WSA - Profitable sulfur management

Introduction

The WSA technology is an excellent alternative to the Claus technology for sulfur management within oil refining, coal gasification, gas sweetening etc. High steam production, feed flexibility, ease of operation, and low CAPEX & OPEX are some key benefits for the operator when selecting the WSA technology. Today we have +130 references world wide.

Combustion & NOx reduction

Figure 2 shows a typical WSA plant that handles H_2S gas and sour water stripper (SWS) gas from a refinery. The plant consists of three steps. In the first step the gases are combusted to produce SO_2. The combustion of the ammonia contained in the SWS gas leads to generation of a certain amount of NOx. The flue gas from the combustion is cooled to approx. 400°C in a waste heat boiler, generating high-pressure steam at around 60 bar g.

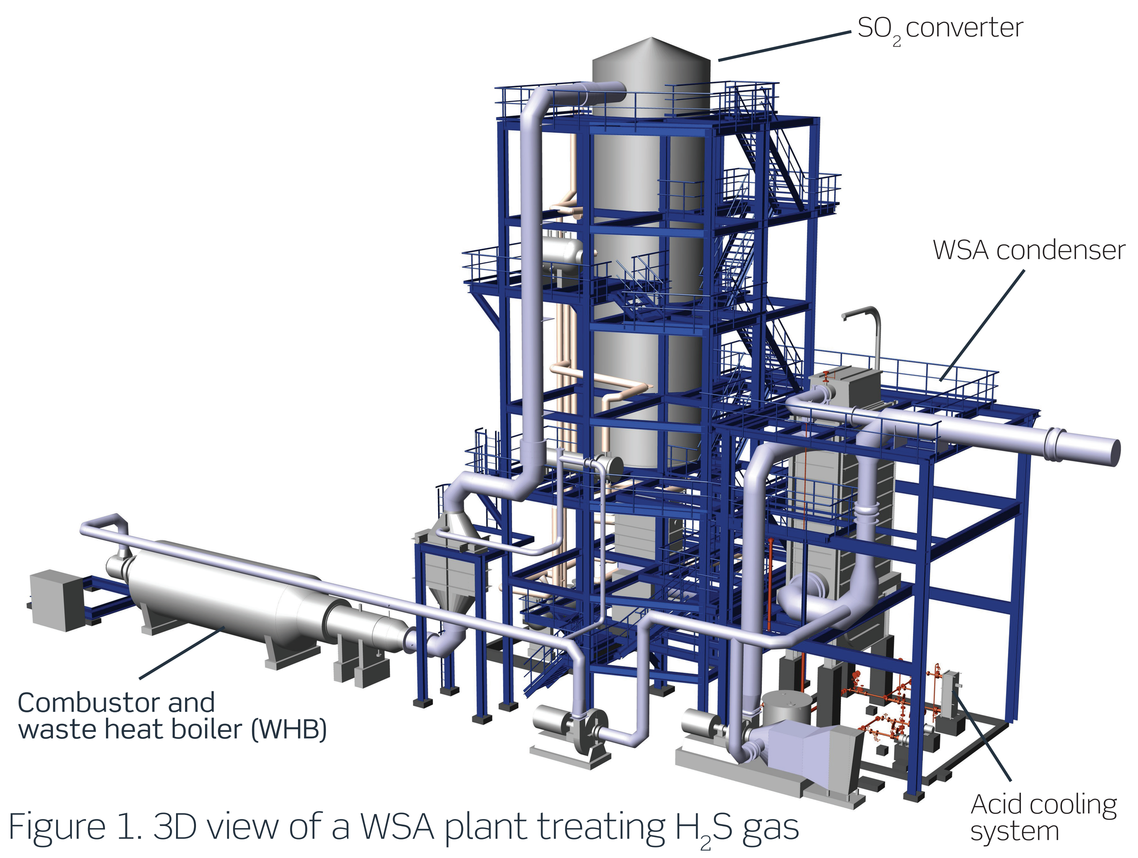

Figure 1. 3D view of a WSA plant treating H_2S gas

A small stream of SWS gas is bypassed the combustor so as to provide the necessary ammonia for the reaction with the generated NOx in the SCR reactor. The catalyst applied is from the monolithic Topsoe DNX series. The reaction generates atmospheric nitrogen and water vapor only.

If no ammonia-containing gas streams are to be handled, the NOx removal step can be avoided.

Conversion

The temperature of the gas after the first step is still around 400°C. The second step is the exothermal conversion of SO_2 to SO_3. This takes place in a three-bed catalytic SO_2 converter. The catalysts applied are of the Topsøe VK-W series. Three catalytic beds are normally required to give a conversion in the order of 99.6 %. Cooling between the beds takes place by superheating of the steam from the waste heat boiler to typically 400°C. The cooling after the last bed to approx. 290°C takes place by additional steam generation in a boiler connected to the same steam drum as the waste heat boiler. During this cooling the SO_3 generated in the SO_2 converter will react with water vapor in the gas and form sulfuric acid vapor. This is like the SO_2 conversion an exothermal process, and the reaction enthalpy is recovered in the form of steam.

