Flash Steam

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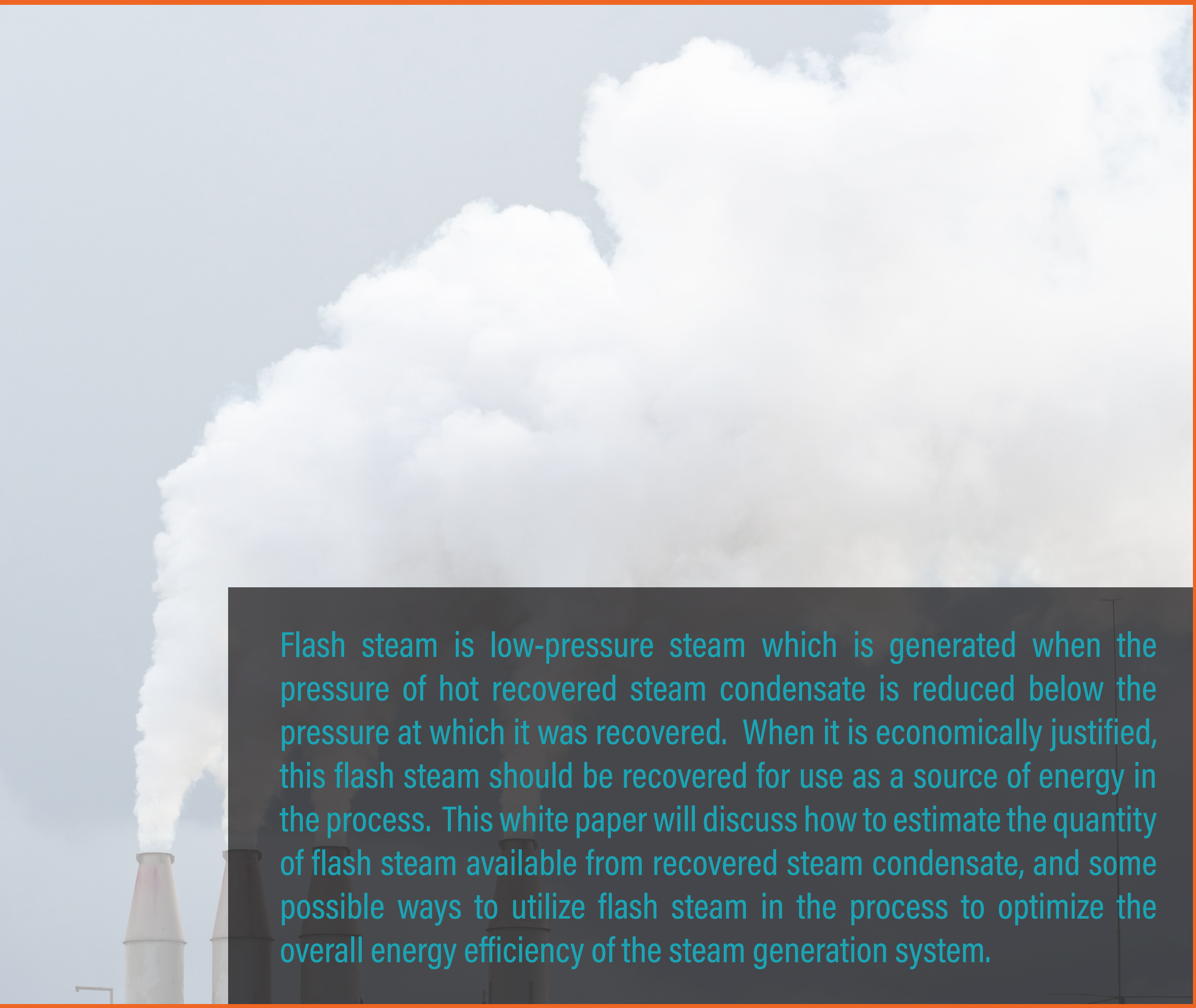
CONTENT

ABSTRACT



Flash steam is low-pressure steam which is generated when the pressure of hot recovered steam condensate is reduced below the pressure at which it was recovered. When it is economically justified, this flash steam should be recovered for use as a source of energy in the process. This white paper will discuss how to estimate the quantity of flash steam available from recovered steam condensate, and some possible ways to utilize flash steam in the process to optimize the overall energy efficiency of the steam generation system.

Basic Science of Flash Steam Generation

When steam is supplied to a heat exchanger, an internal coil, a vessel jacket, or some other heat transfer device, the steam will give up its energy to the fluid being heated and will condense, producing steam condensate. Typically, this steam condensate will be saturated liquid whose pressure and temperature are determined by the heat transfer conditions in the heat transfer device.

