MODERNIZATION OF EXISTING COKE OVEN GAS TREATMENT PLANTS TO IMPROVE PLANT PERFORMANCE AND MEETING ENVIRONMENTAL REQUIREMENTS[1]

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Abstract

In integrated steel mills coke oven batteries and coke oven gas treatment plants are in operation for decades. During the lifetime of operation the equipment of the coke oven gas treatment plant is subject to significant wear and tear. Furthermore the requirement regarding clean coke oven gas quality has increased by the downstream process in the steel mill as well as from environmental authorities. Due to the high capital investment cost of new coke oven gas treatment plants it is economic and worthwhile to investigate in modernization and upgrade of existing processes and equipment of an existing coke oven gas treatment plant to meet the new demand. Such modernization and revamping work has been carried out by DMT at many coke oven gas treatment plants around the world. In this paper we will highlight the steps involved in the process from an initial study or change in mode of operation of the plant up to the stepwise implementation of modernization projects. DMT will demonstrate on practical examples e.g. design of tar decanting system or revamping of sulphuric acid and ammonium sulphate plants up to the upgrading of desulphurization processes (Claus process). This paper focuses on: i) steps required starting and implementing the modernization of a coke oven gas treatment plant considering plant requirements and environmental regulations, with an overview on process technologies available; ii) examples of technical solutions for upgrading of coke oven gas treatment plants.

Key words: By-product plant; Modernization; Revamping; Practical examples.

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1 INTRODUCTION

Because of increasing environmental regulations and demand of better COG quality, steel mills/coke plants are facing the challenge to meet those regulations by upgrading/modernizing their existing plants or to purchase new equipment. Furthermore worn equipment has to be revamped or even replaced to assure ideal production conditions to maintain/increase productivity.
DMT GmbH & Co. KG (DMT) supports those operating companies to face these challenges by preparing studies, upgrading/modernizing or revamping existing plants or even implementing whole new by-product plants on a "Greenfield" basis.
DMT established a well-known reputation as a know-how provider in its field. Especially upgrading or revamping running plants during operation (brownfield) is one of the specialties provided by DMT. Brownfield is an expression which is used to describe works in an operating plant, which is one of the special services DMT is providing to its customers. So the costumer is able to upgrade/modernise his plant during operation.
On top DMT provides Best Available Techniques (BAT)[1] to its customers who can rely not only on a prefunded know-how but also on high quality equipment.
This document will give you a good insight how to face these challenges with a theoretical guideline and practical examples.

1.1 Maintain/increase Productivity

As mentioned above, worn equipment has an impact to the plant´s productivity. Sometimes worn equipment can be repaired and it is possible to catch up the production goals of the plant again. In other cases worn equipment has to be replaced, because repairing would be to cost intensive or even impossible. In those cases the old worn equipment has to be replaced by a new unit with the same properties.
But sometimes a client wants to change to a whole new process route, may it be because of increasing production or to meet environmental regulations.
The challenge in all those cases is, that the replacement has to take place during the normal operation of a plant, which has its challenges by its own. Those challenges can be a limited space, pipe lines with hazardous material next to the worn unit, lowest impact on the process during the necessary works etc.
DMT is providing those services, amongst others, to the client and had become an expert in this field.

1.2 Environmental Regulations

Environmental regulations are getting more important worldwide. Even developing countries are facing stricter regulations than years before. Many countries are taking European standards[1,2] as an example to create own regulations or to implement European standards as such. Because of old plants in such countries, revamping or upgrading those plants will be a task which has to be tackled in future years to meet upcoming environmental regulations.
Especially the allowance of SO_2 emissions are increasing. Hence, sulphuric acid plants are getting more and more out-of-date and the Claus process becomes the favourite choice of many customers because its "Zero-Emission" process.

The European Union published different documents regarding regulations and Best Available Techniques. Those documents could be / are an example for many other countries around the globe.

2 FIRST STEP – A STUDY

If an operating plant is not able to meet new environmental standards or the productivity is decreasing, preparing a study to tackle these problems should always be the first step. Those studies can be prepared by DMT, who are able to provide a wide know-how covering different technologies gained by many years of practical experience.
Depending on the client's goals, the study will have different results:

- review plant operation;
- meeting new environmental standards;
- increase/maintain productivity;
- implementing new technologies;
- reduce maintenance.

