DEVELOPMENT OF LOW NOISE LANDFILL GAS FLARE

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SUMMARY: Increasing requirements of the environmental standards and planning permission conditions create more challenges to the equipment providers. Environment Agency guidance demands low emission levels and local planners put low noise levels in their conditions for landfill sites. Achieving both at the same time with conventional equipment was found problematic. Biogas Technology has developed a new flare based on innovative type of burners. These burners characterise with significantly lower noise levels in comparison to commonly used pre-mix jet burners. Although the burners had some use in other, non-landfill applications, there was no experience of using them on relatively difficult and variable fuel like landfill gas. Theoretical considerations followed by practical tests in situ resulted in satisfactory solution and new type of flare, compliant with the current market demands.

1. INTRODUCTION

Matching low emissions and low noise posed significant technical challenge. First requirement points towards improvement of mixing of the fuel and combustion air, i.e. developing standard pre-mix burners that by their nature are noisy. The second demand suggested completely opposite direction, i.e. going back to open flares with quiet diffusion type flame. Initial stage of development work entailed improvements of the existing flare. However it was realised after several experiments that the noise level cannot be reduced to satisfactory values. Most difficult issue was low frequency noise that resulted from both pre-mix burners and resonance of the stack. On the next stage several academic organisations were approached with negative result. Their proposals contained interesting theoretical points nevertheless somehow remote from practical solutions that could have been achieved in relatively short time. Proposed R&D programmes were costly, time consuming and did not give guarantees that the desired end effect can be achieved. The third stage entailed involving specialist combustion companies. Several proposals were evaluated; however it became obvious that the level of understanding of the specific combustion parameters of landfill gas was not sufficient. Eventually, it was decided to select most promising option, based on new, patented burner. The burner initially was scaled down, extensively tested in the field, and then incorporated into full scale plant. Along with the practical experiments, some aspects of combustion were investigated using academic potential and Computational Fluid Dynamics software. This was the only approach that gave an opportunity to achieve tangible results in realistic timescales, resulting in marketable product.
2. DEVELOPMENT STAGES OF THE PROJECT

2.1 Theoretical Considerations

The development work on application of the new burner included various theoretical considerations in line with the UK landfill gas flaring guidance, i.e. calculations of air volumes, height of stack, temperature distribution inside the stack and retention time.

The amount of combustion air had to be controlled in line with required operational temperature of the stack (min. 1000°C). On the calculation stage it did not indicate particular problems. In practice, conventional system of louvers proved not sufficient, as it did not ensure range of the adjustments wide enough to match the increased turn-down ration of the burner. The other aspect that was not obvious during theoretical considerations was mixing of air and fuel at the burner and within the existing stack that was adopted for new burners.

Changing calorific value of landfill gas (i.e. methane concentration) gave satisfactory range of operation with positive theoretical results.

Calculations revealed that the existing height of the stack can be kept, as this gave enough combustion air by natural draught and also the retention time was satisfactory.

The CFD modelling proved that the burner should be an “ideal” one in respect of the temperature distribution (Figure 1) within the stack in all checked planes. Following modelling, experimental values were obtained. These were fed back to the model to calibrate it and check validity of the theoretical assumptions.

![Temperature distribution within the flare stack](image)

Figure 1. Temperature distribution within the flare stack (left – theoretical, right – experimental; scale in Kelvin)
In similar way velocity magnitude and equivalence ratio were modelled. These parameters gave an idea about correctness of the air volumes and velocities at various gas flows as well as the completeness of combustion. Modelling of the emissions was undertaken to a degree, however after evaluation of several batches of data it became obvious that the CFD had reached its limits and in order to achieve meaningful data a separate study should have been undertaken on the input parameters.

2.2 Practical tests

Although the theoretical calculations (with all their limitations) indicated this particular burner as ideal, practical tests revealed certain technical challenges, e.g. achieving satisfactory mixing of the fuel with air and minimum velocities within relatively large diameter stack. As mentioned before the CFD was extremely useful tool, however it was necessary to recognise its limitations, mainly due to the nature of the fuel.

First batch of tests were carried out at the scaled down burner (Figure 2). These proved extremely successful, especially in respect to noise. One could be heard distinctly while speaking quietly in the vicinity of the working burner. The most significant noise that was identified during these tests was the one from the gas extraction fan.

