Improving the FGD absorber and ESP performance at Iskenderun power plant

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Kurzfassung

Verbesserte Abscheideleistungen des Rauchgaswäschers und des E-Filters im Kraftwerk Iskenderun

Das Kraftwerk Iskenderun liegt im Süden der Türkei in der Bucht von Iskenderun in der Provinz Adana. Zwei Blöcke mit einer gesamten elektrischen Leistung von 1,210 MW werden durch ISKEN, einer Gesellschaft im Besitz von STEAG (51 %) und OYAK (49 %) betrieben. Der jährliche Brennstoffverbrauch beträgt rund 3,3 Millionen Tonnen SKE, wobei die Kohle aus Kolumbien und Südafrika importiert wird.

Zur Einhaltung der vorgeschriebenen Schwefel- und Feinstaub-Emissionsgrenzwerte mussten die Abscheideleistungen des Wäschers und des Elektrofilters verbessert werden.

In einem ersten Schritt wurde das Optimierungspotenzial des Wäschers und des Elektrofilters basierend auf dem Ist-Zustand (Referenzfall) mithilfe einer Strömungssimulation bestimmt. Sämtliche CFD-Berechnungen wurden mit der Software FLUENT 6.3 durchgeführt. Für die Erstellung der Geometrie und des Rechennetzes wurde das Programm Gambit 2.4 verwendet.

Die resultierenden Geschwindigkeits- und Konzentrationsverteilungen des Referenzfalls lieferten ein tieferes Verständnis für die möglichen Verbesserungen.

In einem zweiten Schritt wurden mehrere mögliche Varianten mit verschiedenen Modifikationen an Komponenten analysiert und bewertet.

Im letzten Schritt wurde die Variante mit dem höchsten Verbesserungspotenzial ausgewählt und detailliert beschrieben.

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Isken Sugözü (Iskenderun) power plant

At the Isken Sugözü power plant 2 x 660 MW hard coal-fired boilers with two FGD scrubbers are operated. Each of the scrubbers is equipped with five levels of recirculation pumps with a flow capacity of 4,100 m^3/h. The flue gas mass flow is 1.9 million normal cubic meters per hour and the SO_2 load differs from 2,150 to 2,850 kg/h according to coal quality. In normal full load operation the FGD unit operates with 4 levels of pumps to keep the emissions below the legal limit of 400 mg/Nm^3.

Purpose of the project

The low SO_2 reduction efficiency of the existing scrubbers had to be improved to ensure that the current limit values and future sulphur dioxide emissions limits at the flue duct are met.

The modification was aiming at:

– Improvement of SO_x emissions without changing the liquid/gas ratio. Increase of the number of nozzles for better distribution of the slurry.
– Meeting of the current SO_x emission limit values with 3 recirculation pumps instead of 4 recirculation pumps by shutting down 1 pump (425 kW) to save energy.
– Increasing the SO_x capture efficiency from 80 % to 90 % with 4 recirculation pumps.

The first study was started in 2008. A CFD modelling project was run by Steag Energy Services to improve the FGD scrubber performance. The flow of the flue gas into the scrubbers was monitored.

As shown in Figure 1, the study did not reveal major uneven flow inside the scrubber tank.

Before CFD modelling, compact deposits around the scrubber nozzles near the walls were detected (Figure 2). Most of these deposits were at the lowest nozzle level. This indicated to non-uniform profiles of velocity, suspension concentration, and temperature, which could also cause poor scrubber efficiency. Other influencing factors could be the position and flow rate of the nozzles, the upstream located guiding vanes, and the duct form.

In the CFD modelling process, the results of a theoretically homogeneous scrubber inlet profile did not show a significant improvement in terms of distribution of velocity, of suspension concentration as well as temperature profile. It became clear that whatever modification had to be implemented for achieving a homogenous inlet profile, it would not have any significant effect on the situation in the scrubber. This could be explained with the relatively high pressure drop caused by the injected suspension through the nozzles of 8.5 mbar. Therefore there was no need to take influence on the inlet velocity profile by modifying guiding vanes or other internals upstream in the flue gas duct.

