Uses of steam at Greatham

Steam from the Main Boilers is fed into the HP Steam Distribution System where it is used in two specific types of equipment, fluid energy mills and calandria thermosyphon reboilers.

1. Fluid Energy Milling (Micronising)

During the coating and drying stages of the finishing process, particles of titanium dioxide pigment combine to form agglomerations. These must be broken down by intensive milling to produce the very fine, grit free pigment required for the product applications. The degree of milling required can only be achieved by grinding the pigment using the energy in high pressure steam. Up to 3 tonnes of steam are needed per tonne of pigment per mill and is used in direct contact with the pigment.

There are three dry pigment streams. Streams 1 and 2 each have 2 Fluid Energy Mills (FEMs) which are operated in series although some grades only require 'single milling' through one of the FEMs. Stream 3 has two processing lines, each of which has an associated FEM. The FEMs use approximately 70% of the steam generated at Greatham.

Operation

From a feed hopper pigment is sucked into the steam flow using a venturi device. Air must also be sucked in along with the pigment or the feed will choke. The steam flow conveys the pigment to the mill where additional steam is injected. The mill contains an integral classification cyclone and the finest material leaves along with the steam from the top of the cyclone and passes to a bag filter. Milled pigment passes out of the cyclone base through a rotary valve.

Most of the pigment grades require two stages of milling to produce the required quality and there are various designs/configurations to achieve this. In some of these the pigment passes through two separate mills in series; in others both stages of milling are effectively contained within the same mill.

The fines are removed from the exhaust gas flow by the bag filters and are returned to the fluid energy mill feed hopper for reprocessing. The steam/air mixture is drawn through the bag filters by variable speed fans. Downstream of the fans the gas stream is continuously monitored for the level of particulates and then passes to the heat recovery system.

The steam/air from the bag filters passes to the heat recovery system. The gases are contacted by water sprays and a portion of the steam condensed. The latent heat of condensation is given up and heats the circulating water. This heat is used for process duties, including spray drier air preheat, and hot water from this system is used as wash water in the pigment washing. This has the additional advantage that any pigment particles removed from the gas stream by the water sprays are recovered. The extent of heat recovery possible is restricted by the limited uses available for the relatively low-grade heat.

2. Distillation Thermosyphon Reboiler

In the ore purification part of the process (called Chlorination), titanium rich ore is reacted with chlorine and coke to produce the intermediate, titanium tetrachloride. This is initially present as a gas but, further down the chlorination process, it is cooled to a liquid. This titanium tetrachloride liquid requires further purification to remove residual traces of solids and other impurities. This is accomplished in a Distillation unit which incorporates a thermosyphon reboiler called a Calandria.

There are two chlorination streams, ICON1 and ICON2, each of which has a Calandria. These use approximately 12% of the steam generated at Greatham.

Tetrachloride boils at 136^{o}C and is vaporised at up to 30 tonne/hour in the Calandria using HP steam at up to 15 barg as the indirect heating medium. The tetrachloride vapour from the reboiler passes up the column to a water-cooled condenser. The condensed liquid runs down into a reflux divider where the product flow is split off, whilst the surplus tetra passes back to the top of the column as reflux. The purified tetra flow runs into one of two product tanks before use in the oxidation process.

Condensate from the ICON 1 and 2 distillation calandrias is flashed to produce 2.9barg steam for low pressure duties. Each ICON stream has a flash vessel and the remaining condensate after flashing runs down into an atmospheric condensate receiver. Here it is joined by condensate returned from low pressure users. Condensate is pumped from the ICON 1 and 2 condensate receivers back to the Main Boilers deaerator.

3. <u>LP Steam Distribution System</u>

The remaining 18% of HP steam is reduced into a low-pressure steam distribution system at 2.9barg. Some of this is supplied by flash steam but additional make-up is required and is provided by reducing HP steam.

Boiler Plant Deaerator

Approximately half of this steam (9% of overall total steam usage) is used in the Boiler Plant deaerator. Boiler feed water is fed first to the deaerator. The water is a mixture of recovered condensate with fresh RO (demineralised) water to make-up for losses. The amount of make-up water is a significant portion of the feed as steam used in the fluid energy mills becomes contaminated with pigment particles and condensate from this source cannot be recovered for reuse in the boilers (although any condensate from this source is reused in the Finishing Plant process area). Fresh RO water is preheated to 80^{o}C, by exchange with hot water from the heat recovery system on the exhaust from the fluid energy mills.

Oxygen carbon dioxide and other non-condensable gases must be removed from the boiler feedwater, as otherwise their presence can lead to severe corrosion at the temperatures and pressures that exist in the boilers. Boiler feedwater is sprayed into the deaerator tower and flows down over a number of perforated plates. Low pressure steam is injected at the bottom of the tower and flows up counter current to the feed water stripping out the non-condensable gases as it does so. The steam vented from the deaerator is routed into the vent of the hot water tank of the fluid energy mill heat recovery system. Here it is contacted by a spray of hot water which condenses any steam present and recovers the heat content.

Coating Tanks

LP Steam is also injected into Coating Tanks which are used in the Wet Treatment part of the Finishing Plant. There are two Wet Treatment streams which feed coating pigment into the three dry pigment streams. Each of the two streams has a Coating Tank and approximately 6% of overall total steam is used through direct injection into these tanks. This is used to keep the the liquid titanium dioxide slurry temperature at the optimum temperature for the coating process.

The purpose of this section of the process is to apply a number of surface coatings to the titanium dioxide pigment particles. This is achieved by precipitating the coatings of aluminium, silicon, titanium, zirconium and phosphorus oxides (either singly or in combination) from acid and alkali solutions of the coating reagents. The use of different coating reagents gives the coated pigment different optical and physical properties resulting in different pigment products. Depending on the coating, the pigment will be used by the customer for different applications.

Other Steam Uses

LP Steam has other minor uses around the site such as heating offices. Approximately 3% of overall total steam is used in these various applications.

4. <u>ADMS Scenario 1 explanation</u>

The boilers are designed to produce 108tph superheated steam at 24barg and 255-273^{0}C. The air dispersion model considered this case as it represents the capability of the boiler package. However, it is a very conservative scenario.

The Process Flow Diagram uses 94tph for the heat and mass balance. This is the theoretical maximum steam demand from the Site users when all Chlorination and Finishing Streams are in operation at the same time. It is calculated as follows.

- FEM use – 550tpd (22.92tph) Titanium Dioxide product at 3:1 SP ratio (steam:pigment) = 69tph steam
- ICON calandrias – 2 @ 5tph steam each (normally 3.5-4.5tph) =10tph steam
- LP steam let down – used in deaerator, slurry heating with live injection, etc = 15tph steam

Total demand = 94tph steam

In practice, SP ratio of 3 is rarely if ever employed. Double micronized grades employ between 2 - 2.8SP, whilst single micronized grades employ 1.2 – 1.6 SP

The boilers have been sized at 108tph capability to provide some redundancy for maintenance.