AT and AE monitoring for a pressure equipment (cowper) for steel production

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Abstract
The cowper is an key tool in process line for steel production. In case of an unforeseen problem the complete process line will be stopped. Therefore a pre-warning against failures is important and pre-warning methodologies have to be evaluated. It is obvious, that AT and much more AE monitoring are excellent for this purpose, especially if all necessary preparations are done properly. According AE standardisation (EN 13455 “General information”) the pre-information’s have to be evaluated on-time and must influence the design and later on also production of the cowpers. During the design stage one of the most critical part is the selection of the “right” sensors, their application methodology and especially also their position. One of the first steps of measurement is to gather the information about the acoustic behaviour of the material and the cowpers at all. The complete test was performed according EN 14584 with $\Delta t$ location. During the acceptance tests the maximum pressure were applied twice, because on one hand the residual stress from the welding process shall be eliminated but much more on the other hand the influence of the inside insulation have to be taken into account. This insulation may be also one of the most critical parts during the life-time of the cowper. Both pressure tests were monitored with AE and the acquired data were evaluated according known and pre-defined evaluation criteria. The aim of these tests was to proof the quality of the production but also give the AE a basic signature of the acoustic behaviour of all sources, which were detected in the structure. The tests gave also an opportunity to improve and verify the evaluation and rejection criteria. The influence of all detected source has to be considered according their present and future influence of the different stages of the service life. The results of the basic pressure test of a new cowper will used for a comparisons for the later AT and planed discontinuous and/or continuous AE monitoring as a pre-warning tool against a failure and for on-time detection of possible defects. The presented works will be checked against the on-going works for the standardisation of AE monitoring of metallic pressure equipment's in the sense of pre-warning methodology against failure and for detection of imperfections (defects).

Keywords: AE localization of defects, AE standardization, AE testing (pressure vessels, storage, tanks, pipes, etc.)

1. Introduction

A cowper is together with the blast furnace an important and very sensitive part in the steel production process line. It has to be tested very carefully during its production. But the behaviour during the long life time, even during the long permanent working periods, is not clear at every stage. Especially if unexpected defects in the refractory lining occur during the working period of the blast furnace these could have catastrophic failures for the blast furnace.

Because Acoustic Emission is an excellent tool to detect defects during the loading and will provide a statement about the integral integrity of any structure. Furthermore Acoustic Emission gives the present status of a monitored as far as we are able to distinguish the AE signal coming of defects from the background and disturb noise.
Because the problems with the to-days art of inspection and testing, AE (testing and monitoring) shall be applied as a new possibility to improve the inspection of cowpers. Because to perform meaningful tests it is necessary to include the preparations to the production a test programme was developed to check new cowpers from their beginning of life-time (production) till to an AE monitoring as an important part for the structural health monitoring.

2. AT during the first pressure test

To get a kind of finger-print a new cowper shall be tested during the first pressurisation we performed the different steps for an AT till to the performance of a proof test according EN 14584.

The results, which we expected from this AT during the loading, were:

- Are active AE sources within the structure (yes or no?)
- How critical the detected AE sources are (activity and intensity)?
- Where these AE sources are localised?
- How the results are comparable with the results of the conventional NDT (VT, PT, MT, UT and RT) during the follow-up?
The measurement of the Acoustic behaviour of the cowper-material (measurement of the wave attenuation, outside and inside, and velocity) were performed in line with the EN 14584. Afterwards the sensors were applied within the determined maximum sensor distance, the sensitive of the sensors were checked and after feeding the measured wave velocity in the system the location ability and accuracy was checked with the Hsu-Nielsen source. For the determination of the detection –and evaluation threshold we have to take into account, that the later on for the AE monitoring the same sensor locations shall be used.

Due to the complex geometry of a cowper, divided into the combustion chamber dome and storage chamber with the refractory bricks, many different test localisations have to be performed, to get a sufficient location accuracy within the complete structure.

The requirements for the loading sequence have to be clarified with the producer before. The final plan for the pressurisation includes, beside a pressurisation of 1% of the test pressure per minute, twice pressurisation till to the test pressure, hold periods and hold at the test pressure. Specific attenuation was devoted to the emergency depressurisation system for a volume of 2978 m³.

After the realisation of the system for pressurisation and safety depressurisation the pressure test would be performed with different aims:

- Permanent leak monitoring system;
Monitoring of the reduction of the residual welding stress and
First data evaluation against the pre-defined acceptance criteria.

During this first pressure test, which was divided into 2 pressure cycles, it was possible to reduce the residual welding stress and create a fingerprint for the specific structure. Also leakages could be found and fixed. All AE sources, which were no absolute negligible from their activity and intensity, were re-tested during a follow up with other conventional NDT methods.

The first pressure test shows and proves the ability of AT to present an integral statement about the status of the structure with a short shut down, gave a more accurate information about the present status of the structure than the conventional test technologies and support any way the safe and economic service of the cowper.

3. AE monitoring

Based on these results we can step over to an AE monitoring, which is in anyway the real task for this cowper. The AE monitoring is an important tool within a complete SHM system. Two problems arise for this aim:
Sensors which withstand the working conditions together with a proper application and Monitoring of the real AE sources based on a high background level caused from the service of the cowper.

Due to the fact, that cowpers have inside a refractory lining the wall temperate during service is normal, but any defect of the lining has to be detected in an early stage and it would be advisable to use sensors which are suitable for a higher temperature range. The application points were defined during the basic AT, but the sensors and application tools have to withstand the hard environment and working conditions within a steel plant.

The disturb noise coming from the production has to be acquired for the different production stages for a more sophisticated data evaluation by any kind of pattern recognition technique. Based on former AT we have an extensive data base to distinguish AE signals coming from the metallic wall and from the inside lining. During tests we found out, that the best result we was gained by the application of a frequency domain pattern recognition systems.

The permanent monitoring shall evaluate every pressure cycle, without any additional loading, to detect any defect in the shell but much more all degradation within the inside insulation (refractory lining) to prevent any further damage of the shell. With a well-established classification system, which distinguishes online any damages in the metallic shell (e.g. crack, corrosion) from those coming from the lining, we can establish a pre-warning system for the cowpers and prevent any failure in the complete production line.

3. Conclusion

During the pre-tests and the preparation for a continuous monitoring the following facts could be proven, that not only AT can use the known advantages, and act as a pre-warning system. Off course the evaluation system has to be adapted on the specific demands for a cowper. Furthermore AE monitoring provides an overall statement about the integrity of the structure permanently (continuous and discontinuous).

In case of permanent AE monitoring we can add to these advantages also that these information’s will be acquired on-line under real working conditions, which gives us the information in-time and make them more reliable. All together in-service AE monitoring from Cowper is the most reliable and economic way to ensure a safe and economic use of the of blast furnace system within the steel production.