ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN: 1584 - 2673

# METALLOGRAFIC ASPECTS OF THE ELEMENTS MAKING UP A STEAM BOILER

Amalia Ana DASCĂL

"Politechnica" University of Timisoara, Faculty of Engineering of Hunedoara,
Department of Engineering and Management, ROMANIA

**Abstract**:
OLT 35K steel is part of the non-allied steel category, used for the achievement of tubes that work at high temperature. Specimen has been taken from this tube type, placed in a steam boiler, from which strip drive test-bars were manufactured. Afterwards, they were tried on driving, at ambiant and high temperature, close to the ones used in operation, so as to determine the mechanical features of the material, after a certain period of use. Conclusions made, concerning the influence of temperature on how the OLT 35K steel deals with high temperature, can be taken from the results and, in this way, you can estimate the remaining life-length of both that material and implicitly that of the source equipment.
**Keywords**:
high temperature, thermal resistant steel, mechanical testing, life-length, mechanical feature

## 1.GENERAL APPRECIATION

In the context of the present economy, the technological process must be done with high efficiency of transformation. Nowadays, this efficiency can be grown only by high pressure and temperature of the technological process, this being the reason for which the development of a steel scale is required, and especially the ones with low allied degree, as they are less expensive.

In the same time, decisions on the material are essential in all fields of industrial practice, because any technical activity has to finally result in a resistance structure or a functional device. And, each new technological process brings about the development of a new material as the achievement of structures and/or device is being conditioned by their existance and usage.

Choosing the right steel, in point of the required features, the aquisition price and the manufacture price, as well as in reserve, has always been a priority in the eyes of designers and industry manufacturers.

*Work Temperature* is an element considered more and more interesting because, in a special way, you can assert that the new technological development depends, in many sectors, on the manner you deal with *how materials behave at high temperature.*

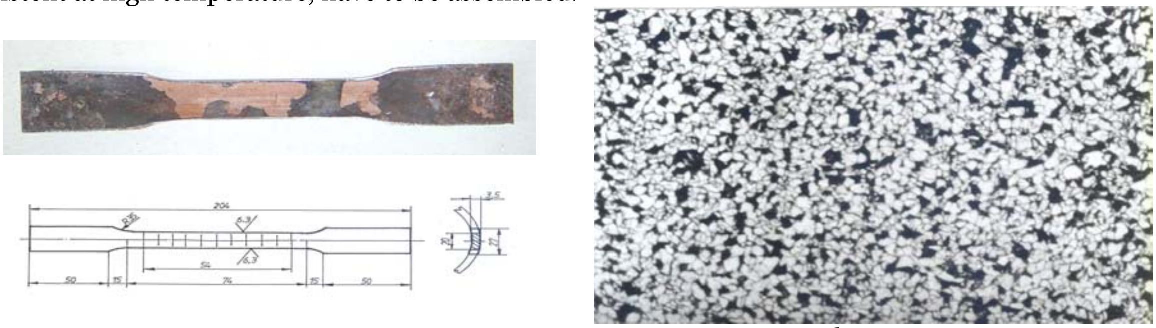
The reliability and quality of the elements wich work at high temperature and pressure is part of the reliability of electrical and thermic energy production units. The working of these units at best parameters is very important because if not the social and economic implications can be huge.

Choosing and using the right steel, in point of the required mechanical features, for a special field of usage, cannot be made without knowing the real behavior of the material, which relies on theoretical and experimental research.

The mechanical features of metals, obtained by testing made with bars, liable to different requirements that are close to the conditions of operation of the elements strength, allow the quality check of their material, fixing the maximum limits of requirements, being essential elements that stand at the discretion of that technologist's designer.

## 2. TEST-BARS USED IN TESTING

Test-bars, generally having the shape and size of those found in testing at ambiant temperature, are used in mechanical experiment at high temperature. Because test-bars are heated in different precincts, it is necessary that the shape and size of the holding extremity is built in such a way to allow their assembly in the holding jaws of the testing machineries. There are situations when, between the extremities of the test-bars and the ones of the holding jaws, some prolonged rods made from metals resistent at high temperature, have to be assembled.



a b

Figure.1. The shape and size of test-bars used in testing: a) test-bar drawn from focus; b) the metalographical structure resulted from the chemical analysis

Ring-shaped transversal samples have been drawn for metalographical analysis, looking at emphasizing the morphology of transformation stages from the material, and establishing the seed size, likely oxidation or decarburization phenomena and other structure faults.

