Forgotten savings: Heat recovery from surface blowdown

1. Introduction

The purpose of this article is to inform thermal plant operators of the interesting fuel savings that can be obtained by recovering purged heat.

The relatively low cost of these systems and the increasing price of fuel make it possible for a quick return on investment.

2. The surface blowdown system, a necessary evil

Upon boiler water vaporization, dissolved solids become concentrated and may reach their soluble limit and form scale [1].

It is necessary to consider the use of a heat exchange system to avoid the formation of scale and keep salt concentration levels inside the parameters recommended by the ABMA [2] and the BS-2486 regulation [3].

The amount of blowdown water depends on the percentage of condensate returned, the quality of the make-up water, and the water quality specified for the boiler.

The water quality of a boiler depends on the working pressure and the type of boiler, with watertube or firetube boilers being the most stringent on water quality.

It is very common to have concentration cycles of 8 (quotient of feedwater divided by the purge water) for a firetube boiler working at 12 bar (174.05 PSI).

A concentration cycle of 8 is equivalent to a blowdown flow volume equal to 14.3% of the steam production.

When the quality of the make-up water is better or when there is more condensate recovered, the concentration cycles will be higher.

Water extracted from the boiler is at an elevated temperature and pressure: the enthalpy that it has **can**, and **should** be taken advantage of.

3. Potential of heat recovery from surface blowdown

In general, thermal power stations are equipped with retention ponds where flash steam is generated at atmospheric pressure. However, it is very common that the flash steam generated is simply processed through a vent and the remaining water is eliminated as liquid industrial waste.

If the surface blowdown has a continuous flow, the flash steam that is generated can be used to power the deaerator; thereby, replacing some of the “high pressure” steam the deaerator uses for power.

Deaerators generally have a working pressure of 1.1 (15.95 PSI) to 3 bar (43.51 PSI), a condition in which O_2 and CO_2 solubility is less.

Figure 1 shows the amount of flash steam generated at 1 bar (14.5 PSI), 2 bar (29 PSI), and 3 bar (43.51 PSI), by the blowdown water.

For example, a boiler working at 9 bar (130.53 PSI) against a pressure of 1.1 bars (15.95 PSI) would generate 0.14 kg (0.31 lbs) of steam for each kg (2.2 lbs) of blowdown water (14% in weight).

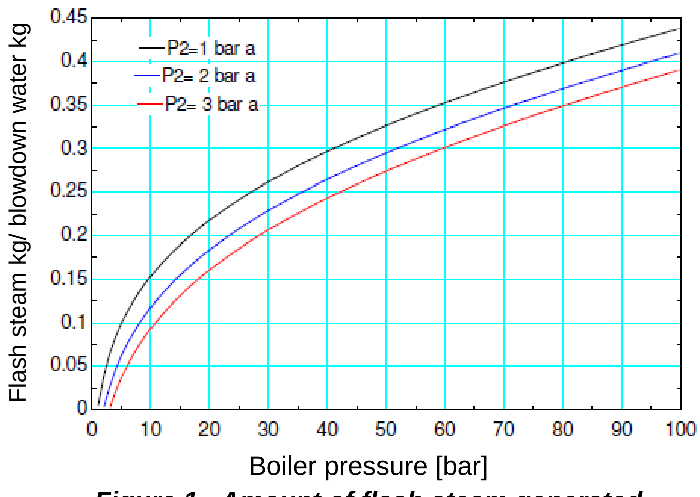

Figure 1. Amount of flash steam generated

In addition to the loss of flash steam, sensible heat is also lost in the blowdown water.

The sensible heat in the blowdown can be observed in Figure 2, with the stipulation that 15°C (59 °F) water with 1 bar (14.5 PSI) of pressure has an enthalpy of 0 J/Kg.

The sensible heat can be recovered by heating the make-up water.

The sensible heat and latent heat (flash steam) are equally present in the surface blowdown. Heat recovery can be achieved in systems equipped with an expansion tank and an integrated heat exchange, like the one observed in Figure 3.

