THE MODERNIZATION OF A STAND FOR MEASUREMENT AND TEST OF RESISTIVE TENSILE STAMPS

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Abstract **- This paper presents the modernization of a stand for measurement and test of resistive tensile stamps, having the theoretical support a constant bending moment beam theory. The modernization consist in replace the action motor by rotating electric type with an linear actuator, attached the microcontroller system for driving this and the realization a record system on magnetic support of the measurements and tests.**

Keywords: *stand, resistive stamp, linear actuator, microcontroller*

1. INTRODUCTION

This paper presents the modernization of a stand for measurement and test of resistive tensile stamps. The old stand was function on the four point theory principle. Among the old stand disadvantages is mentioned the followings:
- the realized of measurements and tests in manually mode;
- the rupture of stamps during the measurements or tests time;
- the difficulty realization of the stamps at endurance test;
- the impossibility of immediately and direct stocking on the magnetic support of the measurement and testing results.

We propose this solution having the two immediately objectives:
a. establish if the method is most adequately;
b. the modernization of electromechanical equipment from stand

2. THE STAND MODERNIZATION

2.1. The requirements for stand modernization

The requirements for a new testing device are:
a. K – factor measure (the gage factor,), who K:

$$K = \frac{\frac{R - R_0}{R_0}}{\frac{L - L_0}{L_0}} = \frac{\frac{\Delta R}{R_0}}{\varepsilon} \qquad (1)$$

where:
R- the strain gage resistance at the strain,
R_0 - the strain gage resistance at zero or reference strain,
L - the test structure length under the strain gage at test strain,
L_0 - the test structure length under the strain gage at zero or reference strain,
ΔR - the change in strain gage resistance when strain is changed from zero (or reference strain to test strain),

$$\varepsilon = \frac{L - L_0}{L_0} \qquad (2)$$

ε - the mechanical strain

b. The loading moment do not brake the beam
c. The results interpretation must be guaranteed
d. The measurements must be making at high and low temperature
e. The beam replacing must be making quick and easy
f. The measurements must be making automatically
g. The testing device must allowed to measure beams up to 25mm × 80mm

2.2. The presentation of old stand

In figure 1 is presented the scheme of old stand

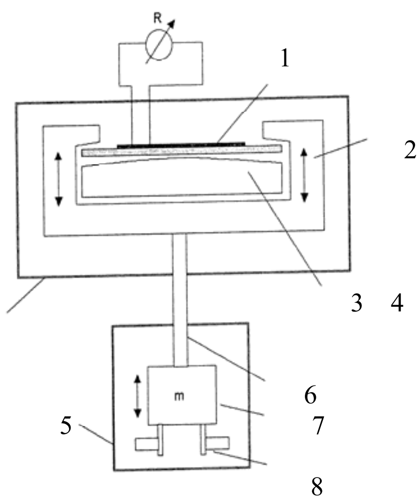

Figure 1: The old resistive stand

1. Beam with strain-gage
2. U-Joch profile which can glide
3. beam shim with an given radius
4. furnace
5. loading device
6. U-Joch loading bar
7. weight
8. motor with eccentric

The schema of elongation measure is presented in fig.2

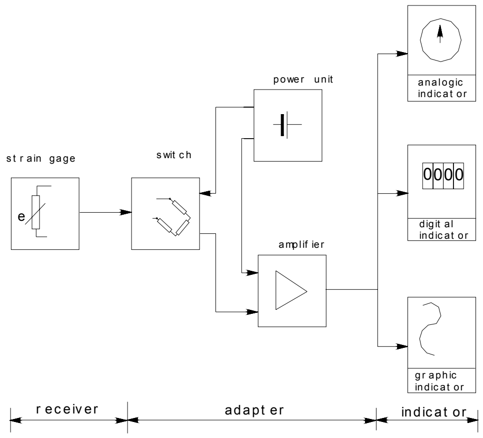

Figure 2 : Elongation measuring circuit using strain gage

2.3. The established of theoretical method for modernization of stand

On the base of authors experience and study of technical literature [1] was conclusion that the theoretical base which used for the old stand modernization will be choose between the four point theory principle and a constant bending moment beam theory. For to establish which between methods will be constitute the theoretical support, was make the theoretical calculus for three kinds of material Steel, Aluminum oxide and Silicon type used at realized of resistive stamps. We are interested to observe witch method allowed we to obtain a bigger elongation, what forces we need to obtain it and how can we measure it in better conditions a longest period. After the calculations will be make and the results will be compare we will chose the method that will be use for testing device construction.
The formulas used to determine deflection f, maximum deflection f_m , force F and elongation ε are indicated following.

