BOILER BLOW-DOWN FLASH RECOVERY

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Abstract

Malelane's boiler blow-down flash, which was previously rejected to atmosphere, is now recovered into the turbo-alternator exhaust steam range and used for process heating duty. Various flash vapour recovery options have been evaluated for operability, maintainability and cost effectiveness. The design considerations for the blow-down vessel and the valve and piping configuration, which resulted from a Hazop Study, are explained. The recovery of 1.6 tons per hour of boiler blow-down flash equates to R260 000 per annum in coal savings.

Keywords: boiler, blow-down, flash recovery

Introduction

During the 1996 season, Malelane Mill management undertook a comprehensive Pinch Study to define the energy investment strategy for the mill with a view to reducing process steam usage. The outcome of this study was a project road map identifying the optimum energy saving path in keeping with funding, operational and technical viability constraints (Singh *et al*., 1997). One of the 'quick win' projects identified in the Pinch Study was to recover vented flash vapour from boiler blow-down from the mill's 3100 kPa (a) boilers.

The boiler plant at Malelane Mill comprises one dedicated 200 t/h bagasse fired boiler and two dual-fuel fired boilers of 90 t/h and 150 t/h each. The practice at the time of the study was to discharge boiler blow-down into a flash vessel and vent the resultant flash to atmosphere and discharge the condensate to effluent. The boiler blow-down rate was estimated to be 3% of the steaming rate.

What is 'blow-down'?

In the process of evaporating boiler feed water to produce high pressure steam, the total dissolved solids (TDS) in boiler water become concentrated. The recommended TDS level for Malelane's 3100 kPa (a) boilers is that level which gives a conductivity of 1800 to 2200 µS/cm. At higher TDS levels, the risk of scaling on the boiler heating surface and the risk of carryover of solids to downstream equipment such as turbine blading increases significantly. The TDS levels are controlled by continuously bleeding off water from the boiler steam drum. However, due to occasional softened water make-up at Malelane, intermittent blown-down from the mud drum is additionally practised to keep the boiler TDS levels in check.

Blow-down recovery options

Several flash recovery designs that presented attractive energy recovery options have been examined for operability, maintainability, funding and safety constraints.

Blow-down for boiler feed water heating using a plate heat exchanger

The ideal match determined from the Pinch Study was to heat boiler feed water from 75°C to 80°C using the continuous blow-down stream. The attractiveness of this option stemmed from the high softened water usage for boiler feed water make up. Since the date of the study, softened water usage has been reduced to acceptable levels such that boiler feed water temperature is now normally above 90°C. The option for heating boiler feed water to raise its temperature another 5°C using blow-down still provided attractive energy savings. The material balance for this scenario is shown in Table 1. This design required the continuous blow-down from each boiler to be piped together and then diverted to a high pressure welded plate heat exchanger unit equipped for cleaning on both sides. The anticipated scaling and associated high pressure cleaning, as well as the complexity introduced due to the need for automatic temperature control protection during periods of turndown, were seen as major handicaps in this design.

Heat recovery from blow-down as direct injection into diffusers

This design involved piping together all boiler blow-down from the different boilers for direct injection heating into the diffuser. Production personnel were concerned about the safety of this design and insisted on substantial accept/reject isolation valve arrangements and automation to ensure safety. An alternative to this design was to pipe together the flash vapour from the existing blow-down vessels and to mix this with diffuser juice in a direct contact heater. The remoteness of the boiler plant from the diffusers introduced pressure drop constraints and hence drove up the cost of flash vapour piping. These factors reduced the viability of this option. The material balance for this scenario is shown in Table 1.

Flash recovery from blow-down into exhaust steam range

This design involved diverting the flash from each blow-down vessel into the turbo-alternator exhaust steam range. The design had to provide for a valve station at each blow-down vessel for acceptance to the exhaust steam range or diversion to atmosphere. The close proximity of the exhaust steam range to the blow down vessels meant that piping costs would be kept to a minimum. Low maintenance and minimal automation became selling points for this option. In addition, Malelane Mill operating personnel gained confidence from the fact that Komati Mill already had a system in place for blow-down flash recovery into the exhaust range, and therefore favoured this option.