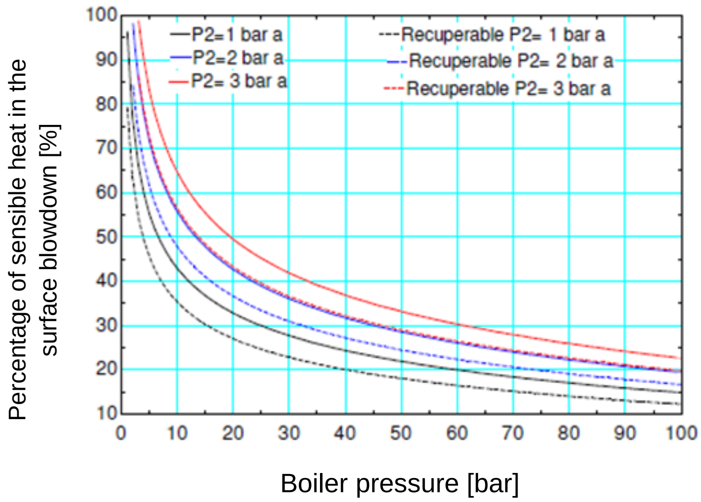

Figure 2. Amount of usable sensible heat in the blowdown

Figure 3. Example of an integrated blowdown separator, courtesy of Wilson Engineering.

Figure 4 shows a diagram of a typical flow that corresponds to the implementation of these heat recovery systems in a thermal power plant containing two boilers.

In practice, it is only possible to recover the heat corresponding to cooling the blowdown water to around 30° C (86° F). This is shown in the segmented line in Figure 2.

In the previous example, the recovered sensible heat corresponds to 83% of the total sensible heat and to 38% of the total heat of the blowdown water (sensible heat + latent heat).

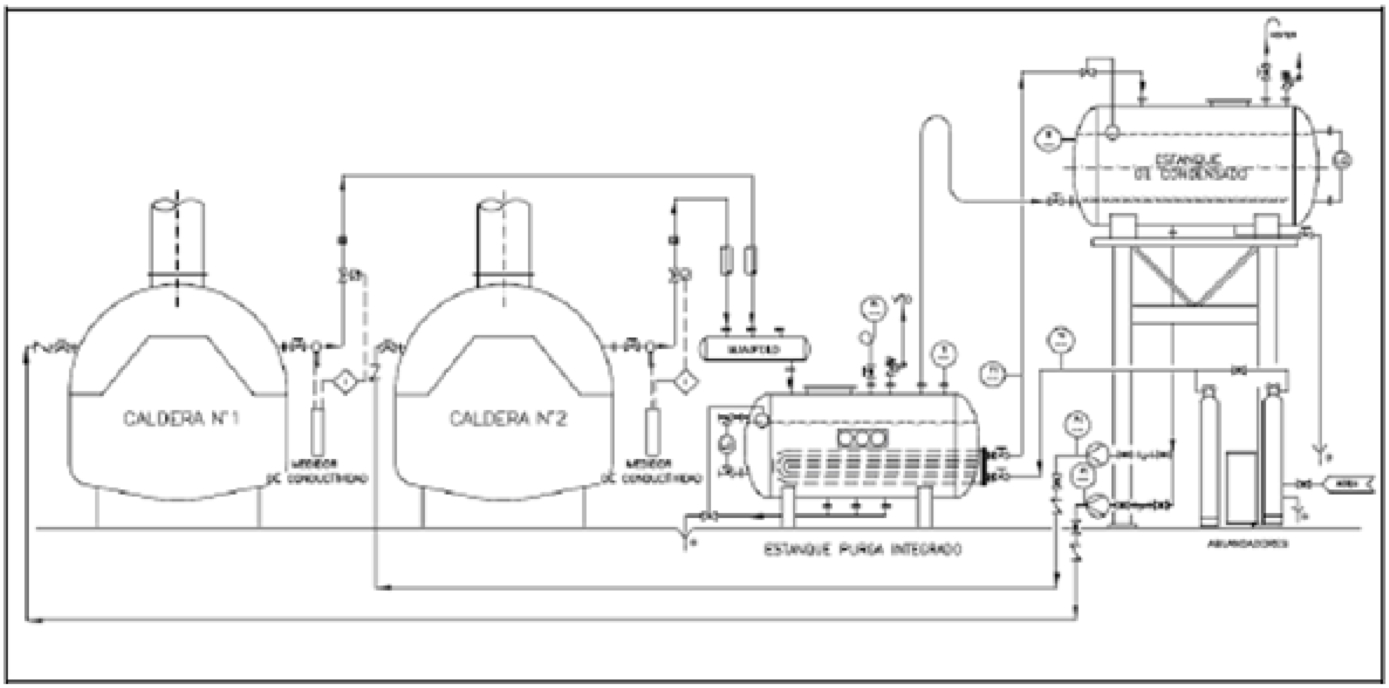

Figure 4. Diagram of the typical flow for blowdown heat recovery

Figure 5 shows the fuel savings that can be obtained by recovering both the latent flash heat and the sensible heat from the surface blowdown.

