NOVEL THERMAL OXIDIZER FOR TANK TERMINALS

DEMONSTRATING OUTSTANDING ENERGY EFFICIENCY AND OPERATIONAL ROBUSTNESS

ITC RUBIS TERMINAL ANTWERP

DUMAG COMBUSTION TECHNOLOGY PARTNERS

Figure 1: Thermal oxidizer units at ITC Rubis, Beveren (BE)

ABSTRACT

In this paper we present the case study of the experience gained in the operation of the 2.9 MW thermal input direct fired thermal oxidizer designed and built by DUMAG and installed at ITC Rubis terminal in Beveren (Belgium).

The specific challenges covered in this paper arose from the nature of the gaseous vent streams at tank terminals, specifically their discontinuous occurrence and their rapid fluctuation in pressure and composition.

IN THIS PAPER WE WILL SHOW HOW THE DUMAG SYSTEM HAS SUCCESSFULLY TACKLED THESE ISSUES IN THE COURSE OF THIS PROJECT AND WE WILL ALSO DESCRIBE SOME SIGNIFICANT ADDITIONAL FEATURES.

We focused on the following major challenges in this project:

1. Auxiliary fuel reduction in idle mode without compromising safety (the safety measure known as dynamic flame arrester is maintained). This is achieved by applying a constant speed burner (CSB), a revolutionary new type of burner with a movable burner nozzle. The result: an 80 % reduction of auxiliary fuel consumption in idle mode compared to a conventional dynamic flame arrester. The unit requires a significantly lower minimum gas flow to operate safely, with major cost savings in auxiliary fuel and power consumption for fans as a result.

2. The advanced process control system increases the ability of the installation to accommodate sudden pressure changes and changes in vent gas composition (which are largely due to manual actions at the terminal). The system was implemented by DUMAG and effectively eliminates the episodes of incomplete combustion and occurrence of black smoke at the stack.

INTRODUCTION

THE SUBJECT OF THIS CASE STUDY IS THE THERMAL OXIDIZER SYSTEM FOR TREATMENT OF CHEMICAL VAPORS AT THE ITC RUBIS TERMINAL IN BEVEREN (BELGIUM).

ITC Rubis is a state of the art storage terminal for storage of liquefied petroleum gas (LPG) and chemical products, with each type of product having dedicated vapor treatment facilities. Here we will focus on treatment of vapors of various chemical products mixed with nitrogen. Some LPG can also be drained occasionally into this mixed vent stream.

Generally speaking, the pressure increase in a storage tank either results from product discharge into the tank or from product vapors heating up due to atmospheric conditions. Venting of each tank is controlled by pressure in the tank. At set-point, an automatic pressure valve at the tank vapor side is opened and the vapors vent until the pressure drops to a defined value. It is ITC Rubis policy not to release any chemical products into the atmosphere uncontrolled, so the vent gas is directed towards vapor treatment, which can be based on recovery (for streams containing a pure substance) or combustion technology (for gaseous mixtures).

There are also various chemical compounds stored at ITC Rubis, and their vapors, mixed with nitrogen and air, are vented into a common collection system forming a gaseous mixture. The whole vapor collection system is thus classified as an ATEX zone 0 area. Vent gas flows towards thermal oxidizers from this vapor collection system due to the vacuum maintained by zone 0 fans at the thermal oxidizer systems. The thermal oxidizers are fed by this means, and in addition the vacuum state at the furthest sources from the oxidizers is also maintained in order to prevent cross contamination of gas phases in tanks with different products. This provides a functional safeguard against cross-contamination due to a failing vacuum.

It can be readily concluded from the description above that the vent gas from storage tanks will vary considerably in terms of composition and volume (more than 50 storage tanks with different products of which a certain amount will reach venting conditions at any given time due to operations or atmospheric conditions). This variation in vent gas composition and quantity of gas is illustrated in Figure 2 (the disturbance is shown on the right hand of the figure)

In addition to this, some special manual operations are performed at ITC Rubis, such as nitrogen blowing of lines or draining of small quantities of LPG into the system, which results in abrupt pressure and concentration peaks in the vent gas.