For the OLT 35K tube material, drawn from the focus and shown in fig.1.b, and after the optical microscope study, it seemed that it offered a ferrite-perlite structure, with a 7-8 outline of real seed, proceeding from SR ISO 643-93, and the tube walls had not have a decarburized structure.

After the metalographical analysis, it is found that the tested material is part of the adherent standard, but stating that small size of molybdenum can be detected. Analysing this fact, in accordance with [2], we can state that, in small amounts, molybdenum is fighting against the reversible return brittleness. Disolved in ferrite and forming carbides, molybdenum improves the resistance features and to a certain extent, the plasticity features of annealed or normalized steel, just like the case at study. Molybdenum also improves the usage resistance and stops the sliding process, by forming carbides, ascertaining a sensitive growth in the steel resistance at high temperature.

Therefore, molybdenum is the ally element that provides the mechanical resistance of steel used at high temperature.

## 3. TESTING

OLT 35K steel – STAS 8184-80 is part of the non-allied steel category, used for manufacturing tubes that work at high temperature. Steel is elaborated in electrical ovens, Martin ovens, in converters with oxygen spraying or other equivalent methods.

The chemical make-up of the used material (drawn from focus), for the experimental testing, is shown in table 1. The mechanical features guaranteed on the delivered products as tubular, established on longitudinal drawn test-tubes, under ambiant testing atmosphere, are given in table 2.

Table 1. The chemical make-up of the OLT 35K steel, drawn from focus

| Material | C | Mn | Si | S | P | Cr | Ni | Cu | Mo |
|---|---|---|---|---|---|---|---|---|---|
| | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| Focus – OLT 35K | 0,15 | 0,76 | 0,34 | 0,011 | - | 0,19 | 0,20 | 0,17 | 0,01 |
| STAS 8184-80 | Max. 0,17 | Min. 0,45 | 0,15... 0,35 | Max. 0,045 | Max. 0,040 | Max. 0,30 | Max. 0,30 | Max. 0,30 | - |

Table 2. The guaranteed mechanical features for OLT 35K steel

| Steel type | Breaking resistance $R_m$[N/mm²] | The conventional running limit $R_{p0,2}$, [N/mm²], min. | After breaking percentage elongation A, [%], min | The narrowing value of the section Z, [%], min. | Impact value KCU 300/2 min. |
|---|---|---|---|---|---|
| OLT 35K | 350...450 | 230 | 26 | 60 | 60 |

In the field of high temperature, driving testing has been made on a universal machinery by adjusting a genuine conception of heating precincts, [1]. Figure 2. a÷f shows the F-Δι curves, obtained for a share of the tested tubes, and the values of the resulted mechanical features are synthesized in table 3. The testing made for establishing the mechanical driving features have taken place between +20°C...+500°C. The values shown in chart 3 represent the average of the mechanical features obtained in sets og 3 bars, tested at each level of temperature. Variation diagrams of the driving mechanical features were outlined by using these values, depending on the testing temperature.

© copyright FACULTY of ENGINEERING - HUNEDOARA, ROMANIA

Therefore, in fig.3, it is shown the $R_m$ feature variation, and in fig.4 that of *A* and *Z* feature. Fig.5 shows a share of OLT 35K bars, drawn from the focus and tested at temperatures of: +20°C, +100°C, +200°C, +300°C, +400°C and +500°C.

Table 3. The driving mechanical features of the OLT 35K steel

| Testing temperature [°C] | Breaking force $F_{max}$ [N] | Breaking resistance $R_m$[N/mm²] | After breaking percentage elongation A[%] | The narrowing value of the section Z [%] |
|---|---|---|---|---|
| 20°C | 34435 | 491,92 | 90,00 | 37,85 |
| 100°C | 33800 | 482,85 | 85,00 | 44,07 |
| 200°C | 27350 | 390,71 | 72,22 | 55,00 |
| 300°C | 34900 | 498,57 | 71,29 | 33,60 |
| 400°C | 34200 | 502,85 | 64,81 | 29,57 |
| 500°C | 39380 | 562,57 | 78,70 | 33,14 |

