HEATBOXQUALITY – DECETRALIZED HYDRAULIC STATIONS ON TESTING RIG

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Abstract

The heat supply for terraced houses and apartment buildings via a 2-pipe network in connection with decentralized hydraulic stations (so called heat boxes) has become more and more important in the past years due to numerous technical advantages (minimum heat losses and return pipe temperature, maximum water hygiene and comfort).

The decentralized hydraulic station plays a very important role in the 2-pipe network, as both the hydraulics and the regulation of the domestic hot water generation and the space heating are integrated in this station.

The heat box also includes the components for the hydraulic alignment with parallel consumers (other flats) and the instruments for the heat- and water accounting.

The quality of the realisation of all these functions is finally responsible for satisfying the users-comfort as well as achieving highest energy efficiency.

Nevertheless, in the past no profound testing methods and measuring results and no key figures were available which guaranteed the quality and enabled a comparison of different products.

This circumstance provided the motivation for the project "HeatBoxQuality", which focused on the development of an adequate testing method, the setting up a test rig, the test of nine products of the five Austrian main suppliers, basic work for further targeted optimization.

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1. Assessment criteria, testing scenarios and test rig

As mentioned before, many tasks occur on hydraulic stations. For a better understanding of project methology and project results, the main energy relevant functions of hydraulic stations are summarised.

- **Domestic hot water generation:** The hot water generation works in flow-through principle with a plate heat exchanger. Here a so called "proportional flow controller" (a mechanical device), regulates the primary supply volume flow, if secondary hot water is tapped.

- **Space heating:** Also the space heatingis performed via the hydraulic station. If the station is equipped with a so called ”priority domestic hot water generation”, the space heating is shut down during hot water generation. If that function works properly, the primary supply flow rate is reduced on a lower level.
- **Stand-by-operation:** At this operating state a low amount of primary heating water flows over a so-called “keeping-warm-bypass” or “circulation-bridge”, to keep the supply line warm until to the heat exchanger.

The aim of the project was to measure and analyse these functions of a hydraulic station and present the quantitative result with a special focus on the achieved user-comfort and achieved energy-efficiency. The following evaluation parameters were defined.

Comfort parameters:

Water temperature, temperature fluctuations, time until proper temperature is reached

Performance parameters:

Maximum tapping flow rate, maximum flow rat for space heating

Energy-efficiency parameters:

Primary grid flow-rate, return flow temperature

In order to determine these comfort parameters, performance parameters and energy efficiency parameters, four scenarios were developed and transformed into reproduceable sequences via a programmable logic controller. The four scenarios including the variation of parameters are:

Scenario 1 – Function of the domestic-hot water generation at defined tapping profiles

The test starts with a stand-by operating phase in that the Station is warmed up to operation temperature. Then theses defined tapings (flow-rate 4-, 7-, 10 l/min, duration 4 min; combination of flow rates and max. flow-rate) happen. Finally the scenario is closed with a 60 min. stand-by-operation. In that scenario the following parameters were varied: primary grid temperature (50°C-70°C), primary grid differential pressure (100 – 500mbar), cold water pressure (1.5 – 3.5 bar) and cold water temperature (10°C – 15°C). This bandwidth of variations resulted in 13 runs of this test with every hydraulic station.

Scenario 2 – determination/identification of the primary hydraulic characteristic curves

The primary supply differential pressure (from maximum to zero) decreases continuously during a constant tapping flow rate. In this scenario the cold water pressure is varied what results in 3 run-throughs for each station.

Scenario 3 – determination of the proportional characteristic

The tapping flow rate increases continuous until maximum followed by a continuous decrease of the tapping flow rate at constant supply parameters (primary temperature and primary differential pressure). In this scenario the supply differential pressure varied as well as the cold water pressure which resulted in 7 test runs with each station.

Scenario 4 – combined operation of domestic hot water generation and space heating

The test starts and ends with a stand-by operation phase. Between tapping profiles got overlapped with space heating operation. In this scenario the primary supply differential pressure, the space heating flow rate and the cold water pressure varied, and so each station has to go through 9 tests-runs.

The implementation of these scenarios in a test rig which consists of the hydraulic, control, measurement as well as data-logging combines, was done in the test lab of the AEE-INTEC.

