CO_2 case: Calculation of energy savings in the Topsøe SNOX™ flue gas cleaning plants

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Background

Accoat has for many years coated parts for the SNOX™ plants all over the world. These coatings withstand the high temperatures in the desulphurisation unit and make the process possible.

Accoat uses a substantial amount of energy to produce these coatings and it is the scope of this paper to compare the amount of energy used in the coating process to the possible savings in the SNOX™ units.

The SNOX™ process

SNOX™ stands for that Sulfur and NOx gases, that effectively is removed from the flue gas.

In the removal of NOx from the gases Ammonia NH3 is mixed with the flue gas and the mixture led through a catalyst bed. The reaction is:

$NO + NH_3 + 0{,}25\ O2 = N_2 + 1.5\ H_2O + 410$ kJ/mol.

About 90% of the NOx is removed in this process.

In the following SO_2 reactor the gas passes another catalyst bed, in which about 98% of the SO_2 in the gas is oxidized to SO_3 :

$SO_2 + 0.5\ O_2 = SO_3 + 100$kJ/mol.

The gas is led to the WSA condenser, a giant heat-exchanger 7 meter high, 1.5 meter wide and 2.5 meter long and equipped with 720 pcs. 7 meter long glastubes in which the gas is cooled to about 100°C. During the cooling in the tubes the SO_3 is first hydrated to concentrated sulphuric acid gas:

$SO_3 + H_2O = H_2SO4$ (gas) + 100 kJ/mol.

Later the sulphuric gas is cooled to under the de point and formation of 95% sulphuric acid is the result. This is collected in large fluoroplastic coated tanks until sold and shipped as pure concentrated sulphuric acid.

H_2SO4 (gas) + 0.28 $H_2O = H_2SO4$(95% conc) + 80 kJ/mol.

It can be calculated, that these 4 exothermic processes ad so much energy to the processes, that about 0.8% of the total energy production of the SNOX^{TM} plant.

Below is calculated the amount of energy and release of CO_2 for one unit.

Data for unit 2, the SNOX^{TM} power plant at Nordjyllandsværket (NEFO)

For the NEFO plant in Northern Jutland (Nordjyllandsværket) in Denmark these savings are calculated using the following data from 2007:

Size of plant	225 MW electricity + 42 MJ/s heat for households.
42 MJ/s=	42x3600 = 151.200 MJ/h. 1 MJ = 0.27 kWh, so 151.200 x 0.27 = 40.824 kWh = 41 MW
Actual Production 2007 =	From (1): 269 + 41 = 310MW
Operation hours	4500
Coal consumption ton/h	105
Coal used for SNOX^{TM} unit	4500 x 105 = 472.500 tons/year.
Total coal for both units	1.206.037 tons/year
Total emission CO_2 for both units	2.759.949 t/year
CO_2 emission for SNOX^{TM}	472.500/1.206.37 x 2.759.949 = 1.081.072 tons/year
Savings on SNOX^{TM} unit	0.8% of 472.500 tons coal = 3780 t coal/year
Less CO_2 on SNOX^{TM} unit	0.8 % of 1.081.072 = 8649 ton CO_2/year
Coal savings per MW	3780/310 = 12.2 tons coal saved per MW
CO_2 savings per MW	8649/310 = 15.0 tons CO_2 not released in the air.

Accoat's emission of CO_2 producing the parts for the WSA unit

Normally the so called tubeplates in the WSA tower, one upper one and one lower one is coated with a fully fluorinated fluoroplastic coating of a minimum thickness of 550µ. In practice the film thickness is about 800µ.This coating protects the steel plate for corrosion from the corrosive sulphuric acid and from the high temperature of the flue gas.

In the coating process Accoat liberates CO_2 from the natural gas used for heating the plates up to about 400°C several times. For the calculations the following conversion factors are used:

For each 1000 KWh the power stations emits 494 kg CO_2 (NESA).
For each 1000 m^3 natural gas is emitted 2253 kg CO_2(DGC).

Emission of CO_2 by coating of one tube plate with 8.5 m^2 fluoroplastic coating

Process	Electricity KWh	Natural gas m^3	Total amount CO_2 in kg
Heat treatment		60	135
Sandblasting	165		82
Heating before priming		5	11
Heating when coating		120	270
Electricity to air pressure when spraying etc.	20		10
Total CO_2 emitted			508

Normally 2 plates are coated per WSA unit, which makes the amount of CO_2 emitted per unit to1016 kg or 1.016 tons. For the NEFO plant the emission will be about
72 x 1.016 = 73,2 tons of CO_2.

Conclusion

Calculations based on data from the Ohio demonstration plant and from NEFO, the first commercial plant SNOX^{TM} plant has shown, that the exothermic reactions in the process saves a lot of energy, thus about 0.8% less coal is used and similarly 0.8% less CO_2 is emitted to the atmosphere.

Topsøe has installed about 70 WSA plants (some with NOx cleaning also) all over the world and some larger than the NEFO unit. If it is assumed, that each plant contains 10 WSA units and that the coatings last for 10 ears (which is a low estimate). This amounts to totally 700 WSA units. NEFO has 72 units, which means that about 10 times the NEFO savings in coal and CO_2 emission is the result. As the plates last more than 10 years the savings amount to at least 100 time those at NEFO.

This means that 378.000 ton coal is saved from being used and the atmosphere is spared from 864.900 tons CO_2.

Compared to this Accoat releases 700 x 1.016 = 711 ton of CO_2.

Acknowledgement

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References

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