PRIMJERI KVAROVA DEFORMACIJOM METALNIH KONSTRUKCIJA NA INDUSTRIJSKIM POSTOJENJIMA

EXAMPLES OF FAILURES DUE TO DEFORMATION OF METAL STRUCTURES IN INDUSTRIAL PLANTS

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REZIME

U ovom radu su predstavljeni neki aspekti procijepa između troškova mašinskog (ili opšteg) održavanja i havarija uz plastičnu deformaciju čeličnih konstrukcija u proizvodnim firmama u BiH. U teoretskom dijelu rada je predstavljen i obrazložen dijagram za ispitivanje zatezanjem za tipične čelike iz kojih se proizvode toplo valjani nosači (I, U, T i sl...), od kojih se prave čelične konstrukcije. U praktičnom dijelu je uz niz fotografija napravljenih u sudskim vještačenjima nakon havarija uz prethodnu pojavu plastične deformacije. Tu je naglasak da je za čelične konsturukcije u proizvodnim firmama u BiH opasan ulazak čak i u oblast od preko 60% od napona tečenja, tj u oblasti elastične deformacije, a kamoli ulazak u oblast plastične deformacije. Najčešći uzrok za to je procijep između troškova za mašinsko (ili općenito) održavanje i potrebe za kvalitetnim (posebno planskim i preventivnim) održavanjem (oštrim zimama, hemijski agresivnom atmosferom itd), što ponekad i ponegdje rezultira havarijama, koje dovode do eventualnih povreda radnika, te djelimičnog ili potpunog uništenja konstrukcija odnosno postrojenja.

Ključne riječi: mašinsko održavanje, procijep, troškovi, havarije, plastična deformacija konstrukcija-postrojenja

ABSTRACT

Some aspects of a controversy between the expenditures in mechanical (or general) maintenance and the demolishes-damages with a plastic deformation of steel constructions in BiH production companies. Typical tension test diagram for a typical construction steel (for hot rolling I, U, T and similar sections) is presented and explained in the theoretical part of this paper.

In the practical part of this paper some judicial cases-pictures related to the plastic deformation of the structures-facilities are presented. They are related to an occurrence of plastic deformation of the a.m. structures-facilities, and a highlight is on the fact that in B&H companies even the area of over 60% of yield point loading is dangerous, meaning even an elastic deformation area is as well dangerous, not only plastic deformation area. Most usually a reason for an occurrence of plastic deformation is in a controversy between maintenance expenditures and the a proper mechanical maintenance, especially preventing one (harsh winters, chemically aggressive environment), but it can cause the injuries of the workers, as well as of part or full construction-facility.

Key words: mechanical maintenance, gap, costs, breakdowns, plastic deformation of structures-plants

1. INTRODUCTION

There is the figure 1. [1] representing a typical tensile test diagram of mild steel for construction (EN 10024 - for hot rolling I, U, T and similar sections). First figure [1] represents a.m. stress-strain curve-diagram with three most important points of testing (elastic limit, tensile strength and fracture point).

