Expert Report

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Boilers and burners combine correctly

The need to save energy and reduce emissions makes boiler/burner capacity optimisation unavoidable. The best setup helps to keep boilers operating for decades with low damage and maintenance levels. In this writer's opinion, the importance of diligently identifying the actual capacity required and covering this using several individual boilers with a pooled output receives far too little attention. Thus, avoidable damage and extremely inefficient modes of operation can be observed in various places. The following suggestions indicate how the operating performance of boiler systems can be effectively improved.

Classification of boiler systems according to consumption criteria

Boiler units and their individual outputs can only be classified according to expected minimum, maximum and medium loads. Operating safety aspects are also important in this regard, but should not be the only criteria.

The heat is primarily needed for production assemblies

Renewal of old systems with unchanging consumption criteria
WIf a boiler system is only being changed over for reasons of age or modernisation or due to adjustments for environmental protection regulations, the load diagram is usually known. If this data is not available, it is worth identifying the actual energy need through note-taking over representative periods of time before planning begins. The periods when least energy is needed (e.g. weekends and nights in summertime) and also of peak energy consumption (e.g. cold winter days when at maximum production) are important in this. Records and research on the speed in which the need for energy changes (e.g. sudden peaks in energy need) should also be kept.

If the criteria mentioned are recorded or known, the maximum states of the heat medium that are actually required should be checked. Any unnecessary increase in the supply flow temperature in the case of hot water systems or the steam pressure in the case of steam systems represents avoidable costs and ineffective operation from the outset.

Old existing heating networks often have excessive design temperatures and pressures and should be reduced to what is needed, provided the installed lines and consumers allow for this.
If there are heavy consumers with scheduled programs, the extent to which it makes sense and is possible to intelligently link the control of the consumer which triggers the energy need and the boiler control should be checked.

In many cases, the size of an overall boiler system can be reduced through this, with the boiler system being notified early of the load need through external impulses and thus the boiler system being switched to standby mode. If sudden peaks in consumption only arise at short notice or at greater intervals, the extent to which it makes sense to store energy using gravity or hot water accumulators should be checked.

New planning

It can be said from experience that new planning very often results in over-dimensioned boiler systems as planners, manufacturers, component suppliers and operators often add on a bit to the actual need. These reserves included in the calculations should be researched in discussions. If there is a way of finding out information on already connected devices and their actual energy needs from other operators, this should be followed up on. However, the involvement of reputable suppliers of individual components and consideration of expansions that may be subsequently planned are a prerequisite for specific dimensioning of the overall boiler system.

Unless an increase in capacity has already been definitively planned in advance, conceivable additional potential in the future should be taken into account when designing the network and the size of the boiler house, but not when dividing up current overall capacity across boilers.

he heat is primarily needed for heating purposes

Unlike production heat, the actual load request in respect of heat for warmth is determined by the weather. The range of load requests is usually significantly larger and less defined than that of production heat systems.

While boiler systems are partly only kept in operation at the height of summer to cover the need for hot water for domestic use, the entire heating capacity is required with sufficient operational safety on cold winter days.

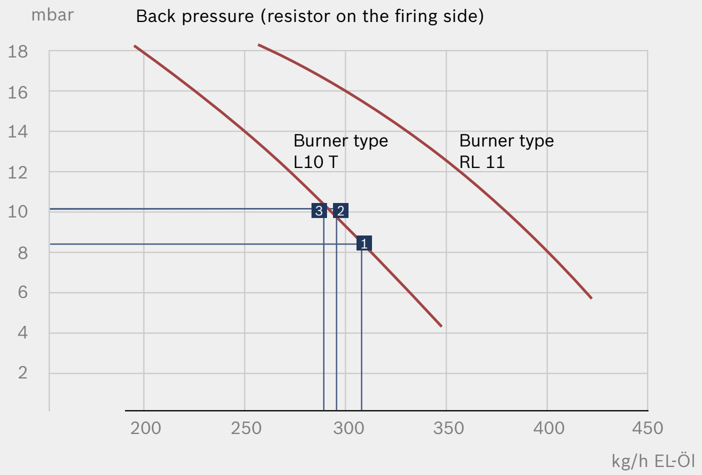
When determining peak capacity, it should be noted that this is usually only needed on a few days a year. If necessary, only an emergency operation with reduced heat may be available and have to be accepted if a boiler or burner fails. However, it must be ensured that system parts and network components never freeze.