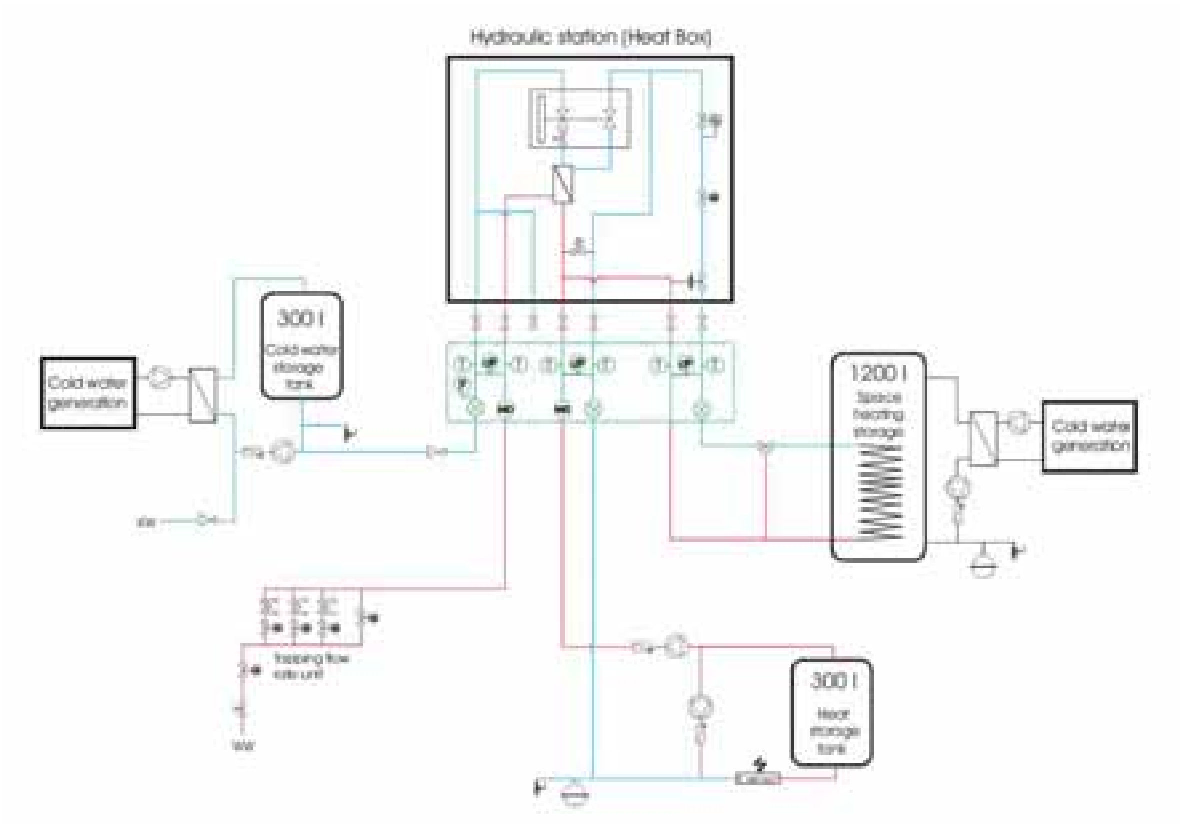

Fig. 1. block diagram of the test rig incl. the defined measurement values (green box)

All in all nine different hydraulic stations of the five major suppliers in Austria were tested. Seven of these stations were designed for radiator heating (five with conventional “proportional flow controller”, two with additional temperature corrective). One of the tested Stations was designed for floor/wall-heating-system and one Station was designed for applications with extreme reduced supply temperatures. All hydraulic stations were tested with its factory settings, without any adaptation from the project team.

2. Measurement results

The measurement results of the single hydraulic stations, test scenarios and the parameter variation were visualised in time-line diagrams. These diagrams were the basis for many comparison diagrams of the different hydraulic stations. Some of these comparison diagrams are presented in the following.

Figure 2 shows on the basis of Scenario 1, domestic hot water temperatures and primary return pipe temperatures over the tapping flow rate at a constant supply differential pressure of 300 mbar.