The distribution profile in the scrubber was dominated by the implemented number, position and type of nozzles. CFD modelling figured out that overall suspension mass flow with double number of nozzles were reaching much more homogeneous velocity and suspension concentration profile.

As a result, it could be seen that the recirculation rate of the scrubber suspension is sufficient for the measured SO_2 content. Noticeable are the few nozzles per m^2 or in sum over all layers per m^2 with the consequence of a local more uneven l/g. Only when taking into account these facts it was recommended to increase the number of nozzles per layer by preserving the recirculation rate and change at the same time the type of nozzles to full cone nozzles with a spraying angle of 90° at the wall side and in the centre to hollow cone nozzles with a spraying angle of 120° which is state of the art. The full cone nozzles at the wall side are preventing that a great amount of the suspension almost immediately is hitting the wall of the scrubber and is lost for the desired deposition reaction. The 120° spraying angle of nozzles in the centre produce more droplet interactions and therefore a regeneration of the surface available for the reaction besides a more homogeneous injection in the flue gas flow.

After CFD modelling, one of the proposed modifications for the scrubber was increasing the nozzle quantity. Therefore, the design of the recirculation spraying headers had to be changed. Also, new type spraying nozzles had to be selected for better spraying quality according to the capacity of the pumps. Thus, the dimensions of headers

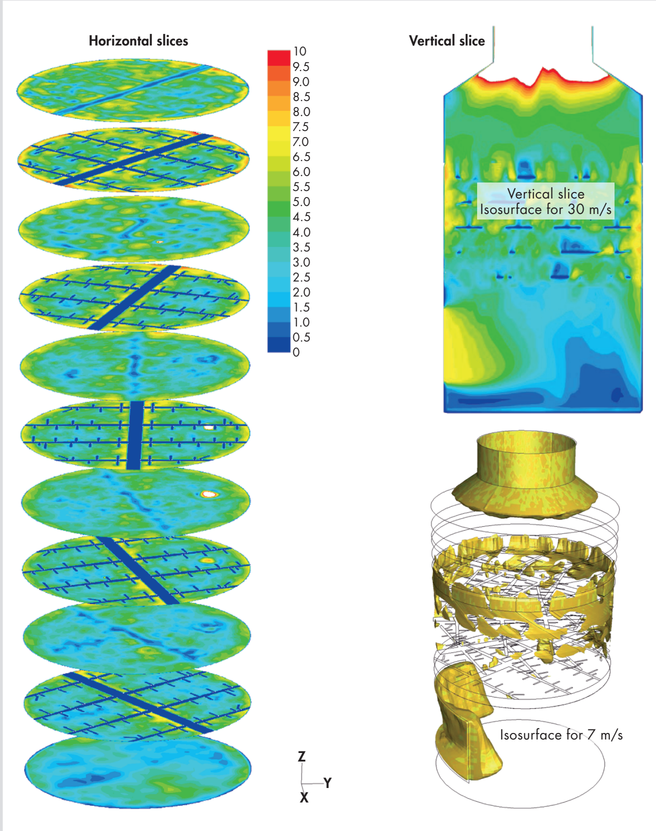

Fig. 1. Isosurface for 7 m/s of the FGD scrubber.