Greater care should also be taken when determining the minimum capacity of the smallest boiler. Sufficient certainty when determining the temperature, both in relation to the maximum heating temperature required by the consumer and the temperature spread, is particularly important here for interpretation purposes for possible sequence control, etc.

The greatest outflow of heat from the heating station occurs in winter when consumer groups are switched from night-time reduction levels to daily operation. If these deactivations are not scheduled well apart from one another, there is usually a peak requirement in the early hours of the morning which vastly exceeds the design capacity of the heating system. This should be prevented at all events through intelligent heating control planning and staggered schedules for switching on the individual consumer groups. Possible reductions in temperature following changeover in the network until the boiler system has "caught up" again should be accepted here also.

Burner grid with maximum output graphs

Case study for expert selection of a burner with a large turn down ratio of 1 : 4



Example 1:
Three-pass compact boiler of type UL-S 5000
Gauge pressure 10 bar
Back pressure in the furnace 8.5 mbar
Fuel consumption 307 kg/h EL oil
Boiler output 5000 kg_{steam}/h
Burner turn down ratio with type L10 T 70: 307 ~ 1 : 4.4 **1**

Example 2:
Three-pass compact boiler of type UL-S 5000 with ECO
Gauge pressure 10 bar
Back pressure in the furnace 10.7 mbar
Fuel consumption 293 kg/h EL oil (4.5% saving)
Boiler output 5000 kg_{steam}/h
Burner turn down ratio with type RL11 105: 293 # 1 : 2.8 **2**

... in the case of a reduction in the boiler output of 3 - 4 %:
Fuel consumption 284 kg/h EL oil
Boiler output 4840 kg_{steam}/h
Burner turn down ratio with type LIOT 70: 284 ~ 1 : 4 **3**

Requirements in respect of the total system

If sufficiently certain data is compiled, the total energy capacity can be identified.

Division of the total system into several individual boilers

Standby systems are generally no longer being installed nowadays as the costs for these and standby losses are too high. Because of this, it should be ensured that the boiler system can continue to operate, even at limited capacity, if the largest individual unit should fail until the fault or defect can be rectified.

In any case, it is worth dividing the system into at least two boiler units. Using the previously calculated energy needs diagram, the smallest boiler should provide the basic load at night or at weekends in the summer to ensure a minimum of burner shut-downs. This boiler is also used as the peak load boiler when the need is greatest, usually winter mornings.

If there is a greater need for heating stations to provide heat for warm water in surges in summer also, as is usual with barracks and production companies for example, the minimum boiler capacity should be designed to safely provide this capacity.

In individual cases, the inclusion of heat accumulators as a buffer has proven itself ideal, particularly in the case of solid-fired systems.

In the case of small systems (total thermal capacity < 4 MW), it is worth using simple sequence controls across staggered temperature/pressure ranges. Better, and by all means recommended for larger systems, is sequence control regulated via heat and steam meters which facilitates optimal load matching. However, there are often compromises due to the considerable costs of such equipment and these can prove very disadvantageous subsequently.

Conclusion: the control concept must be known when the total system is being planned – particularly in the case of thermal heating systems.

Burner allocation

Für die Brennerauswahl ist die Festlegung der minimalsten Leis-It is important to determine a boiler‘s minimum load requirement when selecting a burner. 40 – 60% of the nominal output is the minimum output in the case of 2-level burners, approx. 35% in the case of 3-level burners, and it can be even lower in the case of continuously variable burners. Smaller boilers up to approx. 2 MW primarily have 2 or 3-level burners. A lower basic load is not achieved here with continuously variable burners, but the additional costs for the burner, maintenance and adjustment are significant. Larger boiler units with a burner output of 2 MW upwards work well with continuously variable burners, as the turn down ratio is larger compared with 2 and 3-level burners.

