Summary

The doctoral dissertation is devoted to the analysis of working conditions and the optimization of contact tower of SO_2 to SO_3 conversion in conjunction with a heat recovery steam generator. Its practical goal was to develop a computational algorithm that enables the simulation of working parameters of the analyzed object.

Both the contact tower and the heat recovery steam generator are part of the technological process of the Sulfuric Acid Plant (FKS), whose primary task is the production of sulfuric acid from sulfur oxides that are components of waste gases generated, among others, during the production process of the "Legnica" Copper Smelter and the "Legnica" Combined Heat and Power Plant. The analysis of working conditions and optimization of the device are complex issues due to the nature of FKS's operation, i.e., working under variable metallurgical conditions, including the composition, flow rate, and temperature of the converter gas. Fluctuations in the aforementioned parameters lead to the generation of excess process heat, and if it cannot be dissipated outside the system, they force unfavorable temperature ranges for the operation of individual stages of the contact tower from the point of view of SO_2 oxidation kinetics.

The conducted research included study and analytical work, laboratory analyses, modelling work, and field studies. Within the scope of this work, five potential optimization variants of the analysed object were examined. The first variant involved the development of new catalysts to replace the existing ones. To this end, the properties of the currently used catalysts were thoroughly analysed using advanced laboratory techniques such as WD-XRF spectroscopy, ATR-FTIR spectroscopy, and XRPD diffraction. The knowledge gained was used to develop new materials (referred to as A1 and B1 in the study), obtained through rhenium doping, whose effectiveness was then tested in a laboratory reactor setup. Experiments showed that the newly developed catalysts required initiation temperatures approximately 20–30°C lower and had better conversion efficiency than the previously used commercial materials. Under laboratory conditions, the efficiency of A1 compared to its commercially available counterpart (A0) was higher by up to 6.4%, and in the case of B1 (relative to commercial B0), by up to 2.7%. The results obtained on a laboratory scale were extrapolated to an industrial-scale contact tower. Analyses showed that the use of rhenium-enriched catalysts resulted in an increase in the amount of steam produced by up to 0.82% and an increase in the amount of sulfuric acid produced by up to 1.55%. Optimization variants 2-4 considered the possibility of operating the contact apparatus with rhenium-doped catalysts at temperatures lower by 5, 10, and 15°C, respectively. The analyses demonstrated that compared to the baseline catalysts, it

would be possible to improve the amount of sulfuric acid produced by up to 2.51%, although this would be associated with a reduction in the stream of produced steam by more than 25%. The fifth variant assumed the possibility of improving the amount of sulfuric acid produced in the installation through the appropriate selection of feedstocks for the smelting furnaces. The results showed that if the use of sulphur-rich feedstock led to an increase in SO_2 concentration by 0.1% before the apparatus, then for an average SO_2 concentration of 7.65%, an increase in acid production of 1.30% (for current catalysts) and 1.34% (for rhenium catalysts) would be achieved.

Wrocław, 26.08.2024 r.

Kamila Jóźwiak