Initially it was planned to use the existing blow-down vessels but after inspection and crack testing it was realised that one of

Table 1. Blow-down heat recovery options.

	Blow-down heat recovery using a Plate Heat Exchanger	Blow-down heat recovery for Diffuser Heating	Blow-down flash recovery into Exhaust Steam
Mass flow rate (t/h)	6.8	6.8	6.8
Hot Stream	Boiler blow-down	Boiler blow-down	Boiler blow-down
Supply temp. °C	237	237	237
Exit temp.°C	95	80	123
Cold stream	Boiler feed water	Diffuser Juice	Exhaust Steam
Supply temp.°C	90	75	123
Exit temp. °C	95	80	123
Tons Flash	-	-	1.6
kW Recovered	1146	1255	1196
HP steam saved (t/h)	1.30	1.42	1.35
Coal saving	R155 500	R170 000	R161 500
Installed Cost	R250 000	R250 000	R300 000
Payback (years)	1.6	1.5	1.9

Note:

- Savings are based on continuous blow-down rate of 3% and exclude the benefit of intermittent blow-down heat recovery.
- Coal savings have been based on a 38 week season and 85% overall time efficiency.

the vessels was not suitable for use as a pressure vessel and the other did not have adequate disengagement height for entrainment prevention. This necessitated the fabrication of two new vessels designed for adequate entrainment prevention and for pressure vessel duty. Even with the additional cost, the energy savings still proved attractive. The summary data for this scenario are shown in Table 1.

Factors considered in the design of blow-down vessel

The key dimensions and relative positions of nozzles and entrainment arrestor are shown in Figure1. The critical factors considered in the design of the blow-down vessel and associated valves and piping are covered below.

Entrainment prevention

The disengagement height was sized generously to prevent entrainment under normal conditions. It was felt, however, that during periods of intermittent blow-down, the flow rate could be in excess of 50 t/h for short durations. Under these conditions, the quantity of flash would be such that droplets could be entrained into the exhaust steam line. Entrainment protection has been addressed by the installation of chevron pattern arrestors.

Maximisation of flash

The introduction of boiler blow-down into the blow-down vessel is achieved via a tangential inlet pipe, at a relatively high entry velocity. This creates a high swirling effect, which promotes flashing. Erosion of the vessel wall at the entry point due to high velocities is minimised by an impact plate welded to the vessel side wall.

Removal of condensate

The condensate is removed from the bottom of the blow-down vessel. An adequately sized steam trap has been installed on each blow-down vessel to allow condensate to drain without exhaust steam loss. In addition, an automatic valve and level control loop provides for drainage in the event that the steam trap fails or if it cannot cope with the volume of blow-down during periods of intermittent blow-down. Further high level