Condensation

The third step is the condensation of the sulfuric acid vapor. This takes place in a heat exchanger with vertical glass tubes cooled on the outside by atmospheric air. This "WSA condenser" is the heart of the process. A sketch of the condenser can be seen in figure 3.

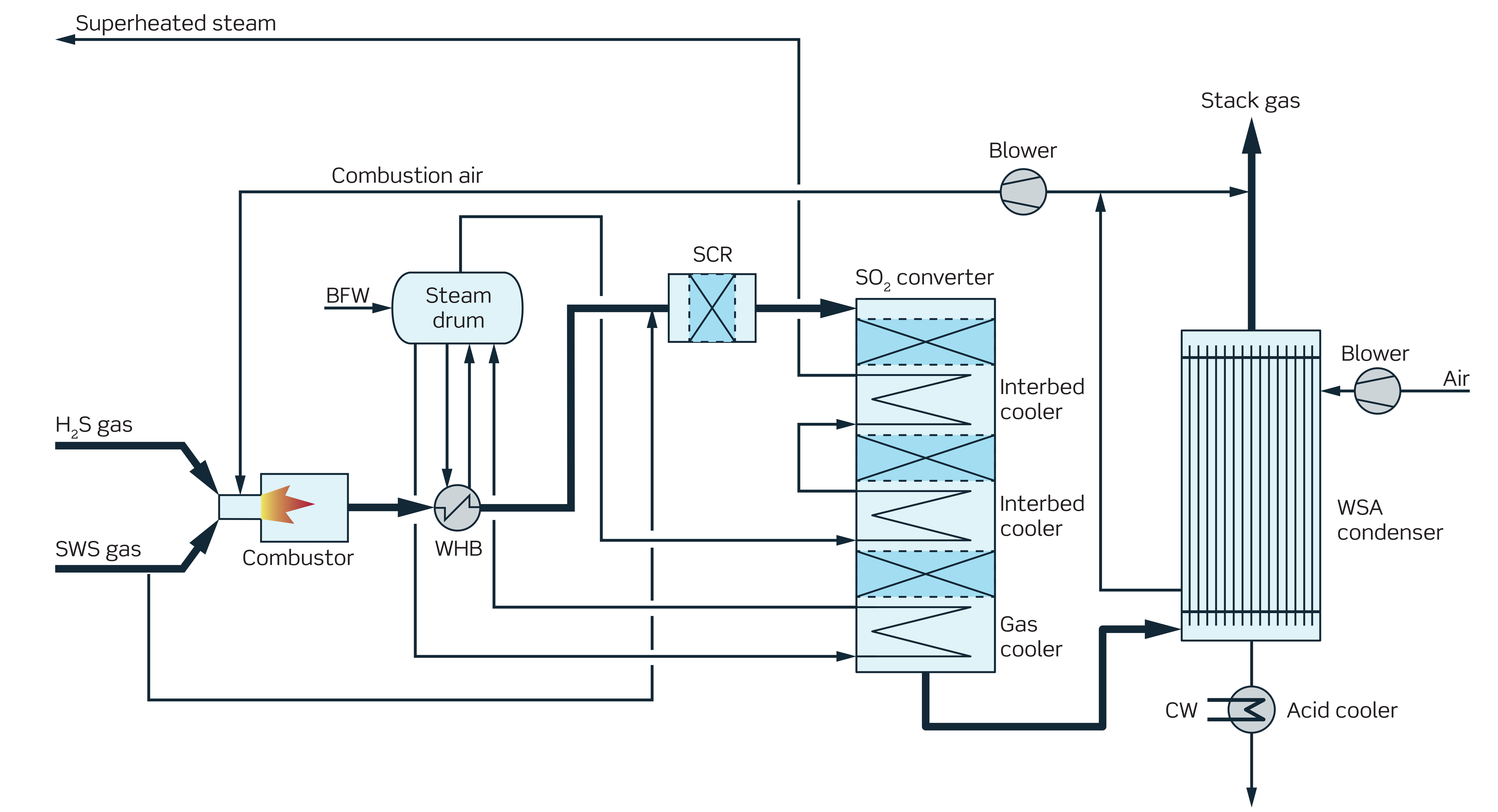

Figure 2. Typical WSA plant cleaning H_2S gas and SWS gas

This is the first place in the process flow where liquid sulfuric acid is present, so all the materials in contact with the acid must be acid proof. The tubes are made of glass resistant to acid and thermal shocks, the bottom section is lined with acid proof insulating bricks, and the tube plates and the top sections are coated with fluorinated polymers. The internals in the glass tubes are made of PTFE and glass. The cooling of the gas to approx. 100°C makes the sulfuric acid condense. When it flows down the inner tube surface in counter-current with the hot gas, it is concentrated to around 98% concentration. It leaves the condenser and can be cooled and pumped to storage. The gas that is now almost free of sulfur compounds can be directed to the stack. The air that has been used to cool the condenser is available at around 240°C as combustion air in the combustor. In this way all the heat of the gas down to 100°C is utilized for steam production.

