

GALS-1 AE SYSTEM APPLICATION FOR HOISTING MACHINES DIAGNOSTICS

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INTRODUCTION

Application of the acoustic emission (AE) method for general technical state evaluation of high risk objects have become a standard practice long ago. This method attracts technical experts first of all with its convenience and cost-effectiveness – we get information about technical state of the whole object using just few probes and without any scanning (and so with no need to prepare the entire surface) – quickly and relatively cheaply. In addition AE method qualifies defects not according to their size (as conventional methods do), but rather according to their tendency to develop at working stresses – i.e. according to their risk level.

There are a huge number of codes describing AE inspection of different types of pipelines (gas and oil main pipelines, ammonia lines, industrial pipelines, etc), cisterns, tanks, cylinders and other pressure vessels. Many AE instruments implementing those codes have been developed and are widely used.

But only few companies tried to make AE inspection of hoisting machines and using its results for making expert decision for technical diagnostics of those machines until recently. While as for normative documents – they up to the authors were absent. According to known codes the hoisting machines diagnostics is made using conventional methods (visual, ultrasonic, penetrants testing etc). Performing of all those procedures (and also object preparation for them) made hoisting machines diagnostics very durational and expensive. As a result – frequently testing was not done in full scale and experts had to make their decisions basing on insufficient information about objects technical state. And so there were excluded: neither defect lost (i.e. caused by human factor), nor incorrect classification according to risk level for the further usage.

INSPECTION TECHNIQUE

For solving of this situation – lowering of the labor input of hoisting machines diagnostics and boost of its effectiveness – the Center for Technical Expertise of Southern Railway of Ukrainian Railways (CTE SR) and Ukrainian Scientific Research Institute for NDT have developed a technique of AE diagnostics of hoisting machines.

Technique allows examining of following types of hoisting machines:

- ✓ Single-girder and double-girder overhead cranes;
- ✓ Portal bridge cranes with elements of tubular, box-type and truss-type structure;
- ✓ Arm cranes;
- ✓ Railway cranes;
- ✓ Lorry-mounted cranes;
- ✓ Tower cranes.

Other types of hoisting machines can also be inspected according to this technique provided appropriate appendices to it will be developed. According to this technique an AE method can be used as:

- Separate preliminary integral method providing detection of developing defects in all structure including welded joints;
- Additional method (to conventional ones) providing reliable evaluation and qualification of defects (as those which tend to develop and those which don't develop);
- Basic method for prognostication of possibility of safe operation of hoisting machines with cracks in metalware.

Acoustic emission method can be used for periodical or permanent evaluation of the hoisting machines technical state.

The technique describes application of three location levels according to information value and interference immunity grade:

- Zone location – the least information valuable (location is made accurate within zone around each sensor) and has very pure interference immunity, but on the other hand uses minimal number of AE system channels possible;
- Linear location – allows to estimate a cross section in which the source of AE activity is situated; has interference immunity better zone location has; uses approximately twice as more AE system channels than zone location does;
- Planar, cylindrical and grid location – these types of location allow to determine the concrete place (ideally point) in which the AE activity source is situated (e.g. in which truss diagonal and at what distance from its end), have the highest grade of interference immunity, but unfortunately require maximal number of AE system channels (3 to 4 times as many as needed for zone location).

The technique describes both combined and successive ways of application of these location methods. In the issue possibility of large hoisting machines inspection by AE systems with relatively small number of channels without loss of quality is provided.

GALS-1 AE system (manufactured by the PROMPRYLAD Company) was chosen to implement this technique. The main argument in favor of choice of this very system was an exclusive presence in GALS-1 software of algorithm of location on truss structures (grid location). This is very important since there are many truss structures in hoisting machines. In addition this system has already shown itself to advantage for bridges metalware inspection to the time of the technique development start [1]. And at last it was very important that GALS-1 developers are open to development of systems software according to clients (in this case – technique authors) needs.

The technique authors together with CTE SR experts and representatives of GALS-1 company-manufacturer have been inspecting cranes of each type both in process and after finish of technique development. Developing defects (cracks) were detected at some of the cranes and their risk level was estimated. Corresponding experts' reports were written basing on AE testing results. AE testing was repeated after repair and has proven the repair quality.

EXPERIMENTS

Most bright examples of AE inspection of hoisting machines according to the developed technique are described below.

A. Tower crane KB 160.4

Approximate metalware length – 880 m, number of welded joints ≈ 280 . The cracks in the ends of truss diagonals, which characteristic feature is the development only during the tower turning, are detected using the AE testing technique; because there a lot of hard-to-reach places, the cracks were not detected.