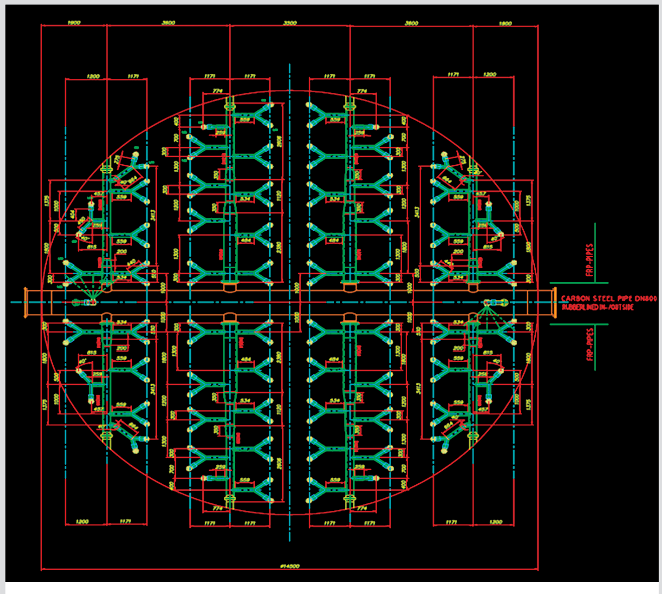

Fig. 3. New design of spray bank.

spray arms and nozzles were changed for the new design.

Last year it was detected that the absorber recirculation lines were damaged by abrasion. These lines had to be renewed. It was decided to apply the proposed modification for increasing the nozzle quantity. This was realised in unit 10 by own plant staff.

Before the outage, the nozzle orientation inside the scrubber was designed carefully to minimise non-scrubbing areas in the absorber. The headers were adjusted according to this nozzle orientation by the plant´s own engineering team using a CAD software. Y connectors were used to install new nozzles (Figure 3).

Twin-absorb nozzles were selected for the modification which was applied to three levels. For each level, the number of recirculation nozzles were increased from 66 to 128 with smaller diameters and flow rates without changing the liquid/gas ratio of each spray level. By increasing the recirculation nozzle quantity a larger scrubbing area – meaning minimisation of the amount of untreated raw gas – can be covered in the absorber. Thus, the SO_x emission were reduced.

Three different types of nozzles were used for the modification. The nozzles close to the absorber wall were full-cone with 90° spraying angle, nozzles close to the main header were hollow-cone with 90° spraying angle, and nozzles at the centre are hollow-cone with 120° spraying angle.

The new type of nozzles also reduced the SO_x emission due to their secondary atomisation property which occurs by the impingement of the recirculating slurry particles. The impingement effect of the particles makes the slurry droplets fragment into very small grain sizes which increases the surface area of the slurry. Thus, the reacting surface area also increases. The increased reaction surface area of the slurry increases the amount of the chemical reaction between slurry and SO_2.

Installation process

New nozzles were installed at the newly designed Y connectors with a special adhesive with high chemical resistance. For reducing the curing time of the adhesive, heating blankets were used. This process needs extra caution because it is important that the nozzles are mounted to the Y connectors in the right orientation.

The installation required a special and safe scaffolding which in turn needed a proper floor. Reinforced metal planks were placed on the positive-displacement bodies in the absorber. After the preparation of the floor, scaffolding could be constructed (Figure 4).

The diameter of the scaffolding was 14,500 mm with 14,250 mm height. It was constructed from +8 m to +22 m height (just below the first stage of the recirculation headers) in the absorber. After construction of the main scaffolding, additional scaffolding was constructed on top of the main scaffolding to reach level 5 (+29 m). The deadweight of the scaffolding was 19,550 kg.

The old nozzles and headers were removed from the absorber. Headers of new design installed from their flanges and supports. The supports and the blind ends of the headers were fixed according to the lamination method. The Y connectors were fixed to the headers with GRP (glass-reinforced plastic) adhesive set (Figure 5).

After the Y connectors had been equipped with nozzles, the connectors were rein-

Fig. 2 Deposites around the nozzles were eliminated after modification of the spray system.

forced by lamination with veil, fabric, glass mate, and mixture of vinyl ester bonding set (resin+hardener+accelerator) as well as black silicon carbide have been used (Figure 6).

The only difference with unit 10 is the connection between Y connectors and headers. For unit 20, it was opted for flanged connection instead of lamination. Alloy-59 (2.4605) material nuts, bolts, and washers were used for mounting to avoid corrosion. Epdm-coated steel gaskets were also used.