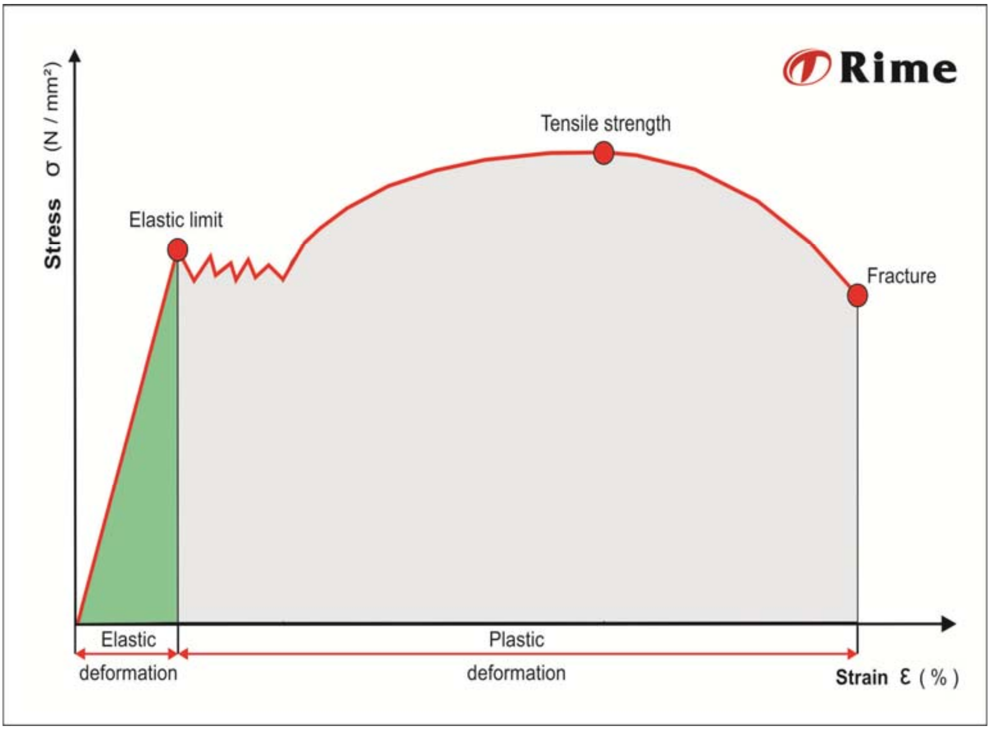

Figure 1. Typical tensile test diagram of mild steel [1]

Tensile test is one of the ways of examining how strong a material is. This may refer to how advance the tensile machine is especially in a case that it runs under the computer's control. With the computer's control, it is even more flexible to adjust the speed and accuracy of the test to match up with the need of the use of the material. Furthermore, tensile test requires a piece of a sample, to perform the test. Performing the testing will require destroying the sample in order to measure how much can the sample stand of force, and accordingly in a diagram-curve is easy to determin the a.m. most important points of testing (elastic limit, tensile strength and fracture point).

"Green area" at figure 1. where an elastic deformation exists is so called safe area in experimental circumstances, but in long term use of these steel constructions in B&H industrial companies, it could be compromised, because of improper construction and maintenance, especially in case of harsh winters, chemically aggressive environment, vibrations, etc.

Yield point in the stress-strain curve is the one at which the curve levels off and plastic deformation begins to occur. It is extremely difficult to determine precisely yild point and in the practice is inaugurated so called offset yield point (proof stress).

As a yield point is not easily defined on the basis of the shape of the stress-strain curve an *offset yield point* is arbitrarily defined. The value for this is commonly set at 0.1% or 0.2% plastic strain [1].

Additionally in materials science and in theory of plastic deformation there is an explanation that critical resolved shear stress is the component of shear stress, resolved in the direction of slip (beginning of plastic deformation), necessary to initiate slip in a grain of a material. Resolved shear stress is the shear component of an applied tensile (or compressive) stress resolved along a slip plane (most close packed plane) that is other than perpendicular or parallel to the stress axis. The resolved shear stress is related to the applied stress by a geometrical factor, *m*, typically called the Schmid factor, which has the maximum value at the slip planes having 45° angle towards the direction of the force. That is why even so called "green area" presented at figure 1. is not absolutelly safe, regarding the occurance-beginning of plastic deformation, which is supsed not to occure, at all, at the industrial structures and facilities [6].

2. PRACTICAL APPROACH TO A RELATION OF MECHANICAL MAINTENANCE IN CONTROVERSY BETWEEN THE EXPENDITURES AND THE DEMOLISHES-DEMAGES WITH PLASTIC DEFORMATION OF THE CONSTRUCTIONS

The figures 2. to 8. supplied in the practical part of this paper, express a significant extent of the plastic deformations, which lead to the break of a structure in metallic material production plant, and similar figures 9. to 12. express also a significant extent of the plastic deformations, which did not (yet) lead to the break of a structure in non-metallic material production plant. They are both taken from the court expert judicial cases in different B&H companies [2].

