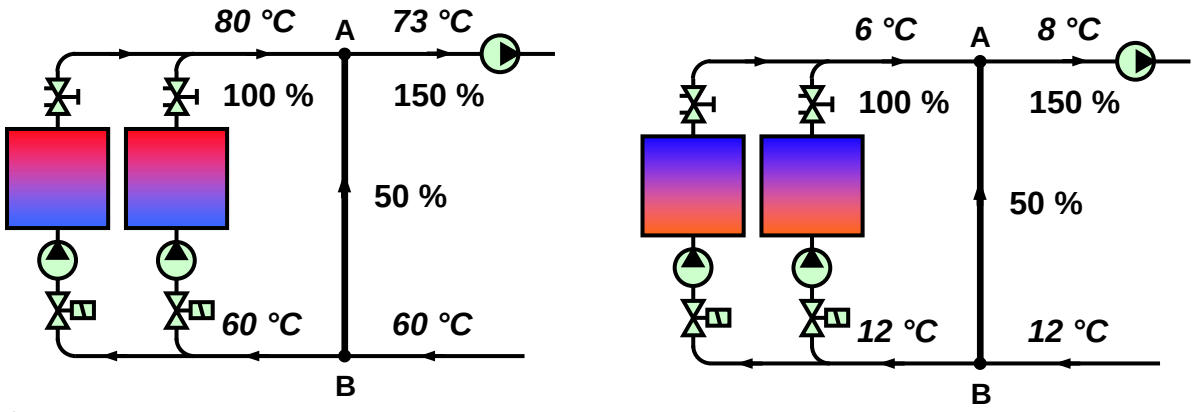

Fig 3
Incompatibility problems in heating and cooling

In these examples the secondary pump is oversized and the distribution takes 150 % flow, whilst the production x2units only deliver 100 %. The difference, 50 %, has to go through the by-pass in direction B to A, creating a mixing point between supply and return water at A and the correct supply temperature cannot be reached. In the heating example, the supply temperature will only be 73 °C instead of the desired 80 °C and in the cooling case the supply temperature will be 8 °C instead of the produced 6 °C.

This can happen even if the secondary pump is not oversized, e.g. if the distribution is not properly balanced. If so, there will likely be an overflow at each start up, creating the same problem.

Then, what to do? Since the required power is not transmittable, especially at high loads when really needed, the room temperature will be too low in heating and too high in cooling. People will complain about this situation and there will be demands for some actions.

- Increase the pump?

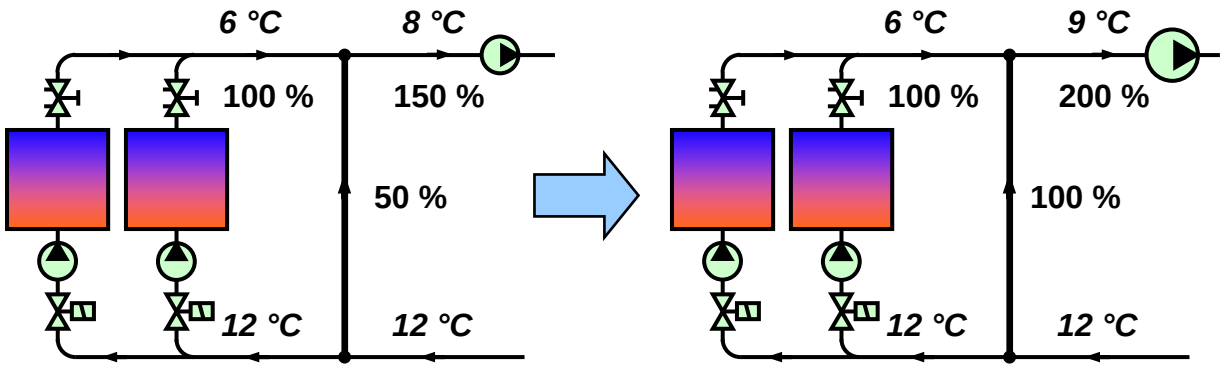

Fig 4
Increasing the secondary pump head

Increasing the distribution pump head as a reaction to complaints might look quite natural, but it will make the situation even worse. The root cause of the problem is a too high secondary flow and an even bigger flow will just increase the flow incompatibility and therefore the mixing. The supply water temperature will decrease further in heating and increase further in cooling, in this case from 8°C to 9°C.

- Add a production unit?