A study should present three solutions to approach its goals, so the client has the opportunity to choose which solution is the most appropriate one.

- short term solution;
- medium term solution;
- long term solution.

Short term solutions are options which can have a certain impact but should be considered as a preliminary solution. Adjusting temperatures etc. could be one option, depending on the task.
Medium term solutions can be understood as revamping or maintaining worn equipment. These are not so cost intensive as long term solutions and belong to normal plant operation.
The long term solution is normally the most cost intensive solution. But regarding future perspectives, it is the most efficient solution. In these terms implementing new technologies or replace worn equipment is the normal recommendation.
Chapter 2.1 will present a study done by DMT where this guideline was successfully followed.

2.1 Example of a Study

DMT prepared a technical study for the optimization of the operation of a by-product plant in India. The client couldn't achieve the demanded quality of the partly cleaned coke oven gas (COG) after his naphthalene scrubbers. Therefore DMT got the order to prepare a study how to optimize the by-product plant operation with regard to increase the COG quality to the required level.
In this paper DMT would like to present a rough insight in the normal procedure to prepare such a study. But this paper will only highlight certain steps and findings and not the whole study as such.
The scope of DMT services comprises the following aspects:

- inspection and assessment of the present by-product plant equipment condition;
- investigation of the current mode of operation and operational problems;
- collection and analysis of operation data;
- discussion of identified problems and possible solutions;

- submission of a technical report with recommendation for immediate solutions as well as medium and long term solutions.

To fulfil the requirements, demanded by the client, two experts were sent by DMT on site to collect data and to visually inspect the following plant components.

- primary gas coolers;
- electrostatic tar precipitators;
- gas exhausters;
- ammonia scrubbers;
- ammonia recovery unit;
- naphthalene scrubbers;
- naphthalene recovery unit;
- gas distribution unit with boosters and gasholder;
- COG piping.

Example:

2.1.1 Ammonia recovery unit

This plant had ~7-8 g/Nm³ of NH_3 in its crude COG, the target to fulfil the customer requirements was 40 mg/Nm³ in the cleaned COG. But in this example the plant was able to reach a level of 100-200 mg/Nm³ only. Furthermore the client noted that his trays of his distillation plant collapsed many times.

After the visual inspecting of the ammonia distillation unit and checking the provided data, DMT remarked the following points.

- The panels of the internals were bended in the area of the support point
- Only single flow trays were installed (instead of single and double flow trays)
- Pressure pulses inside the column

2.1.2 Short term solution

The short term solution provided by DMT was as follows:

- Double flow trays should be installed – higher static stability to avoid bending; and same process performance;
- Constant pressure – to avoid mechanical stress.

2.1.3 Medium term solution

Beside the immediate solutions suggested by DMT, it was also recommended to:

- Check the tray design - capacity of 78 m³/h could not be reached; and Plus spare capacity for a new H_2S/NH_3-scrubbing water regeneration system

2.1.4 Long term solution

To ensure a reliable process and to meet environmental regulations, DMT presented a long term solution as well. This long term solution on one hand would need larger investments but on the other would guarantee a stable and “clean” process.

In this solution the client would have to:

- Replacing the distillation columns by two ammonia stills and two deacidifier columns, which can handle coal- and scrubbing liquor of modern scrubbing systems – columns would be equipped with a double flow tray system;
- Implement a elementary sulphur plant (Claus plant) – to meet environmental standards; and to ensure a constant pressure.

3 PRACTICAL EXAMPLES

The following chapters will present practical examples of medium and long term solutions done by DMT. Those examples are covering different projects around the world. Short term solutions will not be covered in this chapter, because those solutions can be roughly divided into equipment and operating solutions. The normal operating solution is to increase the temperature, to steam columns etc., the equipment solution could be to implement new/more measuring equipment, exchange pipes etc. Hence, to present practical examples of short term solutions won't be necessary.

3.1 Tar separation

DMT implemented a new tar separator in Europe, because the old one (Figure 1) was in a poor condition and it was not possible to renew it to meet the production goals and environmental standards.
This plant produced 4-5 t/h of tar but of a poor quality with a water content of ~20%. Therefore DMT designed and commissioned a new tar separation unit.

Figure 1.Old tar separation unit.