Practical tests in the field resulted in decision about staging the combustion air and adjusting its distribution along the base of the flare to avoid “recirculation” areas that slowed it down. These were identified by both CFD and practical experiments in the field, observing the pattern of inflowing air. Minimum velocity within the stack was achieved by finding experimentally the correct size and positioning of the burners at the flare base.

Extensive field tests on burner settings, emissions, and noise at one of the large landfill sites supplying over 2000 Nm$^3$/h of landfill gas proved viability of the application.

Noise and emission measurements proved validity of selection of the solution, as the low frequency noise was practically eliminated and the emission tests. Initial overall noise level was reduced by nearly 3 dBAeq (Figure 3) and the NOx emissions were between 30 to 50% value required in the Environment Agency Guidance (150 mg/m$^3$ at STP) and 3 % ref. O$_2$).

Figure 2. Flame during the scaled down test – evidence of correct combustion parameters
Correct operational parameters of the burners were identified during the trials. Most important and difficult one was determination of the range of gas delivery pressure to ensure correct dimensions of the burner in respect of design fuel flow rate. Experiments were carried out in respect of various positions of the burners within the stack to find out the best distribution of the fuel and air to ensure optimum mixing. Another stage of experiments involved finding proper staging of the combustion air. During the course of experiments it became obvious that it is possible to achieve much larger range of turn down ratio in comparison with previously used type of burners. The experiments proved also that the burner acts as a barrier preventing burn back of the flame into gas delivery pipe, still burning efficiently even at minute delivery pressures. Although not certified for this purpose, it gave additional safety factor on the top of usual flame arrester incorporated into the pipework.

2.3 Tests follow up

Considering the need of upgrading several existing flare units and developing completely new product, two design options were considered. The first one – an application for the burner and necessary modifications to upgrade existing flares and the second one - designing completely new plant based on new burner, both fully compliant with the regulatory requirements. With this flexibility at the design stage Biogas Technology offered the customers most economical solutions.

Burner characteristics discovered in the course of the scale down tests, described in the previous section, resulted in applying the new burner as a pilot burner for several applications as safer and quieter solution.

Field trials on scaled down burner triggered also design of low volume flare, as the new burner had much better turn-down ratio in comparison to the old one. The demanding market in
the UK and rest of Europe, in particular in the countries that recently joined the European Community identified need for low capacity flare unit suitable to serve relatively small landfills and sewage treatment works. The low capacity flare enabled to provide customers requiring flaring relatively small volumes of biogas – from 50 to 200 Nm³/h.

The flare design has been also thoroughly reviewed from the ATEX Directives 95 and 137 and DSEAR points of view in order to comply with the recent legislation.

Following requirements of regulators in certain countries, a continuous monitoring of combustion parameters (CO and NOx) and inlet gas parameters (CH₄, CO₂, O₂, gas flow rate and pressure) has been included in the flare options. The flare has been marketed under the “CEN” name revealed as LOW C = capacity, E = emissions, N = noise (Figure 4).

3. FURTHER WORK

At the moment extensive field tests continue on both large capacity and the CEN flares. It is planned to finalise them within next few months and the full scope of the results will be available during the presentation of this paper at the Symposium. There are several units installed already on various sites, with options open for any necessary further improvements pending the outcome of tests. Supported by sophisticated telemetry and remote control features the CEN range of flares provide the landfill operator with the necessary reliability of operation demanded by the latest regulatory requirements. This ensures complete operator efficiency and accountability.

Figure 4. Complete CEN flare at the exhibition stand.
through the provision of logged operating data. The CEN Flare range has also been designed to accommodate additional instrumentation and process control features as optional extras. This enables the landfill operator to choose the level of control and instrumentation to meet site specific requirements and gives him comfort and confidence in safe operation of the plant and associated equipment.

4. CONCLUSIONS

Problems with landfill gas application of the new type burner have been successfully solved using experimental approach supported by theoretical modelling. The theoretical modelling revealed some limitations regarding the CFD model and the input data that may lead in the future to more extensive research. Operational parameters of the new burner were identified during practical field tests. Issues with correct positioning and fuel parameters during practical tests were successfully solved. The development has been carried out with academics leading in the field of combustion, burner manufacturing company as well as the landfill site owner.

Having such flare in his portfolio, Biogas can look forward with confidence while setting up programme of replacing some of the existing equipment within relatively short timescale as required by the regulators. Several units are already successfully operating on various landfill sites.

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