Basics for AT and AE Monitoring of a Cowper

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Abstract. A cowper is a very sensitive part of the steel production process line. For the pre-warning against any kinds of failure AT and much more AE monitoring would be excellent tools. To perform meaningful tests it is necessary to include the preparations in the production process. During the production of the cowper all necessary steps for an AT (selection of the sensors and their application, measurement of the acoustic behaviour etc.) have to be performed during the production and shall finalised with a basic AT according the EN 14584. In any case the pressurisation till to the maximum test pressure has to be performed twice not only for the reduction of the residual welding stress but also the influence of the inside isolation have to be performed twice. Both tests have to be evaluated against proven acceptance/rejection criteria, where it is necessary to evaluate any source at this stage of the service life for comparisons later on.

Later on the result of the basic pressure test shall be used for a comparison later on where the AE monitoring shall use as a pre-warning method against a failure and for early detection of possible defects.

The steps of the AT will be demonstrated on the pre-tests for a new cowper, where all necessary works, especially the evaluation of the different parts of the pressure equipment. The results for this AT will be implemented in the final preparation for a discontinuous and/or continuous AE monitoring of the cowper without a stop of the production and/or a stop of the pressure equipment on-time.

These first results will be used for a comparison with 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 defect detection.

Introduction

A cowper is an important part in the steel production process line and therefore it will be tested very carefully during the production, although its behaviour during the long life time, even during the long permanent working periods, is not clear at every stage. Especially if a defect in the refractory lining occurs unexpectedly during one working period this could have catastrophic failures like the blast of the furnace.

That is why Acoustic Emission is an excellent tool to detect defects during the loading and will provide a statement about the overall integrity of any structure. Furthermore Acoustic Emission provides information on the present status of a monitored structure as far as we are able to distinguish the AE signal coming from defects from the background and disturb noise.

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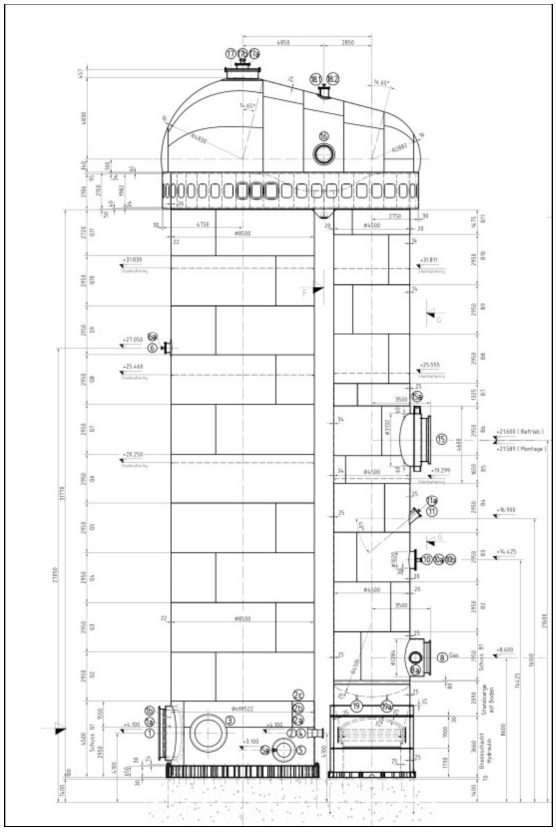


Pic.1. Scheme of a to-day cowper with storage- and combustion chamber connected with the dome

Because of the lack of a state of art inspection and testing method at the moment it was decided to introduce AE (testing and monitoring) as a new possibility to improve the inspection of cowpers. For performing 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.

1. AT during the first pressure test

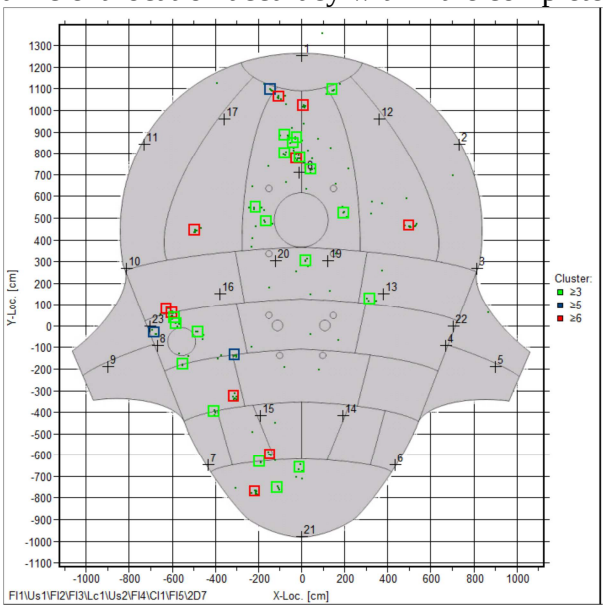
For getting a kind of finger-print a new cowper shall be tested during the first pressurisation we performed the different steps for an AT till to the performance of a proof test according EN 14584.

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.