The collected condensate is normally sent to the boiler feedwater system and reused to generate steam. The steam condensate either flows by pressure difference after being passed through a steam trap or is collected in a condensate tank and pumped. At the point in the condensate return system where the pressure drops below the pressure at which the saturated liquid condensate was collected, a portion of the condensate will flash to form steam. The two-phase flow of condensate and flash steam continues in the condensate return system, with the amount of flash steam continuing to increase as the pressure in the return system continues to drop, until the condensate return enters a flash vessel, in which the flash steam is separated from the liquid condensate.

The details of the thermodynamic process by which flash steam is generated can best be explained by considering the enthalpy of the condensate and the steam. As anyone who has used the Steam Tables knows, the enthalpy of water in either liquid form or vapor form is a function of the temperature and the pressure of the liquid and the vapor.

For illustration purposes, assume that saturated steam condensate at 250 psig is sent to a flash vessel operating at atmospheric pressure. How much flash steam will be released from the atmospheric flash vessel per pound of the recovered steam condensate?

The enthalpy values for the steam and the condensate at these conditions are as follows:

Temperature of saturated water at 250 psig:	406 °F
Enthalpy of saturated water at 250 psig:	381.7 Btu/lb
Temperature of saturated water and steam at 0 psig:	212 °F
Enthalpy of saturated water at 212 °F:	180.1 Btu/lb
Enthalpy of saturated steam at 212 °F:	1150.3 Btu/lb

The total process of flashing the condensate from a high pressure to a lower pressure to generate flash steam can be assumed to be an adiabatic process. Therefore, the total enthalpy of the high-pressure condensate recovered equals the total enthalpy of the flash steam plus the unflashed condensate at atmospheric pressure:

Enthalpy of condensate at 250 psig =

Enthalpy of steam at 0 psig x Fraction of condensate at 250 psig flashed to steam

+ Enthalpy of condensate at 0 psig x (1 – Fraction of condensate at 250 psig flashed)

Substitution of the enthalpy values into the above equation yields this result:

Fraction of saturated condensate at 250 psig flashed to steam at 0 psig = 0.2078

Calculation of Amount of Flash Steam Generated from Condensate

From the discussion above, a general equation can be developed for calculating the amount of flash steam which will be generated at a given pressure from steam condensate recovered at a higher pressure:

$$X_{Flash} = \frac{H_L(P_1, T_1) - H_L^S(P_2)}{H_V^S(P_2) - H_L^S(P_2)} = \frac{H_L(P_1, T_1) - H_L^S(P_2)}{H_{VAP}(P_2)}$$

Where:

P_1, T_1	= pressure and temperature of recovered condensate to be returned
P_2	= pressure of flash vessel in which recovered condensate is flashed
X_{Flash}	= fraction of steam condensate flashed to steam in flash vessel at P_2
$H_L(P_1, T_1)$	= enthalpy of steam condensate at P_1, T_2
$H_L^S(P_2)$	= enthalpy of saturated water at P_2
$H_V^S(P_2)$	= enthalpy of saturated steam at P_2
$H_{VAP}(P_2)$	= enthalpy of vaporization for steam at P_2

Note that the above equation does not assume that the recovered condensate from the heat transfer device is saturated liquid, hence the inclusion of temperature and pressure in the condensate enthalpy term. This more general form of the flash steam equation accounts for the potential of subcooled condensate to be sent to the flash vessel – as would be the case for condensate which is released through a thermostatic steam trap, which discharges subcooled condensate.

UTILIZATION OF FLASH STEAM

The recovery of hot steam condensate will result in the generation of flash steam. How to best utilize that flash steam is an economic decision. Recovery and reuse of the flash steam saves some or all of the energy costs and the other operating costs associated with producing boiler feed water and heating the boiler feed water to generate steam. Consequently, there is a clear economic incentive to recover and reuse flash steam. But to do that, some level of capital expenditure is required. That cost must be justified by the net overall energy savings resulting from the reuse of flash steam. Assessment of the extent to which flash steam recovery should be pursued must be made on a case-by-case basis.

From a process perspective, there are certain factors which make the recovery and use of flash steam increasingly attractive. First, the steam condensate flow from which the flash steam is generated needs to be reasonably consistent. Many of the flash steam recovery methods typically employed will not function properly if the rate of flash steam being generated is highly variable. The availability of a steady-state flow of flash steam significantly expands the options for recovering the energy in flash steam.

Second, it is advantageous if there are process streams or utility streams which can profitably exploit the energy available from flash steam. Among hot utility streams, most flash steam is low-grade energy, since most flash steam is available as low-pressure or near-atmospheric steam. Given its energy level, flash steam is therefore best utilized in process applications where streams require heating to the 150-250 °F range. Such applications are not common in most facilities.

Third, the amount of flash steam available needs to be above a certain threshold to be able to support the cost of the hardware required to utilize the flash steam. The technologies used to recover flash steam energy tend to become more capital intensive as the flash steam energy level decreases, so a large flash steam volume is required to achieve the economy of scale required to justify the capital expenditure for the flash steam recovery equipment.