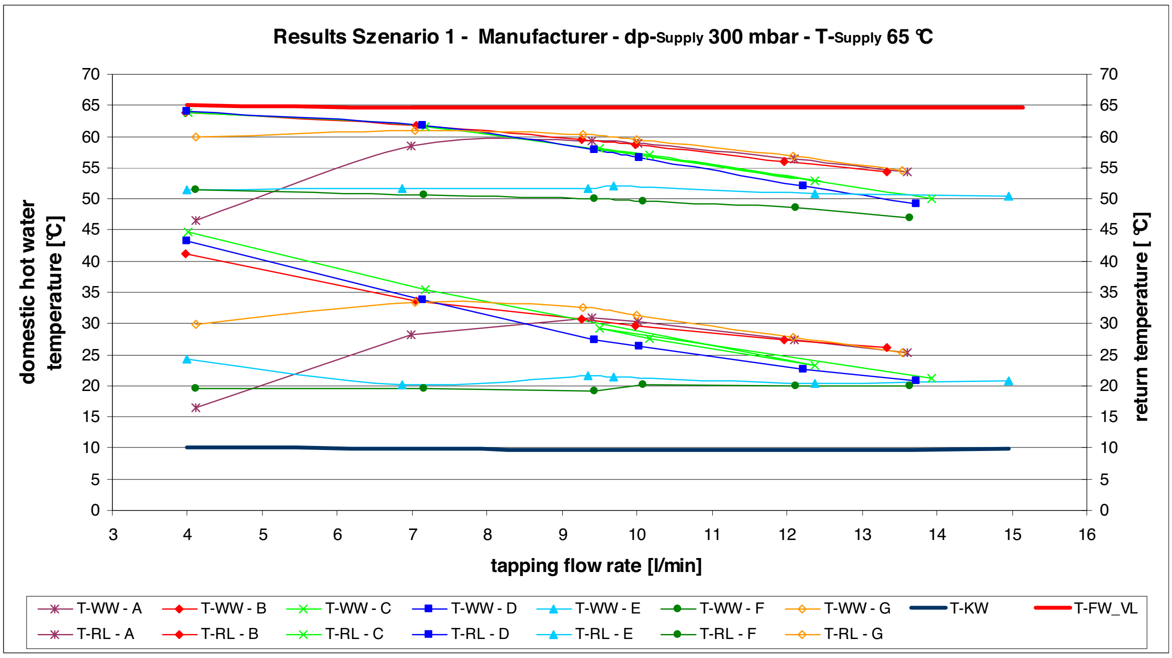

Fig. 2. Analysis Scenario 1 – hot-water temperature (upper curves) and return pipe temperatures (lower curves) on the Y-Axis over the tapping flow rate on the X-Axis. The seven Stations for radiator-heating operated on constant supply parameters (dp_{Sup}= 300mbar, T_{Sup}=65°C)

With these frame conditions in all hydraulic stations the hot water temperature never drops below the defined comfort limit of 45°C, at low as well as at high hot-water tapping flow rate.

Concerning the return pipe temperature, the diagram shows that with all stations at tapping flow rates above 6 l/min return pipe temperature does not exceed 35°C. The bandwidth on the domestic hot water as well as on the return pipe temperature results from the functional principle of the proportional flow controller. Constant hot water temperatures and very low return pipe temperatures (20°C) show the two hydraulic stations which support the proportional flow controller with an additional hot water temperature corrective (stations “E” and “F”)

Figure 3 shows the supply differential pressures for the different 7 stations that are necessary to reach the defined comfort parameter 45°C at a maximum tapping flow rate. It shows the bandwidth between 130 and 240 mbar referring to the defined surrounding conditions. The return pipe temperature at these operating points is lower than 20°C.