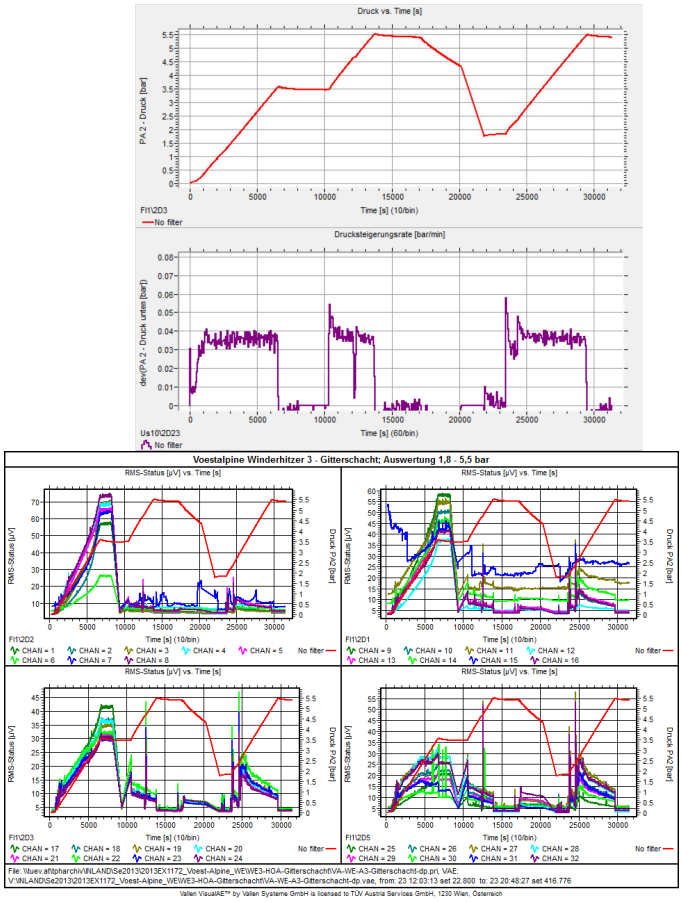
Pic. 2. Sensor locations and test localisation in the dome of the cowper

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 m^3.

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

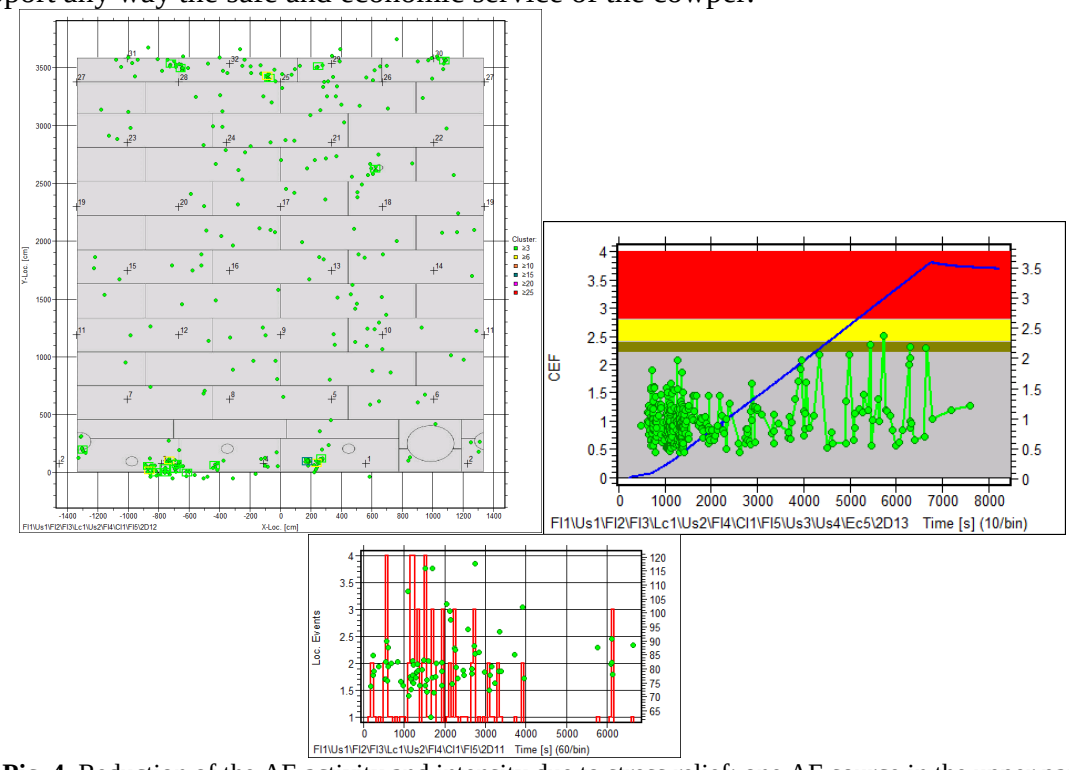
- ✓ Permanent leak monitoring system;
- ✓ Monitoring of the reduction of the residual welding stress and
- ✓ First data evaluation against the pre-defined acceptance criteria.

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.



Pic. 3. Realised loading scheme and leakages on the manway and the flue gas flange

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.



Pic. 4. Reduction of the AE activity and intensity due to stress relief; one AE source in the upper part

2. 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. The best result we have had with frequency domain 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 clearly 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.

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, like:

- ✓ To be a pre-warning system
- ✓ To provide an integral statement about the integrity of the structure and
- ✓ To work not invasive for the structure.

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