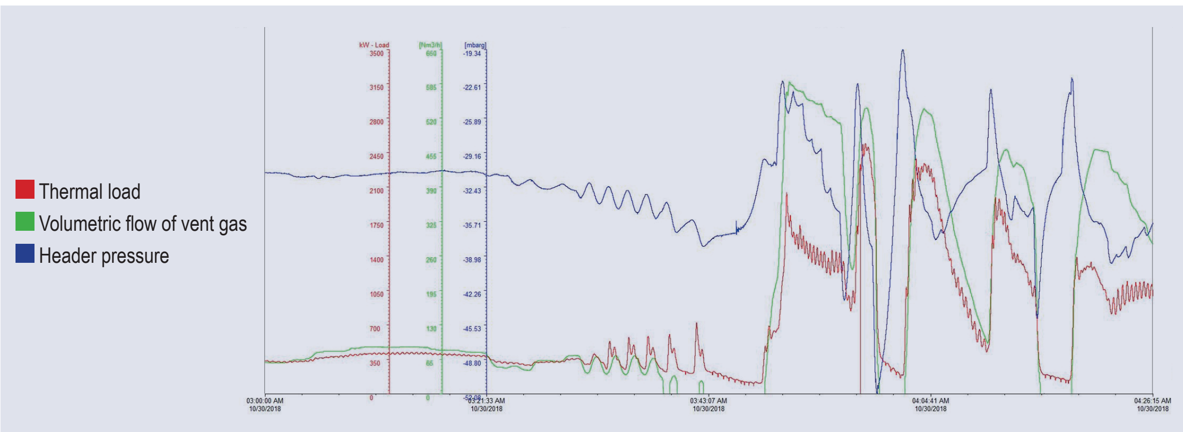

Figure 2: Illustration of the vent gas flow and composition changes

Another feature of vent gas is its discontinuous availability at tank terminals. As a consequence of this, there are periods of reduced operation. In these periods, the thermal oxidizers receive almost no combustible content but must still secure the vapor control function so as to remain capable of receiving vent gas at any given time. This requirement presents a challenge in terms of energy efficiency.

Figure 3: Black smoke due to incomplete combustion during a test run

EARLIER SITUATION

CONVENTIONAL THERMAL OXIDIZERS

Prior to the addition of the DUMAG thermal oxidizer, ITC Rubis operated two conventional thermal oxidizers with a similar thermal capacity to the new one that has been installed.

These conventional direct fired thermal oxidizers with vertical combustion chambers feature what is known as a dynamic flame arrester which is a common protection device in this systems of this kind.

When the flow rate of vent gas falls below a critical value there is the risk of a backflash: the flame will not be introduced into the combustion chamber but burns back towards the source of the vapors.

The dynamic flame arrester is used to prevent this using additional air to ensure that the total flow rate does not fall short of the critical low setpoint under any circumstances. Additional air is added in the event of a lower flow of vent gas, resulting in an appropriate velocity of the feed stream, which is above the velocity of flame propagation. This additional air flow ensures that the flame is always in the direction towards the stack and will not flash back. However, in order to maintain the combustion temperature (typically above 850°C) at all times, additional auxiliary energy is needed, precisely at the times when vent gas is very low or does not contain significant organic content. This is unfavorable and causes increased operational costs of the unit (especially in discontinuous operation).

Difficulties sometimes occurred in handling varying compositions (calorific value) and changing the amounts of vent gas in the existing units, especially during drain operations. Cooling/combustion air is fed via air inlet with shutters based on the principle of natural draft. The shutters are meant to control the air flow, and thereby the temperature. Due to the size and construction, however, the design could neither provide a quick response to the described changes nor accommodate to the pressure/concentration peaks in the vent gas. As a consequence, a visible flame or eventually black smoke resulting from incomplete combustion could be detected at the stack outlet. The involuntary attraction caused by such event might draw the attention of the neighborhood and authorities (see Figure 3).

THE TECHNICAL CHALLENGE

In the scope of this project, DUMAG was presented with two imperative targets that needed to be met and successfully demonstrated in use for guaranteed performance:

1. **Increasing the energy efficiency in "idle" mode:** achieving an overall reduction in auxiliary fuel consumption at low and no vent gas flow.

2. **Producing "invisible smoke":** increasing the ability of the installation to accommodate sudden vent gas pressure and composition changes.

We are pleased to state that we have succeeded in designing, building and operating a skid mounted, modular system meeting all the exceptional targeted performance requirements.