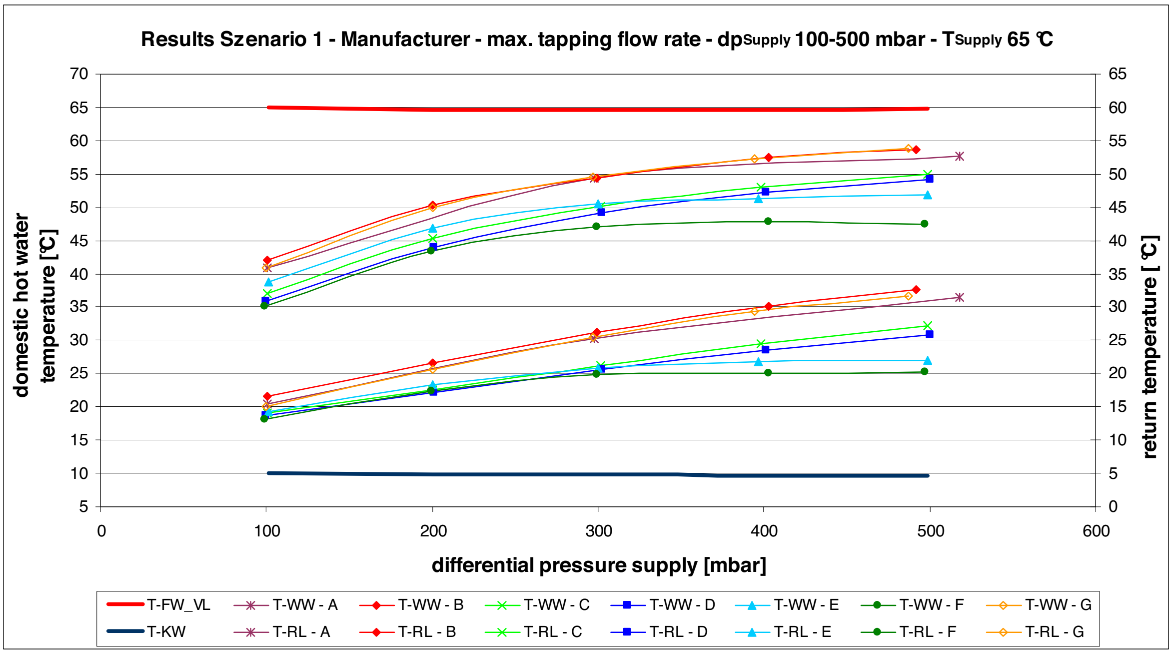

Fig. 3. Analysis Scenario 1 – Domestic hot-water temperature (upper curves) and return pipe temperatures (lower curves) on the Y-Axis over the supply differential pressure on the X-Axis. The seven Stations for radiator-heating operated on constant supply and demand parameters (T_{Sup}=65°C, max. tapping flow rate)

In order to characterise the proportional behaviour of the hydraulic station the so called "proportional factor" (quotient of primary supply flow rate and tapping flow rate) was defined. In a theoretical optimum this factor is at a value of 1throughout the spectrum of tapping flow rate. This would implicate lowest supply flow rates and lowest return pipe temperatures throughout the tapping spectrum.

Figure 4 shows the characteristic curves of the proportional factors of the seven stations (radiator-heating type). The diagram shows that the characteristics are very different from each other and not typically in the above mentioned optimum. They don't show necessarily a proportional behaviour. The two Stations with the additional temperature corrective get very close to the theoretical optimum.

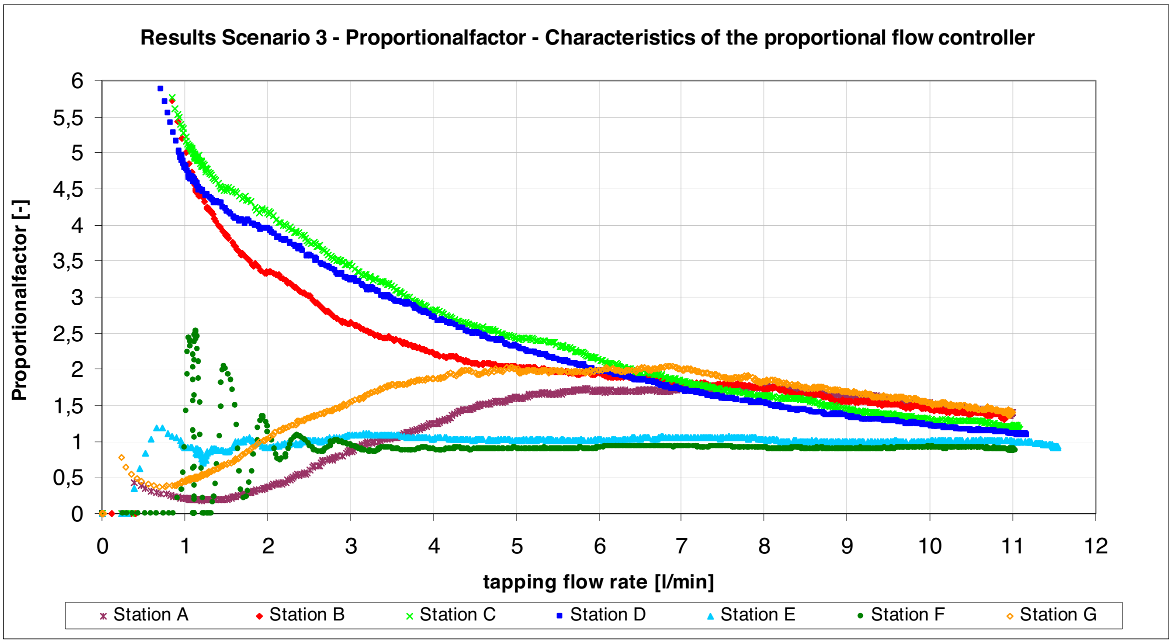

Fig. 4. Proportional factors (supply flow rate/ tapping flow rate) of the 7 candidates with completion standard "radiator-heating system"