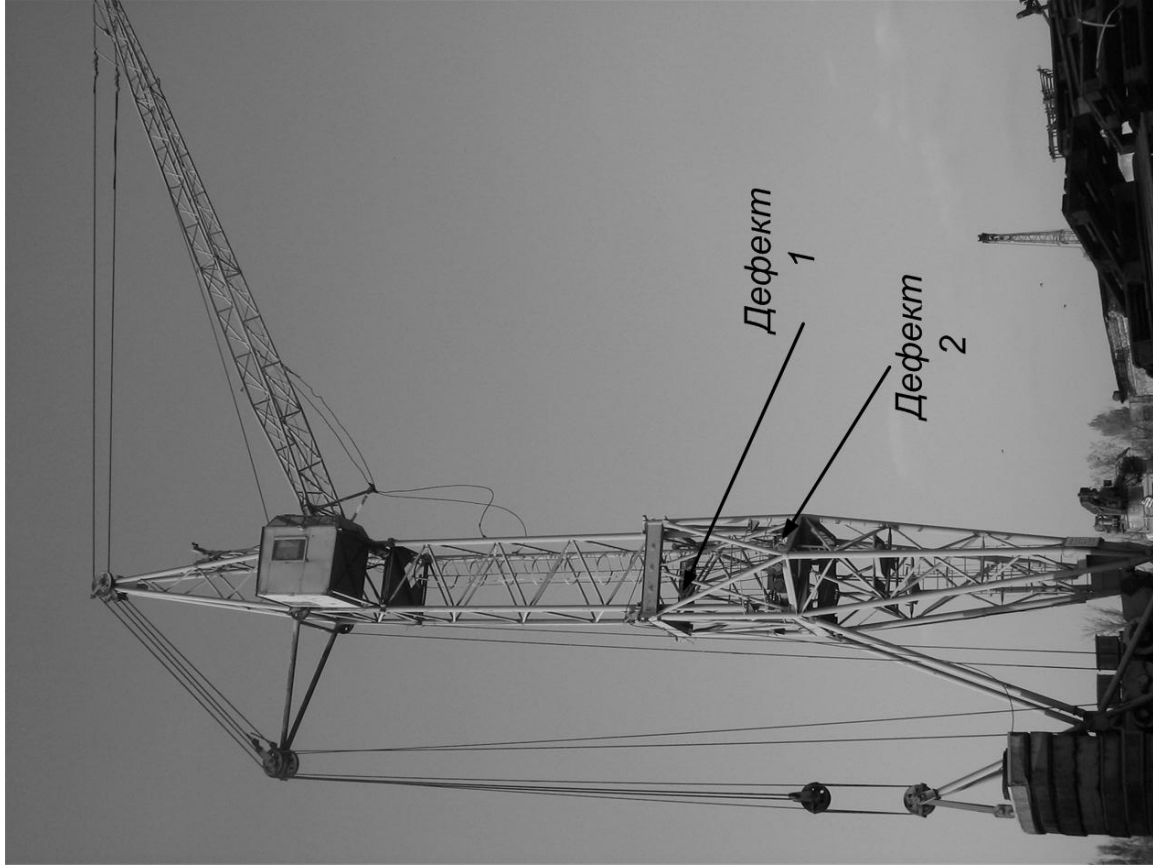


Fig. 1 General view of the crane and place of flaws detection



Fig. 2 Detected defects

B. Gantry crane

Common data of the crane: load capacity – 10 tones, span – 16 m, total length of metalwares – 540 m, number of welded joints $\approx$ 110 m.