High conversion

If more than 99.6% conversion of the sulfur is required, WSA-DC, a double condensation version of the WSA technology can be applied. In this way the SO_2 conversion can reach a level up to 99.99%, which is much higher than required by any legislation today. This means that even for high conversion rates, WSA technology can be operated without TGTU.

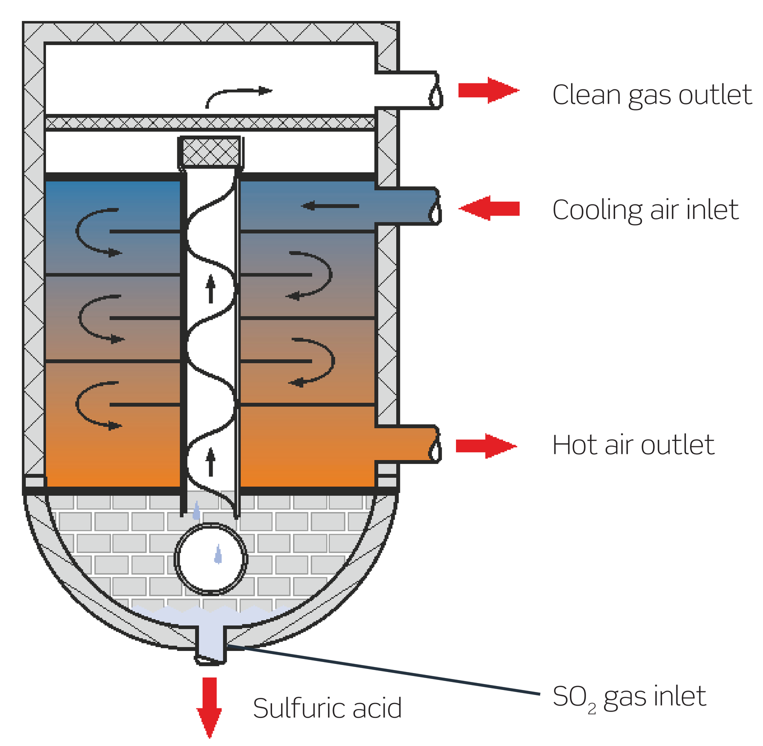

Figure 3. WSA condenser principles

WSA and SNOX™ references

Industry	No.
Oil refining	40
Metallurgy	14
Coking	32
Gasification	30
Viscose	7
Other industries	10
Total (January 2015)	**133**

Economics

In this section a cost benefit analysis has been made by one of our many customers, where WSA has been compared with the conventional Claus technology.

The below tables shows production income, consumption expenses and conclusion in where it can be seen that the comparative advantage for this customer by using the WSA technology is > $ 27 Million assuming a plant life of 20 years. The basis for this study is a plant which is treating an amine off gas (H_2S) with a capacity of ~30 TPD elemental sulfur and 99.5% sulfur recovery.

Production figures	Unit	Unit price	WSA		Claus + TGU	
			Prod.	USD	Prod.	USD
		USD	per hour	per year	per hour	per year
Sulfuric acid (as 100%)	MT	32	3.56	978,939		
Sulfur (as 100%)	MT	100			1.16	999,974
High pressure steam	MT	17	9.50	1,388,965		
Low pressure steam	MT	13			2.70	301,874
Total production value	**USD**			**2,367,903**		**1,301,848**

Consumption figures	Unit	Unit price	WSA		Claus + TGU	
			Cons.	USD	Cons.	USD
		USD	per hour	per year	per hour	per year
Fuel gas	MT	130			0.23	257,152
Oxygen	MT	47			0.56	226,363
High pressure steam	MT	17			1.33	194,455
Boiler feed water	MT	0.34	11.2	32,750	3.70	10,819
Cooling water	MT	0.03	30.8	7,947		
Fresh water	MT	0.03			1.00	258
Electric power	kWh	0.08	205	141,047	400	275,213
Waste water treatment	MT	0.12			1.00	1,032
Total consumption cost	**USD**			**181,744**		**965,292**
Total production value	**USD**			**2,367,903**		**1,302,880**
Net production income	**USD**			**2,186,160**		**337,588**

Financial		WSA	Claus + TGU
Maintenance costs	% of TIC annually	2	3
Operators		1	2
Investment	MM USD	10.0	10.0
Net present value	MM USD	28.5	1.0
Internal rate of value	% p.a.	23.0	-9.0
Surplus over 20 years	MM USD	18.6	-8.8
Comparative advantage of WSA over 20 years	**MM USD**	**27.4**	

WSA

HALDOR TOPSØE