DUMAG CSB burner for increased energy efficiency

DUMAG installed the proprietary DUMAG CSB burner (see Figure 4) in the unit at ITC Rubis; this burner is capable of achieving a turn-down ratio as low as 1:30 without compromising in safety. Automatic control of the burner neck position maintains a constant pressure drop resp. gas velocity over the burner. When the amount of waste gas is lower, the burner will adjust and the cross-sectional area of the burner becomes smaller. This keeps the velocity constant at the burner neck, offers an effective measure against flame flashback and replaces the traditionally used dynamic flame arrester based on flow addition.

A significant reduction of the volume of air added (and therefore also additional auxiliary fuel) was possible as a result of this development, and the idle operation state (vent gas flow equal to zero with unit lined up) can now be realized with as little as 10 Nm^3/h natural gas, which is needed for compensation of heat losses through the insulation and via the stack.

Figure 4: Example of a DUMAG CSB burner device

The natural gas consumption in idle state is shown in comparison for all three units in Figure 5.

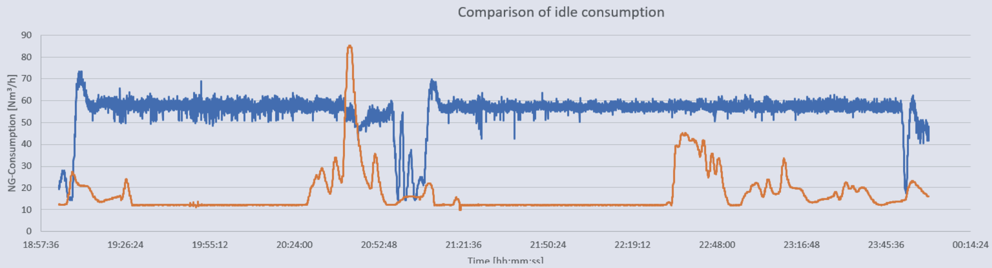

Figure 5: Comparison of natural gas consumption in thermal oxidizers at ITC Rubis during low vent gas flow rates

A verifiable improvement has been achieved. Assuming 2000 hours of idle time operation per year, a saving of approx. 1000 MWh of natural gas can be realized (difference in idle consumption can be seen in Figure 5 as horizontal trend line). This equals more than 200 tons of CO_2 emission reduction per year. Taking an optimistic natural gas price of 0.02 €/kWh as a basis, the expected fuel cost reduction could be at least 20,000 Euros per year.

DUMAG has included a hot-standby mode as an important additional feature for the periods when the collection system does not provide any vent gas over an extended period of time. In this mode, the unit temperature is maintained but the vent gas line is closed and a further lowering of the fuel demand is possible as a consequence.

THE DUMAG BURNER MANAGEMENT SYSTEM HAS THE CAPABILITY OF IDENTIFYING A REQUIREMENT FOR VAPOR TREATMENT AND AUTOMATICALLY AND INDEPENDENTLY RESUMING FULL OPERATION WITHIN 5 – 10 SECONDS IN ORDER TO STABILIZE THE HEADER PRESSURE AND TO FACILITATE SWIFT AND STRAIGHTFORWARD LOADING OPERATIONS AT THE TERMINAL.

Advanced process control for producing ”invisible smoke”

The DUMAG system features a forced draft air fan which is used to control the O_2 at the stack and the temperature of the combustion chamber. A fast reacting system definitely cannot rely on a single control loop only. Operation is monitored by the advanced process control that is implemented and the future operational conditions are also derived from the measurement input received. DUMAG recommends implementing feed-forward-control using a continuous composition analyzer upstream the system as a general rule, but this option was not required at ITC Rubis. In the case of the ITC Rubis unit, the flue gas temperature, the vent gas flow and pressure and thermal load and other further relevant process data are all used for controlling the system in addition to the flue gas oxygen content. DUMAG has parametrized these control loops in a highly effective system, based on its extensive experience in other successful projects. A clear illustration of this effectiveness is how the system processes a sudden introduction of 500 Nm^3/h of pure LPG via the LPG draining system. The DUMAG unit maintains full functionality until it reaches its thermal limit (see Figure 6).

CONCLUSION

DUMAG applied its proprietary technology and extensive process tuning experience gained in various thermal oxidizer applications, and also made full use of its proprietary computer aided engineering tools and its know-how and expertise to provide a suitable solution for the challenges presented by ITC Rubis.

Significant operational cost reduction has been realized for situations of low flow and no flow of vent gas. The most important stride forward, however, is that this has been achieved without compromising on safety or operational flexibility.