Fig. 3 Gantry crane

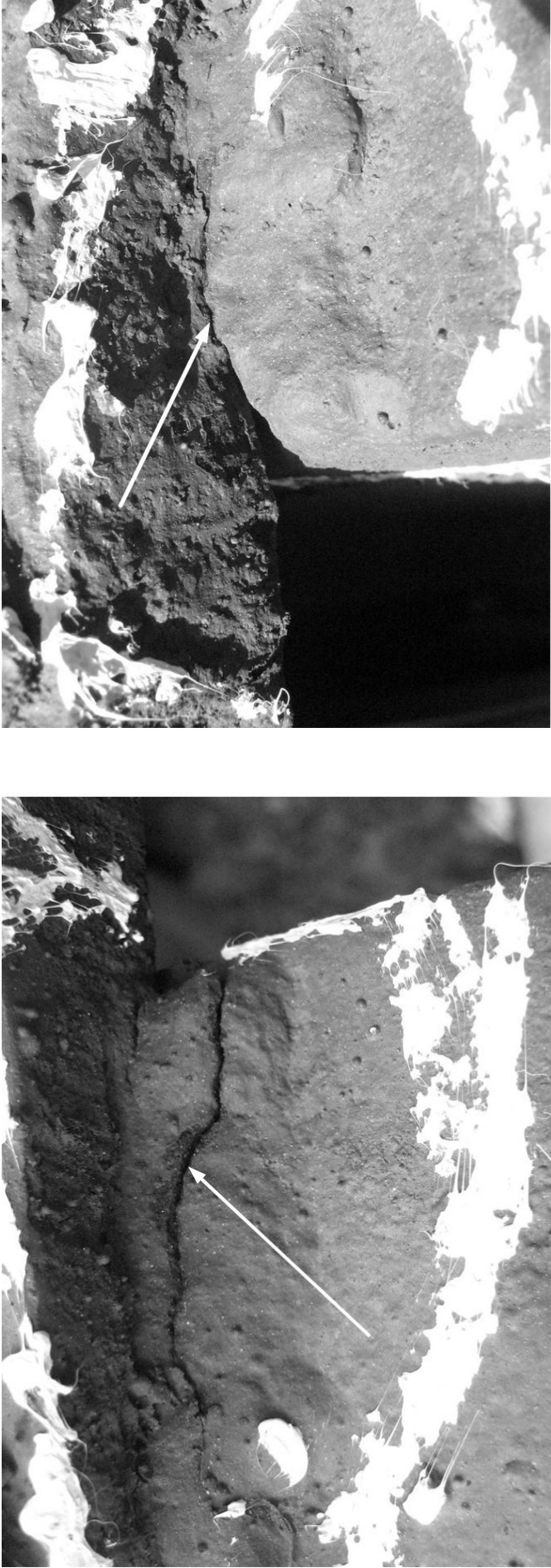


Fig. 4 Detected defects

C. Single-beam bridge crane.

Cracks with sizes, calculated by [2] survivability diagrams, were initiated in the single-beam bridge crane for pilot testing of GALS-1 complex capabilities in "progressive-nonprogressive" crack classification. Common data on the crane are given in Table 1, and location and drafts of initiated cracks – in figures 5 and 6.

Table 1

Data on the material of bearing metalwares of the single-beam bridge crane			
Material of bearing metalwares	Value σ_T (according to the results of hardness measurements calculated by measurements uncertainty)	Calculated stresses (according to the technique of marginal states on the basis of the standard cargo weight)	Cycle ratio $\rho = \frac{\sigma_{\min}}{\sigma_{\max}}$
St 3kp	336 MPa	GB-95 MPa KB-110 MPa	0,12