Results

Due to the modifications, SO_2 emissions were reduced by 35 % at full load with only 3 pumps in operation. Apart from emission reduction the auxiliary station load is reduced which means energy saving of 1 electrical motor with a power rating of 425 kW, which equals an annual saving of 2,800,000 kwh!

The SO_2 reduction efficiency at 100 % load with 4 recirculation pumps was improved by 10 %. efficiency increased from 80 to 90 %.

Improving the ESP performance

Improvement of the performance of the electrostatic precipitator (ESP) was considered as very important in order to reduce the dust concentration, in view of future limit values, and with respect to the environment.

Two ESP units are operated at the Iskenderun plant. Each unit is treating an average flue gas flow 2,815,912 m^3/h. The ESP comprises 3 fields of collecting electrodes divided with two aisles. Two more aisles for inspecting the precipitator are located before the first and behind the last field of collecting electrodes. Upstream, the inlet section is characterised by two gas distribution walls (Figure 7) with only one type of perforated plates. Two guiding vanes were implemented in the pass to improve the profiles in the diffuser. A set of guiding vanes was also designed directly at the gas distribution walls. Below the gas distribution walls inclined plates are attached to prevent that a significant part of the flue gas flows through that area. In the first and last row of the ash hoppers plates are implemented to prevent by-pass through the hoppers. Downstream of the precipitator in the next two bends of the duct, two more guiding vanes are influencing the flow profiles.

Similar to the absorber modification, in 2008, the ESP was modelled by Steag Energy Services with the aid of computational fluid dynamics (CFD).

In a first step the potential of fluid flow optimisation of the ESP was to be determined. The velocity distributions and ash concentration profiles of the flue gas had to be simulated with CFD programs (Figure 8) in order to understand and influence the precipitation process. The reference case (as build) and possible variants could be analysed and evaluated to allow for an improvement. It was possible to improve the process at various parts, e.g. by avoiding by-pass of the collecting electrodes and by forming a predefined velocity and ash concentration profile in the precipitator volume. Deviations from the state-of-the-art ideal profile could be a reason for diminished efficiency of the precipitator. Other factors could be the change of conditions during operation i.e. due to erosion or ash deposits.

It could be seen from the CFD report that the important area to be examined and influenced were velocity and distribution of ash concentration around the fields of collecting electrodes. Therefore, the results of the reference case show velocity and ash concentration profiles dominated by areas of high velocities at the sides and top of the precipitator volume.

Ash concentration simulations have been made for 1 and 50 µm ash particles in kg/m^3.

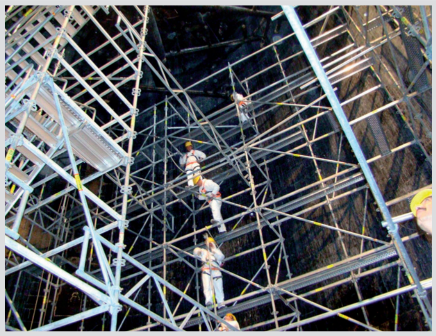

Fig. 4. Scaffolding.

Fig. 5. Orientation of nozzles

Fig. 6. Lamination of Y-Connectors.

As a result from the CFD modelling report, it was decided make the following modifications:

- Implementation of a diffuser outlet gas distribution wall at the precipitator outlet with similar perforated plates as in the inlet area,
- Removal of the existing hopper plates in the first and nearest row to the gas distribution walls and implementation of an hopper grid,
- Additional upwards directed horizontal guiding vanes in the upper section of the first and smaller gas distribution wall clipped in the same way as the existing guiding vanes at the gas distribution walls,
- Implementation of flaps in the area below the gas distribution walls that open the vanes through their weight,
- Implementation of flaps vertically to the left side wall of the ESP inlet to divert the excessive flue gas to the right side because most of the flue gas flows from the left side wall.