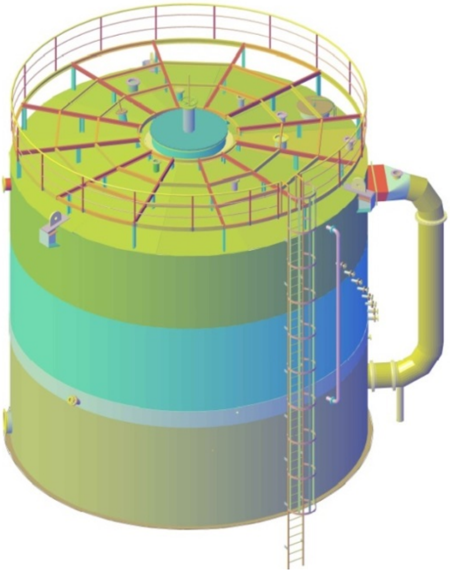

Figure 2. Model of the new tar separator.

This new plant (Figure 2) was designed to achieve a water content of 2%. After this unit started successfully even a water content of 1.5% was achieved.
Figure 2 shows a model of the new implemented tar separator. The sample nozzles of this tar separator can be seen on the right hand side of this model. These nozzles have the purpose to take samples of ammonia liquor to check on which height the ammonia liquor has to be discharged.

3.2 Claus Plant

There are different options to desulphurise COG according to environmental standards. One of the options is the Claus process. On one hand the Claus process will yield a valuable product (elemental sulphur) and is as well-known as “Zero Emission” process.

Figure 3. Claus plant in Asia.

Figure 4. Burner and boiler unit.

DMT implemented a redundant Claus plant in Asia (Figure 3) to meet environmental regulations. Because in case of a shutdown, due to maintenance, there would not have been a possibility to treat the vapours coming from the distillation plant. Hence,

a second Claus plant with 100% capacity had to be implemented. The capacity of the treated COG is 100,000 Nm³/h. The produced elementary sulphur has a purity of more than 99.5%.
This Claus plant is the biggest Claus plant around the world and was designed to treat 6,800 Nm³/h of process vapours. During commissioning even a flow rate of 7,200 Nm³/h was achieved.

3.3 Ammonium Sulphate Plant (Spray Type)

DMT implemented two spray saturators in Europe, each designed to treat 40,000 Nm³/h of COG. As can be seen in Figure 5, COG (not vapours) is directed into the saturator and mother liquor (with a content of approx. 5% H_2SO_4) will be sprayed via nozzles into the gas stream. The mother liquor will react with the ammonia in the COG to ammonium sulphate. The treated COG will have a gas composition of 7-9 g/Nm³ (inlet) and less than 40 mg/Nm³ (outlet).
The following pictures show the installed ammonium sulphate saturator (Figure 6) and the model belonging to it (Figure 7).

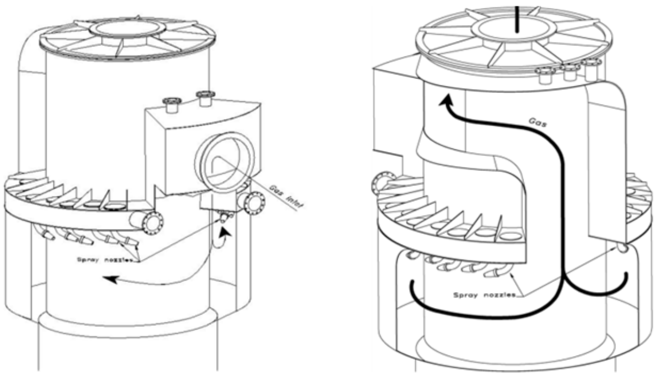

Figure 5. Principle of the Spray Type Saturator.

Figure 6. Ammonium sulphate saturator (spray type).

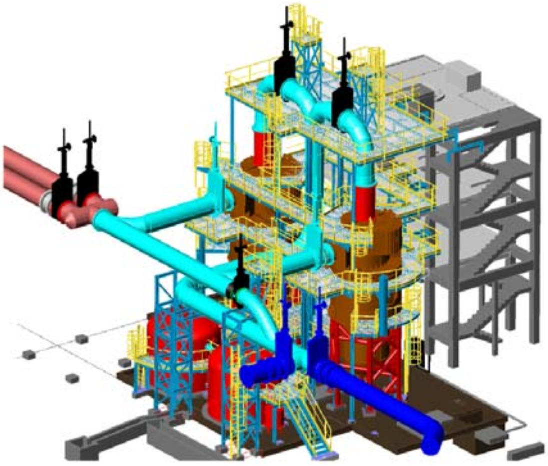

Figure 7. Model of an ammonium sulphate saturator.