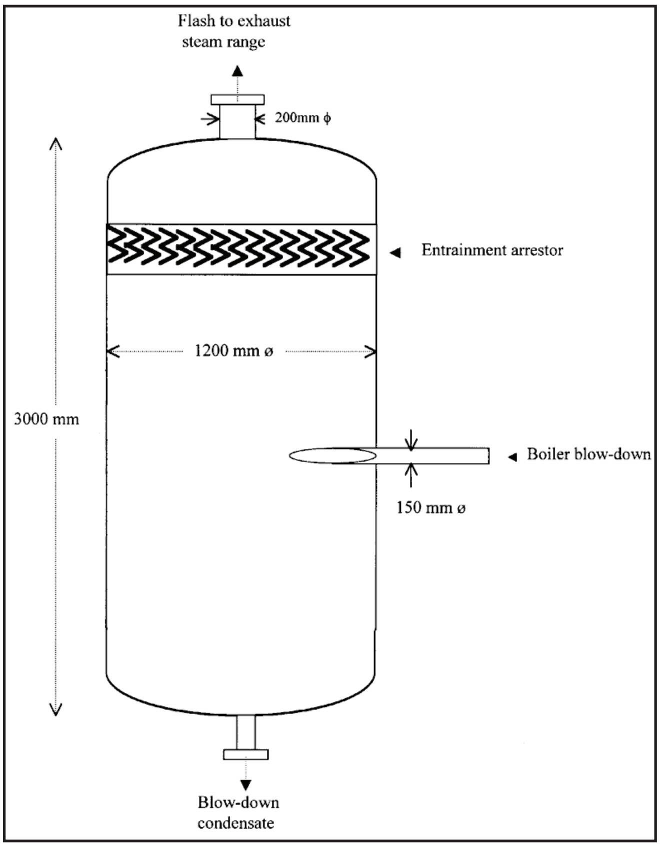

Figure 1. G/A of boiler blow-down vessel.

protection is provided in the form of a separate level probe that activates an automatic bypass valve.

Pressure vessel design requirements

The blow-down vessel has been designed to the ASME 8 DIV 1 code for a design pressure of 900 kPa(a) and a temperature of 400 °C. The higher temperature requirement has come about because superheater header blow-down is discharged into the blow-down vessel as part of the boiler over pressure control philosophy. An adequately sized pressure relief valve has been installed to ensure that the blow-down vessel pressure does not exceed the 300 kPa (a) maximum exhaust range pressure limit. Tight shut-off metal seated valves rated for 400°C have been used for condensate duty and accept/reject of flash vapour. To allow for maintenance work when the boiler is shut down a double block and bleed valve arrangement has been installed on the flash accept line. The valve and piping arrangement is shown in Figure 2.

Operating results

Two blow-down vessels have been in operation since the 1999-2000 crushing season. Under maximum blow-down rate conditions, the condensate build up in the blow-down vessel was insignificant. There has been no incidence of water entrainment from the blow-down vessel into the exhaust steam range.

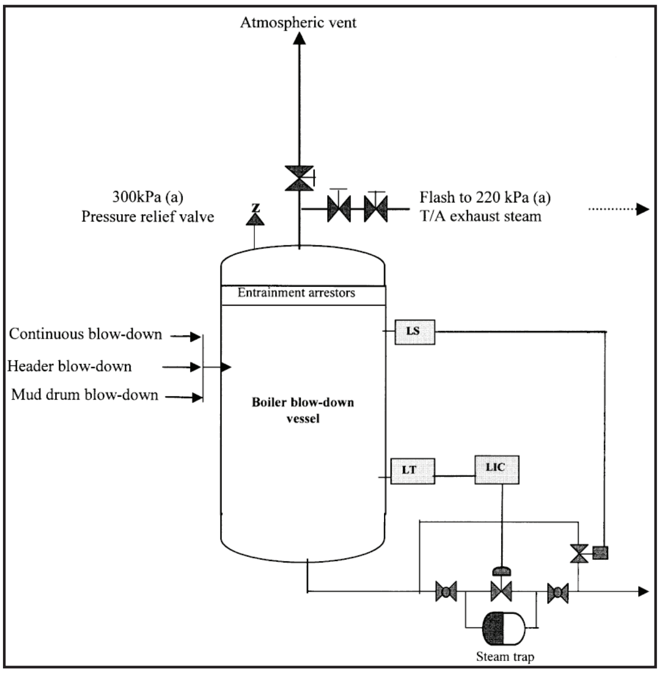

Figure 2. Malelane mill boiler blow-down PFD .

Conclusion

The Malelane mill has installed and successfully commissioned two blow-down vessels for flash recovery into the exhaust steam range. The units have achieved the design requirements. The installed cost of this project was approximately R300 000. In keeping with the overall objective to reduce process steam usage, the resultant savings in reduced coal burning are estimated to be R160 000 per annum.

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