The proposed modifications were carried out 100 %. Modifications were made by own plant staff. Perforated plates, flaps, diverter plates were welded by own plant welders. However, it was difficult to apply these modifications because of the confined space and ash in the ESP unit. Therefore, special caution had to be taken to observe staff safety. Disposable protective overalls, full face masks, dust masks, and gloves had to be worn while modifying the ESP. Furthermore, special scaffolding had been constructed.

The modification was aiming at

- Lowering the flue gas velocity for improving the dust capture efficiency,
- Providing of homogeneous flue gas dispersion into the precipitator, and
- Preventing the flue gas to escape from the sides and top of the precipitator.

All these targets were met. Besides, ash precipitation was improved and re-suspension was lowered. The efficiency of the ESP was increased which results in a reduction of average dust emissions by 15 % at the ESP outlet. Prior to the modification, the average dust emissions amounted to about 65 mg/Nm^3 compared to average 55 mg/Nm^3 after the successful modification.

Fig. 7. ESP inlet gas distribution wall.

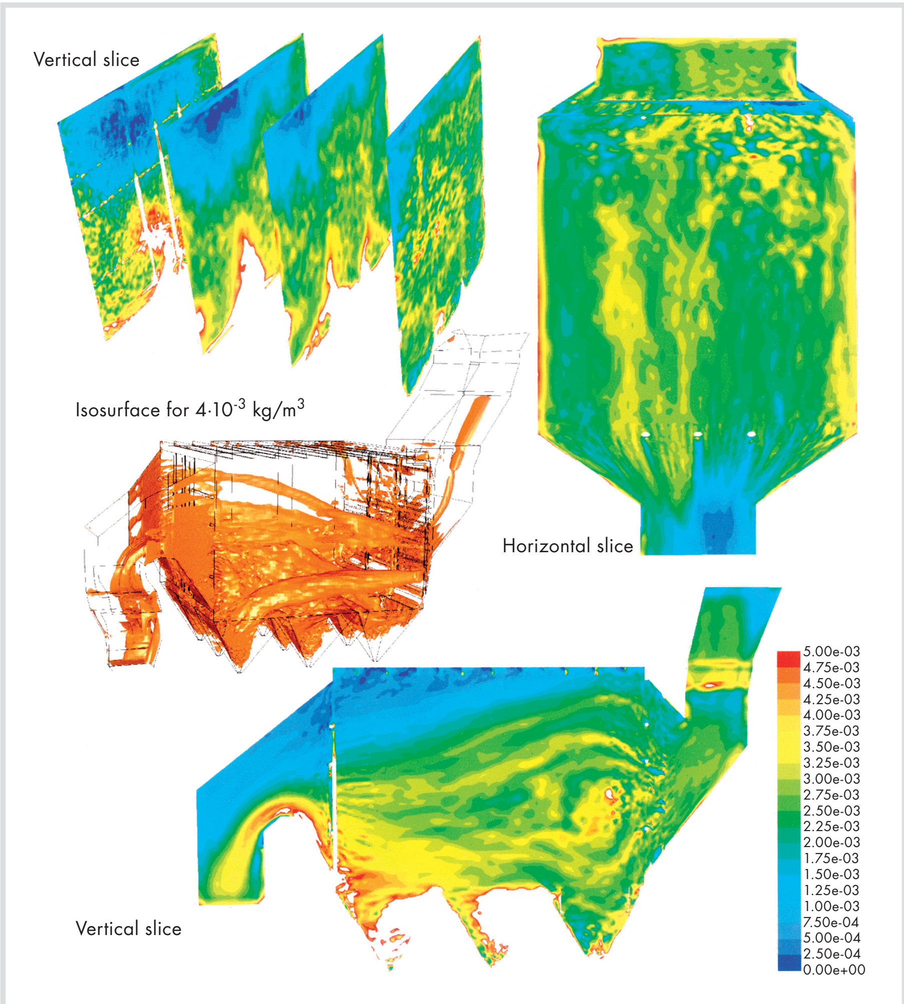

Fig. 8. Ash concentration for 50 µm ash particle in kg/m^3.