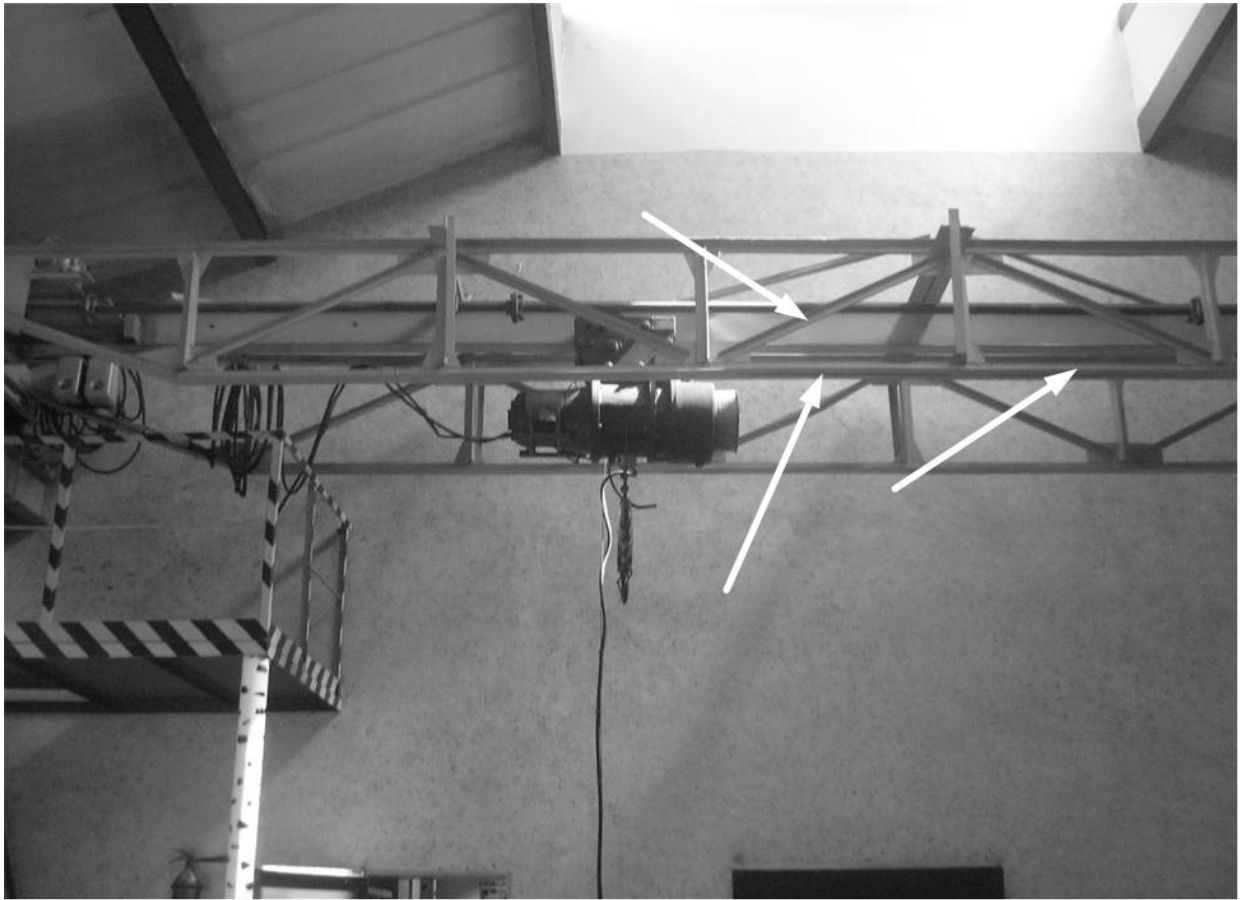


Fig. 5. General view of the master cock; the spots of cracks initiation are indicated with arrows.

There have been performed the tests at which the load has been changed stepwise: $0 \rightarrow 0,5 \cdot Q_{\text{work}} \rightarrow 0,75 \cdot Q_{\text{work}} \rightarrow Q_{\text{work}} \rightarrow 1,25 \cdot Q_{\text{work}} \rightarrow 1,75 \cdot Q_{\text{work}} \rightarrow 2 \cdot Q_{\text{work}}$. Здесь Q_{work} – crane workload.

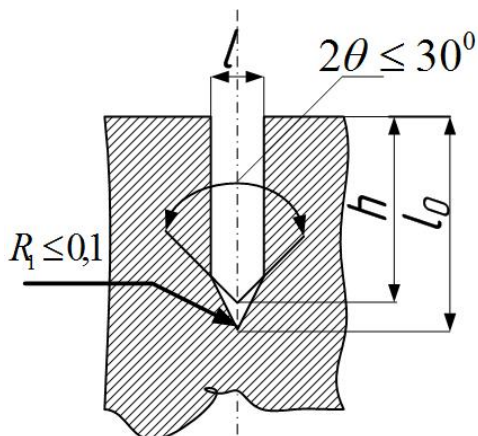


Fig. 6 Initiated crack scheme

It has been ascertained by means of “GALS-1” complex that in spite of double overload and crack dimensions (depth $h=5$ mm, opening width 0,3 mm), the cracks appeared to be non-progressive.

Appropriate expert reports have been compiled basing on the results of AE testing. Having repaired the rejected cranes, AE testing was repeated and proved the repair quality.

The proofing of the technique using GALS-1 AE system has shown its technical strength and high cost-effectiveness. Authors look forward to further development of the technique to test also other types of hoisting machines.

CONCLUSIONS:

- I. Applicability of AE technique as NDT technique for the work with almost all main types of metalwares;
- II. While checking the possibility of “GALS-1” complex usage for the nondestructive testing of metalwares of hoisting machines, the following has been practically established:
 - its high efficiency, which main component is flaw omission exclusion, and its classification by the “progressive-non-progressive” criterion;
 - efficiency and service reliability of “GALS-1” complex;
 - reliability of software operation.
- III. The trials proved that it was possible to employ the testing technique (on real blocks) worked out by the authors.

Literature

1. Bridge construction spans examination using GALS-1 AE complex. – http://www.ndt.com.ua/eng/technology_2_article.html
2. V. Pustovoy, Metalwares of hoisting machines. Destruction and prediction of residual lifetime M, Transport, 1992, 256 p.