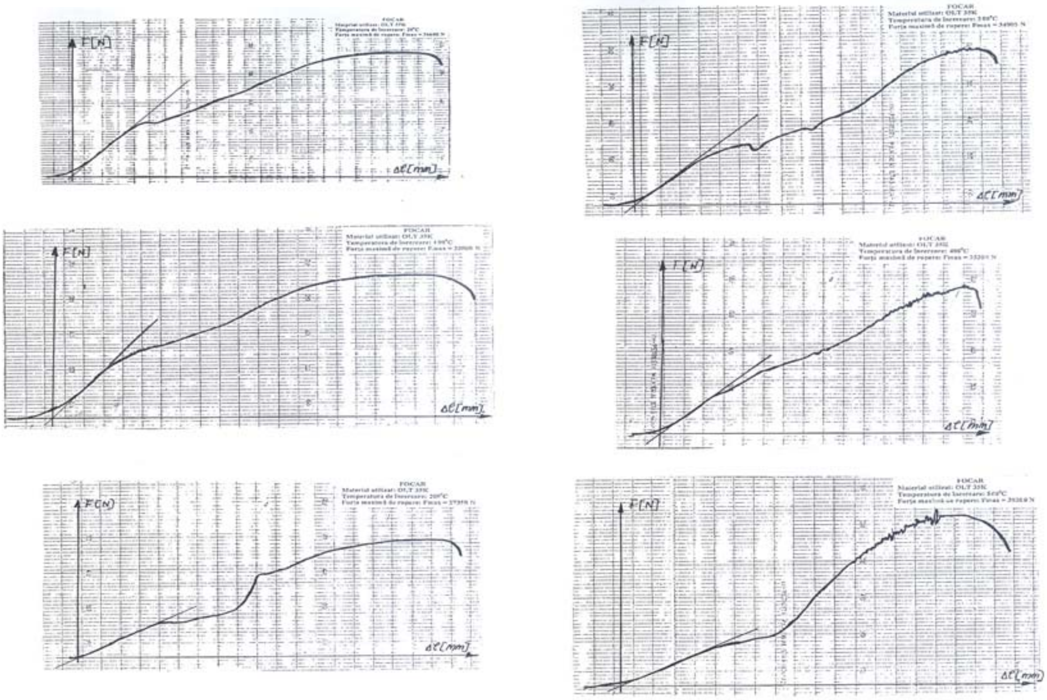


Fig.2. a÷f. F-Δι diagrams, at different temperature, obtained for OLT 35K, focus

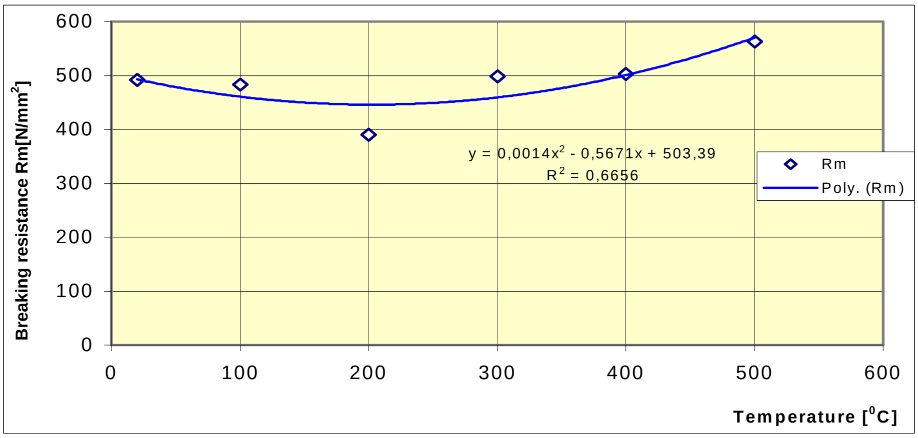



Fig. 3. Variation of characteristics $R_m$ for steel OLT 35K, by temperature

Looking at the dates, you can find out that while the temperature gets high, the breaking resistance $R_m$ and the after breaking percentage elongation gets lower, the first one reaching the temperature of 200°C and the second, 300°C. This could be explained by the fact that steel has lost some of its initial plasticity and resistance features, and still the breaking resistance experimentally established did not decline below the standard required values, for ambiant temperature, by working in the focus of a steam boiler.