3.4 Sulphuric Acid Plant

DMT implemented the combustion unit with a waste heat boiler (Figure 9) of a sulphuric acid plant on a coking plant in Europe, because the old equipment (Figure 8) was worn and could not be maintained any longer. This sulphuric acid plant was designed to treat 120.000 Nm^3/h of COG and is producing 2.5 t/h of sulphuric acid (with a content of approx. 78% H_2SO_4).

Figure 8. Old combustion unit with waste heat boiler.

Figure 9. New combustion unit with waste heat boiler.

On the same unit, DMT provided its services to the client to revamp the lining inside a waste heat boiler of a sulphuric acid plant.
As can be seen in Figure 10, the lining of the boiler was in a poor condition and had to be repaired to meet environmental standards and to maintain productivity.

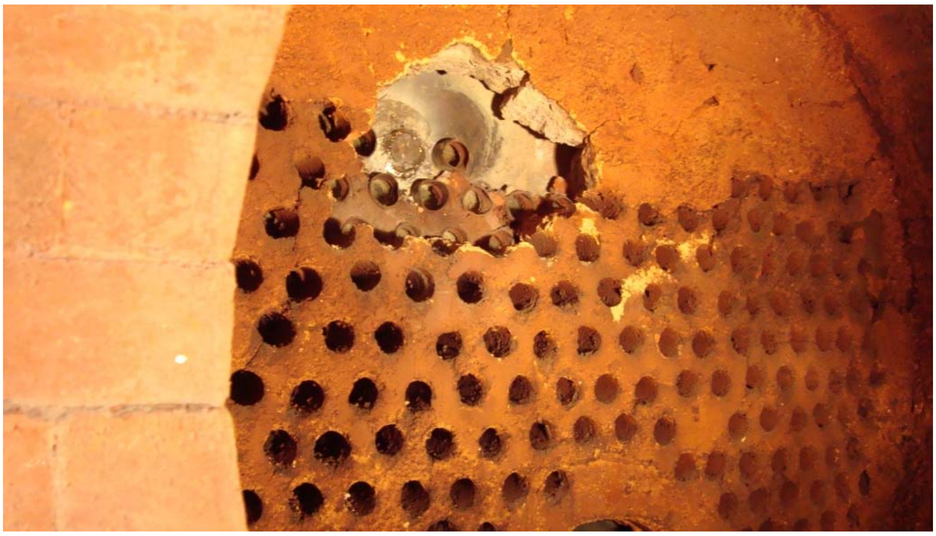

Figure 10. Broken lining inside waste heat boiler.

Figure 11 shows the repaired lining of the waste heat boiler. But this was an immediate solution only. This means, the whole lining had to be replaced in future.

Figure 11. Repaired lining of the waste heat boiler.

The plan was to keep this unit in operation until the new bricks for the lining were available. This took six months until the new bricks were delivered. Figure 12 shows the waste heat boiler with its new lining.
This boiler is able to supply 1.5 t/h of medium steam to wash oil heater of the BTX recovery plant in this plant.

Figure 12. New lining of the waste heat boiler.

4 CONCLUSIONS

This paper has given an overview on modernization of existing by-product plants, implementation of new processes and the steps to achieve those. Due to different options, provided by DMT, the client is able to choose the best option tailored to his needs. The advantage to invest in a study first is that different alternatives will be identified, so the client can choose from various solutions to rectify his deficiencies approach his problem.

It has been proven that through studies, stepwise implementation and modernization the performance of by-product plants has been improved while considering economic situations of the plant or the client.

Because of its wide know-how and experience, DMT is one of the leading providers of those services to the client, starting with a study up to revamping certain equipment or even implementing certain units or whole plants on a green-/brownfield basis.

With its experienced process experts (design and operation) DMT can look back on a long history of successfully retrofitting by-product plants and has executed such projects globally.

DMT is utilising excellent local contacts to meet the demand of the local client’s.

REFERENCES

1 Best Available Techniques (BAT) Reference Document for Iron and Steel Production, European IPPC Bureau-Industrial Emission Directive 2010/75/EU (Integrated Pollution Prevention and Control)

2 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial emissions (integrated pollution prevention and control).