FLASH STEAM RECOVERY
METHODS & TECHNOLOGIES

Depending on the specific circumstances surrounding the condensate/ flash steam flow rates, flow rate consistency, and pressure level, the following flash steam recovery methods may be employed.

Discharge Flash Steam to Atmosphere

Under certain circumstances (for example, the flashing of low-pressure condensate whose flow rate is low and either intermittent or highly variable), the low and erratic flow rate of flash steam may make it impractical to economically recover the energy content of the flash steam. In that case, the flash steam generated can be allowed to vent to atmosphere off the atmospheric flash vessel, and the emphasis is on the recovery and return of the unflashed condensate. While the loss of flash steam to atmosphere is in a sense unacceptable from an energy conservation/thermal efficiency perspective, the cost of the provisions required to obtain recovery of the flash steam energy may not be justified.

Discharge Flash Steam from Flash Vessel Operated at Pressure Above Atmospheric

The flashing of the steam condensate to flash steam does not have to occur at atmospheric pressure, if there is a viable outlet for the total volume of flash steam at a pressure slightly above atmospheric. The flash vessel pressure can be regulated by placing a pressure control valve in the flash vessel's vapor outlet line.

One possible use of this low-pressure flash steam is to supply stripping steam to the boiler feed water deaerator. Many deaerators operate in at pressures in the range of 0-10 psig.

Discharge Flash Steam to an Intermediate-Pressure Steam Header

If the plant site generates and distributes steam at two or more pressure levels, an effective way to recover the energy from the flash steam is to generate a portion of the flash steam in a high-pressure condensate flash drum which operates at the same pressure as the lower-pressure steam header, and then generate the remainder of the flash steam in an atmospheric flash vessel. An advantage of this method of flash steam utilization is that it is more tolerant of condensate flow and flash steam rate variation than many of the other methods discussed here.

To illustrate the impact of this method, consider the following scenario:

- The plant produces high-pressure steam at 300 psig and low-pressure steam at 100 psig.
- Saturated high-pressure steam condensate is recovered at a pressure of 250 psig.
- The high-pressure condensate is flashed at 100 psig to generate additional 100 psig steam.
- The condensate from the 100 psig flash vessel is flashed at 0 psig in an atmospheric flash vessel.

The results for this scenario are as follows:

- 0.0824 lb of 100 psig flash steam is generated per lb of 250 psig condensate
- 0.1220 lb of 0 psig flash steam is generated per lb of 250 psig condensate

In the example in Section 2.0, the 250 psig condensate was flashed at 0 psig, producing 0.2078 lb of 0 psig. In the example in this section, a similar total of 0.2044 lb flash steam was generated. But 40% of the flash steam in this case is higher-quality 100 psig steam.

Discharge Flash Steam to Process Heat Exchanger

The flash steam off an atmospheric or a low-pressure flash vessel can potentially be used to heat suitable process or utility streams in a heat exchanger. In contrast to releasing the flash steam to atmosphere, this method both captures the latent heat energy available in the flash steam and recovers the steam as condensate for reuse.

Suitable streams in this application would be process streams which require heating to a temperature in the range of 150-200 °F. A good utility application would be to use the flash steam to preheat the fresh boiler feedwater fed to the deaerator.

If no suitable process or utility stream is available to exploit the latent heat energy available in the low-pressure flash steam, an air-cooled or water-cooled condenser can be used to condense the flash steam and recover this steam as condensate. However, it should be noted that justifying the recovery of flash steam as condensate solely on the basis of the reduction in boiler feed water production costs is difficult.

Use Thermocompressor to Boost Pressure of Flash Steam to Higher

A thermocompressor is a jet ejector which uses a motive fluid at a high pressure to entrain a fluid at a low pressure to generate a discharge stream of the mixed fluids at an intermediate pressure. When applied to flash steam, a thermocompressor uses higher-pressure steam at the distribution header pressure to entrain low-pressure flash and boost the pressure of the flash steam to a higher, more useful pressure.

Thermocompressors can be particularly useful for steam systems in which the steam is generated and distributed at two or more pressure levels. In that scenario, the thermocompressor can use steam at a higher distribution pressure as the motive fluid to entrain the low-pressure flash steam and exhaust the flash steam into an intermediate-pressure distribution header.

Use Flash Steam as Heat Source to Power Absorption Chiller

For sites which require a chilled water utility supply that also have a large quantity of low-pressure flash steam available, an option is to use the flash steam as the heat source to power an absorption chiller to generate chilled water.

This approach for utilizing flash steam is limited to large steam generation systems, since the capacity range of commercial absorption chillers required low-pressure steam availability on the order of several thousand lb/hr.

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