© copyright FACULTY of ENGINEERING - HUNEDOARA, ROMANIA

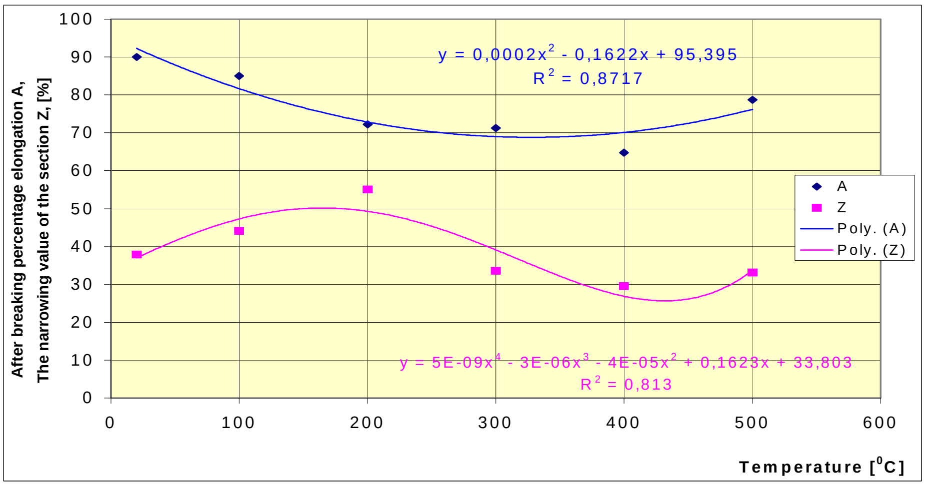



Fig.4. Variation after breaking percentage elongation A and The narrowing value of the section Z, for steel OLT 35K, by temperature

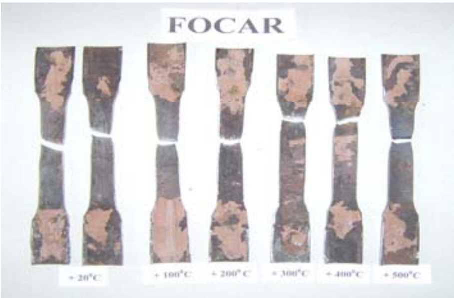



Fig.5. Share of bars, drawn from focus and tested at different temperature

The after breaking percentage elongation is valued between 90%, at temperature of 20°C (maximum) and 64,81%, at temperature of 400°C.

The narrowing value of the section is maximum valued at 55%, for the temperature of 200°C and minimum at 29,57%, for the temperature of 400°C.

Analysing the appeaance of the broken test-bars surface, you can say that temperature influences the critical tangen tension value from the sliding layouts and especially the diffusion process of carbon, so that at a temperature between 250...300°C, the diffusion speed of carbon atoms is great, which makes the dislocation movement possible (in accordance with Ludes lines), that are taking place in the material.

## 4. CONCLUSIONS

Following the metalographical analysis and the testing, it can be concluded that materials still offer great mechanical resistance features, as in the structure of the analysed steel there is a sufficient quantity of perlite and ferrite and fine granulation, which gives an important reason for continuing their exploitation.

A primordial objective to all thermal-electrical power stations is to extend the func'ional length of the elements that work at high pressure and temperature. This extent of the functional length cannot be done in any way, without knowing the real behavior of the material, but only by both strict use of the safety conditions and maintaining the best functioning parameters.

Avoiding the appearance of damage requires a good knowledge of mechanical, phisical, chemical, metalographical and any type of features, in as many conditions as possible, close to the ones in exploitation, which means knowing the real behavior of the material, knowledge that is based on theoretical research and experimental testing.

## REFERENCES:


[1] *Lăpuşan, A., Contributions brought to the study of steel behavior at high temperature. Doctoral thesis, Timişoara, 2004.*

[2] *Cheşa, I. etc., Choosing and using steel. The Technical Publishing, Bucharest, 1984.*

[3] *Dieter, G.F., The mechanical metallurgy. The Technical Publishing, Bucharest, 1970.*

[4] *Mocanu, D.R. etc., Testing materials, vol. I. Destructive testing of metals. The Technical Publishing, Bucharest, 1982.*

[5] *Nădăşan, Şt. etc., The handbook of the technician, from the metal testing laboratory, The Didactics and Pedagogic Publishing, Bucharest, 1969.*

[6] *Nădăşan, Şt. etc., Metal analysis and testing. The Technical Publishing, Bucharest, 1965.*

[7] **** Technical indications for the projection, execution, assembly, repair, installation, exploitation and check of the steam and hot water boilers. C1-85, I.S.C.I.R Collection, Bucharest, 1986.*


© copyright FACULTY of ENGINEERING - HUNEDOARA, ROMANIA