THANKS TO THE ADVANCED PROCESS CONTROL, THE DUMAG SYSTEM SECURES COMPLETE COMBUSTION UNDER ALL REALISTIC CIRCUMSTANCES AND PUTS AN END TO ANY MURKY PLUME AT THE STACK OUTLET.

To summarize some prominent features of the DUMAG system installed at ITC Rubis:

- **Vent gas consumption by means of the proprietary DUMAG CSB (constant speed burner) helping to realize a five-fold reduction of auxiliary fuel consumption in idle mode.**
- **Auxiliary fuel consumption by means of the proprietary DUMAG MFB (multifuel burners).**
- **The system uses a forced air fan for temperature and O_2 control.**
- **Parallel operation of all three units is successfully implemented. Due to its energy efficiency, the DUMAG unit is the primary unit used. When more capacity is needed, the other, less energy efficient units are put to work in addition and the DUMAG unit provides peak shaving. This optimizes energy consumption even further.**
- **Remote support (even during performance testing) is available 24/7.**
- **Carefully adjusted swirl at all burners performed to further reduce NO_x emissions (significantly below the permissive values).**
- **The design is adapted to accommodate a future waste heat boiler.**

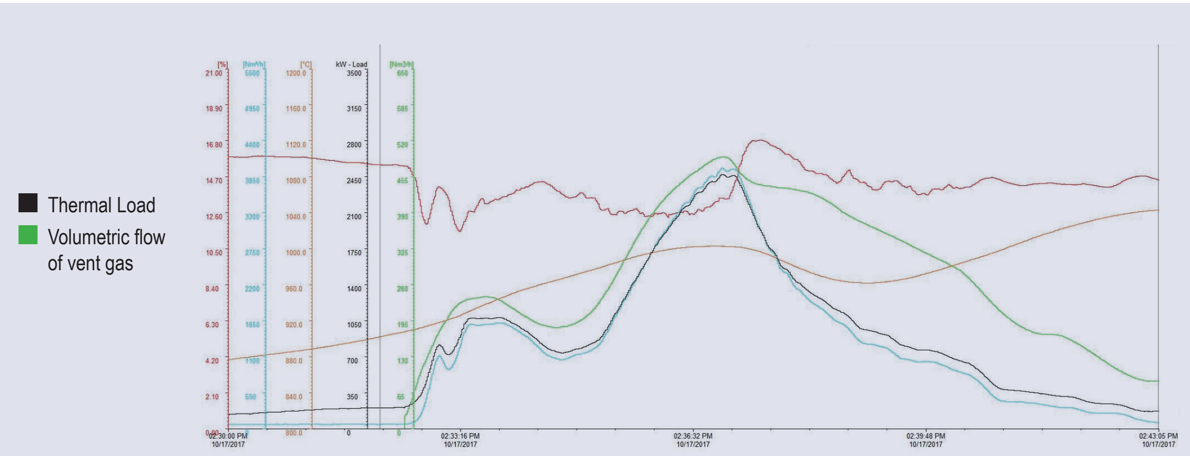

Figure 6: Immediate system response to load changes during peak performance test (500 Nm³/h 1-butene introduced in the vent gas system)

ABOUT DUMAG

DUMAG develops, plans, manufactures and supplies tailor-made burner solutions, modular combustion systems and combination processes for the treatment of exhaust air, waste gas and waste streams originating from a wide range of production applications. DUMAG serves virtually every sector of industry and does so in Europe, Asia and wherever else its services are needed around the world.

In contrast to the current common oxidation technologies applied for the vent gas treatment at tank terminals, DUMAG has developed and implemented a unique process solution over the past few years that offers a substantial reduction in energy consumption during operation. This has been achieved without compromising safety and emission regulation. Owing to the advanced process control system, the solution has an outstanding ability to adapt to the flow rate and any fluctuations in pressure and composition, thereby securing complete combustion. Furthermore, the risk of smoke occurrence at the stack outlet has been eliminated.

DUMAG's Constant Speed Burner CSB, utilizing a dynamically adjusting injection device, is one of the core technologies applied for this progressive approach of vent gas treatment in tank terminals.

Contact DUMAG

If you want to learn more about our industrial solutions for vapor treatment, our innovative burner technology or track record examples, please get in touch with us. We look forward to hearing from you!

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