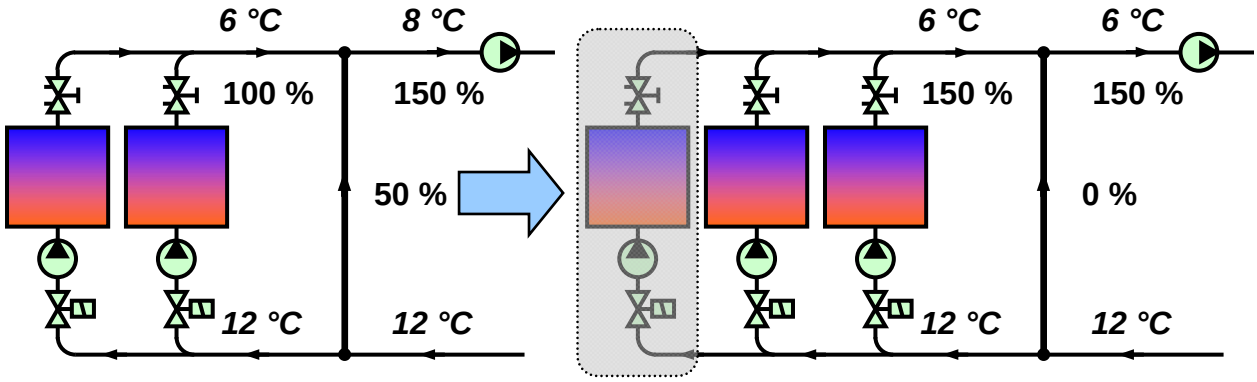

Fig 5
Adding a production unit

Adding an extra production unit can solve the incompatibility problem, but at the very high cost of an unnecessary production unit. In the example given, we add another 5 0% flow from this extra unit, equalizing the flows between production and distribution, making it possible to achieve the design supply temperature. This is, of course, not a good solution since the problem is not a problem of lack of installed capacity, it is a problem of too high flow in the distribution.

- Change the set-point?

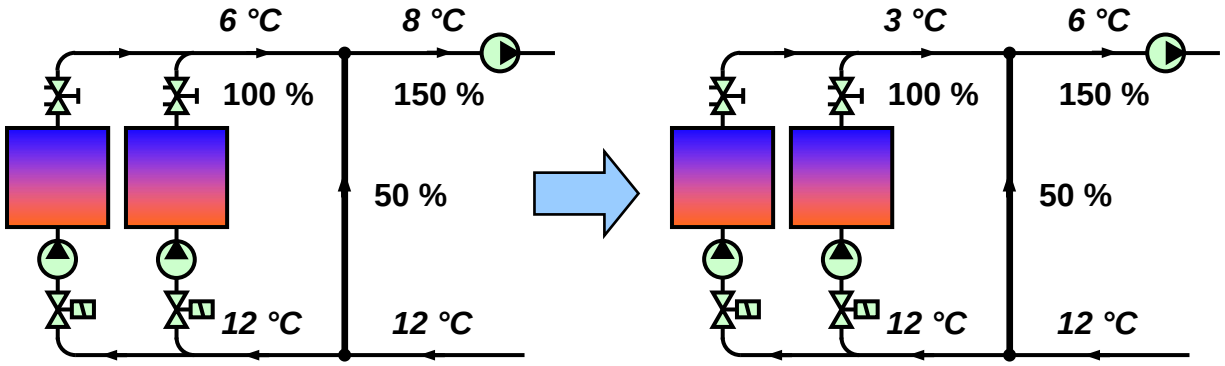

Fig 6
Decreasing the set-point

Decreasing (raising in heating) the set-point of the production unit can compensate for the incompatibility and it will be possible to get the correct supply temperature. However, this will drastically increase the energy cost for the plant and is therefore not a recommended solution.

- Balance the flows?

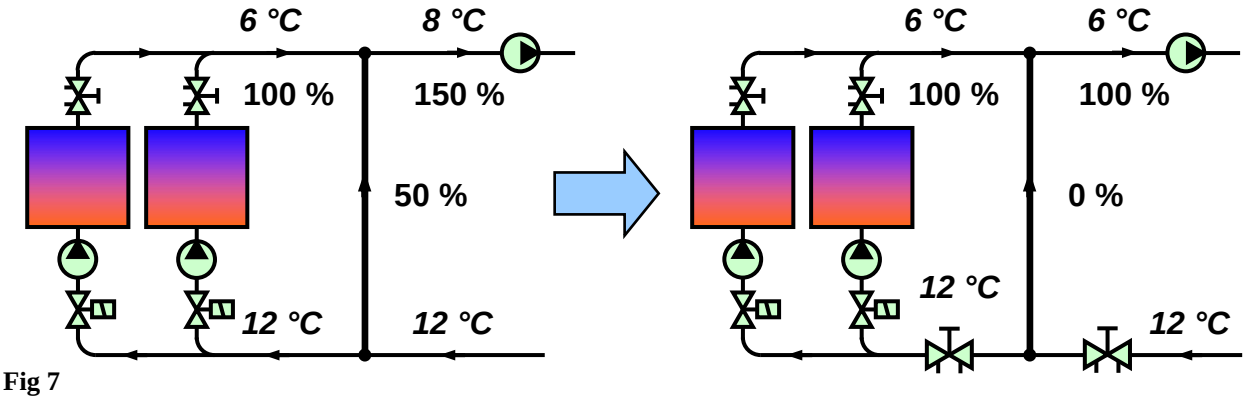

Fig 7
Balancing the production and distribution flows

The incompatibility problems described earlier depends solely on a too high flow in the distribution and it is inevitable that the correct measure is to equalize the production and distribution flows by balancing. In doing so, there will be zero flow in the by-pass line and the correct flow and supply temperature will be transferred from the production to the distribution.
This measure is not only valid between production and distribution; it should be done at every system interface, i.e. where different circuits are in contact with each other.

Conclusion

In order to avoid interactivity problems, a by-pass line between production and distribution is the best solution. However, solving interactivity problems in this way, may lead to compatibility problems if correct measures are not taken. Oversizing the plant, adding extra boilers or chillers, increasing the pump head or changing the set-point will only aggravate the problems or possibly solve them at a very high and unnecessary cost. The correct solution is simply to balance the flows on each side of every interface, which will give the best operation and the lowest costs.

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