These savings are not dependent on an excess of boiler working pressure; rather, they are dependent on the concentration cycles considered in the water treatment.

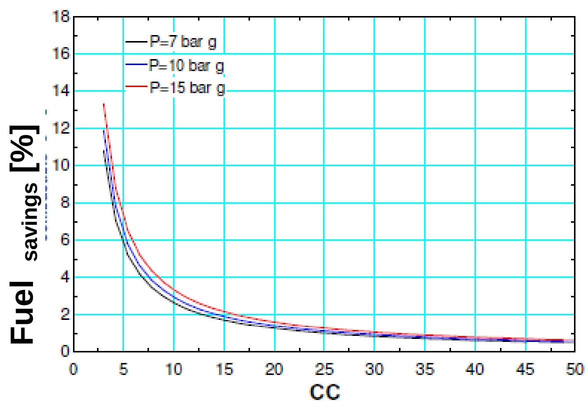

Figure 5. Fuel savings in relation to concentration cycles for different working pressures.

The advantage of implementing a surface blowdown heat recovery system is apparent when it is impossible to improve the quality of the feedwater, as is shown in the previous example.

4. Practical Example

4.1 Assumptions

For practical application, we have prepared the following example which represents real conditions noted in thermal power plants similar to the one displayed in Figure 4.

- Total capacity of the boiler : 40 tons/hr.
- Boiler load factor : 85%
- Working pressure : 10 bars (145.04 PSI)
- Average yield of the boiler : 80 % over PCS
- Fuel : Number 6 Oil
- PCS : 10225 kCal/kg
- Deaerator working pressure : 0.1 bar (1.45 PSI)
- Annual working hours : 3500 hours
- Condensate recovery : 50%
- Concentration cycles : 10

4.2 Savings and operating conditions

In the previous considerations we have determined the flow of the blowdown is 3.8 tons/hr. at a 185° C (386° F) and corresponds to 11.1% of steam production.

The amount of flash steam generated is 592 kg/hr, which is equivalent to 15.6% of the steam used in the deaerator and to 15.7% of the blowdown water.

The fraction of the blowdown that is not converted to flash steam (84.3%), corresponds to a 102° C (215.6° F) condensate that can be chilled to 35° C (95° F), transferring this heat to the make-up water (20.8 ton/hr), heating it from 15°C (59° F) to 25.3 °C (77.54° F).

Feeding the high temperature make-up water to the deaerator allows for a reduction in 449Kg/hr, equivalent to 11.8%, or the high pressure steam consumption of this unit.

The deaerator's steam savings translates to an annual 250 ton reduction in oil consumption, equal to **2.95% of fuel consumption**.

4.3 Financial evaluation

Consider the following costs:

- Oil cost : 200 pesos/kg
- Exchange rate : 520 pesos/ USD

The investment considered in the financial evaluation presented below (Table 1) includes the blowdown heat recovery system, the materials, and the labor required to incorporate this system into the sample thermal power plant.

The increased pressure drop in the system leads to a higher cost in feedwater pump operation; however, this is a negligible cost compared to the fuel savings obtained.

Elements	*Description*	*[USD/year]*
Savings		
	Fuel savings	$ 74, 092
	Total	$ 74, 092
Investment		
	Integrated surface blowdown tank	$ 19, 200
	Freight and importation	$ 3, 500
	Materials	$ 10, 000
	Assembly	$ 6, 000
	Total	$ 38, 700

Table 1: Savings and investment

The economic indicators shown below have been calculated for 10 years of use with a 10% discount.

This investment is very attractive, with a full return in only 5 months.

- Turnaround time : 5 months
- Present net value : US $ 455, 000
- Internal rate of return (IRR) : 208%

5. Conclusion

This article presents the interesting savings that can be obtained by using a heat recovery system.

Due to the recent rise in fuel prices, these savings are becoming more and more appealing.

6. References

[1] Arnulfo Oelker, “Boiler Water Treatment,” Induambiente no. 48, January-February 2001, pp. 94-101.
[2] Betz, Betz Handbook of Industrial Water Conditioning, 1980, Betz Laboratories Inc.
[3] British Standard BS-2486, “Recommendations for treatment of water for steam boilers and water heaters,” 1997.

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