If a boiler’s nominal output is fixed and there is no downward margin, a burner type which is actually too big would be used in many instances. On the other hand, in a case where nominal output is only fractionally reduced, the next smallest burner already offers a considerably extended turn down ratio with a more favourable minimum output. Therefore, there should be more attention paid to adjusting the boiler output to the burner’s power range (refer also to the “Performance Regulation of Steam Boilers” Technical Report), particularly if a total system consisting of several boiler units is to be designed.

The ultimate decision on the burner and its fan must be taken such that the burner will be operating at its upper capacity limit when the boiler is at full load, taking all of the components in the flue gas flow into account. In the low-load range, this facilitates extensive down-regulation of the burner and avoids frequent start-ups and shut-downs (the furnace has to be flushed with fresh air before each burner re-ignition due to the risk of explosion). The air that has to be warmed up in the boiler is then lost via the chimney.

Example:

Boiler type UL-S 5000	
Boiler water temperature	184 °C
Intake air temperature	24 °C
Air heating	160 °C
Pre-ventilation period	65 ... 135 s
Thermal loss per on/off	4,77 ... 9,91 kWh
Energiebedarf bei	
Energy requirement for	
6 on/off per hour	29 ... 60 kWh

Accordingly, the boiler supplier should not be required to use any particular burner type so that it is possible to perfectly optimise the boiler, built-in parts in the flue gas flow, burner, fan and control. Individual boiler outputs within the overall capacity should also be variable with regard to burner optimisation.

In principle, the boiler manufacturer should be allowed a tolerance of ±10% of the total capacity.

Optimised trouble-free operation over many years can only be assured if this margin is given. Here is an example of this (see diagram):
A steam boiler [1] with a nominal output of 5000 kg_{steam}/h was increased by retrofitting an ECO in its resistor on the firing side [2], so that the next largest burner would be needed in theory.
A reduction in the maximum boiler output by 3 – 4% facilitates [3] the retention of the burner used to date with the effect that a control ratio of 1 : 4 as opposed to 1 : 2.8 is achieved – along with all of the other advantages alluded to.

However, things may differ significantly in practice as the characteristics are averaged values. This also includes the previously justified tolerance of ±10% of the total capacity.

If no margin is accepted, a potential capacity reserve, particularly in the choice of burner, will have to be put up with from case to case to the detriment of operation and cost optimisation. However, optimisation is continuing to increase in importance, especially in relation to the environmental protection required of new components which overlie the burner and limit its flexibility. Thus, burners equipped with flue gas recirculation units, for example, are usually only turned off and then started up again up to 4 times per hour, which has significant consequences for the planning and subsequent operation of a boiler system.

Summary

When planning an energy system, more criteria have to be taken into account nowadays than ever before. Past errors must be recognised and avoided.

Choosing the right division of capacity across several boilers with coordinated burners is particularly important. If there is a deficit in planning in relation to this, this will be reflected in additional fuel requirements due to unnecessary start-ups and shut-downs and greater environmental effects.

Over-dimensioned systems increase the wear and tear on components which is greater the more frequently the burner is turned on and off and another boiler has to be switched on and off.

Operating safety is reduced as each process of switching on and off a burner places high demands on the monitoring equipment (e.g. flame detectors) under the pretext that a system should be switched off when in doubt.

Tenders and requests should indicate boiler outputs and tolerances.

An over-dimensioning of the burner signifies restricted control behaviour with all of the disadvantages mentioned.

Many boilers are operated over decades. The firings and control units, on the other hand, must be updated in intervals of 5 – 10 years at least, if not completely replaced. Therefore, an envisaged subsequent increase in the capacity needs should be taken into account right now in the choice of boiler size as there are practically no disadvantages to this. Burners, on the other hand, should always be chosen so that they can be replaced if needed if there is an increase in needs, something which is no trouble for practically all industrial and municipal heating boiler systems.

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