Another essential detail for energy efficient operation of a hydraulic station is given by setting the right temperature levels for stand-by operation. The temperatures reached in this operating mode with the seven stations (completion: radiator-heating) are given by Figure 5. The analysed temperature levels are for the supply pipe in a bandwidth between 40°C to 55°C and also temperatures in the return pipe are in a bandwidth between 35°C to 45°C. Although with some products the valves could be set at a lower temperature level in the factory, it can be said that the flow rates in that operating mode is very low with a maximum flow rate up to 0.5 l/min.

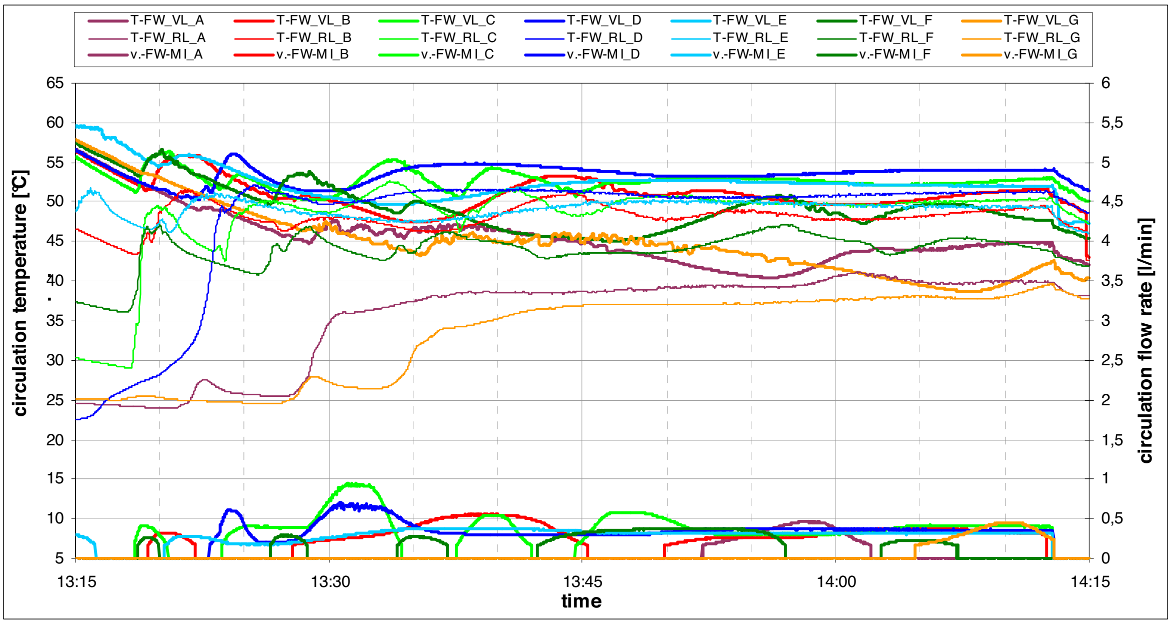

Fig. 5. Stand-by operation of the hydraulic station by comparison. Supply temperature and return pipe temperature measured at the station (upper curves, left axis) and circulation flow rate (lower curves, right axis)

3. Summary and Forecast

Basically the nine tested hydraulic stations show very good results concerning security of supply and user comfort, as the defined surrounding conditions of all stations generated higher hot water temperatures than the required comfort temperature of 45°C over the whole bandwidth of tapping flow rate. Also the maximum tapping flow rate was in an acceptable bandwidth of 13.5 to 15.0 l/min.

In most cases the results regarding the maximisation of energy efficiency operation were satisfying i.e. the lowest supply flow rates and lowest return temperatures were achieved.

Positive and promising approaches show products that support their proportional flow controller with a so called “temperature corrective”. The tests at special hydraulic stations for low-temperature heating (e.g. underfloor heating) as well as stations that were designed for extreme low supply temperature (<50°C) showed good results, thus contributing to an expanded market launch of this technology.

Another result of this project is that there exists now a testing routine for hydraulic stations and a test rig for further tests in the future.

The central results of the project got were clearly arranged and summarized in a guideline, which can be downloaded from the Website of the AEE-INTEC (www.aee-intec.at).