Figure 2. A broken sort of portal crane

Figure 3. Western layout view from a broken portal crane

Figure 4. Eastern layout view from a broken portal crane

Figure 5. Detailed position of heavy bended section of a broken portal crane

Figure 6. Detailed position of a deeply corroded section of a broken portal crane

Figure 7. Detailed position of a welded and deeply corroded section of a broken portal crane

Figure 8. Detailed position of the small ductile breaks of a broken portal crane section

Figure 9. Position of the wooden and steel section supports to plastically deformed sections

Figure 10. Another position of the wooden and steel section supports to plastically deformed sections

Figure 11. Position of the wooden section supports to plastically deformed sections & roof

Figure 12. Detailed position of plastically deformed sections & roof

All these problems (break and demolishes-damages after a significant extent of plastic deformation) visible and presented at the figures 2. - 13. are mostly "produced" as a consequence of poor maintenance, caused by compromising proper maintenance due to CONTROVERSY BETWEEN THE EXPENDITURES AND THE DEMOLISHES-DAMAGES WITH PLASTIC DEFORMATION OF THE CONSTRUCTIONS, which was easy to follow from the maintenance accounting sheets of these companies [3][4][5].
All figures are very illustrative and easy to understand for the teaching staff from metallurgy and materials engineering faculties or institutes, as well as for the mechanical engineering ones. Such a combined teams might organize the visits to metallic and non-metallic product factories around B&H to convey some advises and messages about dangerous consequences of any extent of plastic deformation occurrence on the structures and machinery, as well as any controversy between the expenditures and the demolishes-damages (with plastic deformation) of the constructions.
Special attention during these proposed visits should be paid to the potential reasons for an occurrence of any (dangerous) extent of plastic deformation such as:
A- insufficient safety coefficient in designing
B- overloading
C- welding spots treatment
D- insufficient or non-regular corrosion protection
E- chemically aggressive environment
F- heating and freezing conditions (especially at welding spots)
G- vibrations and shocks
H- other reasons
It is not the aim of this article to treat from metallurgy or material science point of view the a.m. problems from A to H, that can cause an occurrence of any (dangerous) extent of plastic deformation on different steel structures, than to give an incentive for more frequent visits of the teaching staff to the industrial facilities presenting at a spot short review of the a.m. topics, namely from A – H, and to "push" the owners/management towards proper (planed and pre-emptive maintenance).
Another area to enhance the a.m. activities could be organized and followed comparison of maintenance expenditures v.s. proper maintenance, since from my experience as the court expert, majority of the transition companies in B&H are keen to reduce labour force as well as maintenance expenses, but that practice at a same time increases a risk of collapsed or damaged steel structures and facilities, due to a lack of a proper planed and pre-emptive oriented maintenance. Daily, weekly and monthly maintenance periods are advisable to be a part of a production routine-diagram, especially if the facilities are dated from last century.

3. CONCLUSIONS

1- An overloading (or bad welding spots treatment, insufficient or non-regular corrosion protection, chemically aggressive environment, heating and freezing conditions /especially at welding spots/, vibrations, shocks and some other unexpected reasons) can lead to an occurrence of a plastic deformation, and all that can be a consequence of a sort of poor mechanical maintenance, or of negligence of the initial signs of the plastic deformation occurrences.
2- It is advisable to optimize production in a process of an industrial transition, to manage a production on the best performance facilities, to reduce labour force as well as maintenance expenses, but at a same time it increases a risk of demolished-collapsed or damaged facilities, due to a lack of a proper (planed and pre-emptive oriented) maintenance.

3- Regular visits of the teaching staff or experts to the industrial facilities presenting at a spot short review of the a.m. topics presented in the first conclusion, are advisable.
4- It is possible and advisable to enhance an offer of technical-technological consulting activities that could be organized by both Faculty of Mechanical Engineering and Faculty of Metallurgy and Technology, since from my experience, majority of the transition companies in B&H are keen to reduce labour force as well as maintenance expenses, but that practice at a same time increases a risk of demolished-collapsed or damaged facilities, due to a lack of a proper planed and pre-emptive oriented maintenance. Daily, weekly and monthly maintenance periods are advisable to be a part of a production diagram, especially if the facilities are dated from the last century.

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