2.3.1 Summary of the four point theory principle

The calculus is making on the followings relations:

$$I = \frac{bh^3}{12} \quad (3)$$

$$W = \frac{bh^2}{6} \quad (4)$$

$$f_m = \frac{Fal^2}{8EI} \quad (5)$$

$$f = \frac{Fl^3}{2EI}\left(\frac{a}{l}\right)^2\left(1+\frac{2}{3}\cdot\frac{a}{l}\right) \quad (6)$$

$$W_1(x_1) = \frac{Fl^3}{2EI}\left[\frac{1}{3}\left(\frac{x1}{l}\right)^3 - \frac{a}{l}\left(1+\frac{a}{l}\right)\frac{x_1}{l} + \left(\frac{a}{l}\right)^2\left(1+\frac{2}{3}\cdot\frac{a}{l}\right)\right]$$
(7)

$$\varepsilon = \pm\frac{F \cdot x}{E \cdot w_b} \quad (8)$$

who:
E - elastic modulus
I - moment of inertia
W-resisting moment
$W_1(x_1)$ - camber

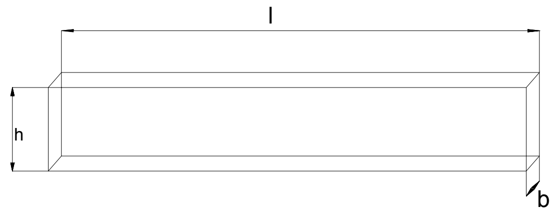

Figure 3 : Beam dimensions

2.3.2 Summary of constant bending moment beam theory

The beam used in this case is a triangular one. It has the following shape and dimensions. Here will be calculating the maximum which pres the beam and the moments diagram for determined force.

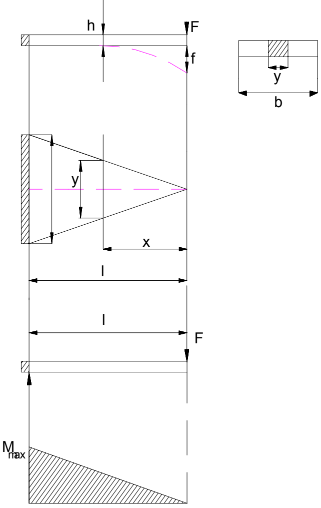

Figure 4 : Moment diagram for constant bending moment beam

The formulas used to calculate are:

$$y = \frac{bx}{l} \quad (9)$$

$$y = \frac{6F}{h^2\sigma_b} \cdot x \Rightarrow \mathrm{F} = \frac{\mathrm{yh}^2\sigma_\mathrm{b}}{6x} \quad (10)$$

$$f = \frac{6F}{bE}\left(\frac{l}{h}\right)^3 \quad (11)$$

$$\sigma = \varepsilon E \quad (12)$$

$$\sigma = \frac{M}{W} \quad (13)$$

$$W = \frac{y \cdot h^2}{6} \quad (14)$$

$$\rho_x = \frac{eE}{\sigma_x} \quad (15)$$

$$\varepsilon = \pm\frac{F \cdot x}{E \cdot w_b} \quad (16)$$

2.3.3. Table whit values obtained for those methods.

In the following table can be observe the force F, deflection F_m and elongation ε obtained by calculations made for that two methods.

Material	The four point theory principle		
	F[N]	F_m [mm]	ε[‰]
St37	2.98	0.15	$2.6x10^{-4}$
$Al_2 O_3$	4.8	0.15	$2.6x10^{-4}$
Si[100]	1.83	0.15	$2.6x10^{-4}$
Si[110]	2.37	0.15	$2.6x10^{-4}$
Si[111]	2.63	0.15	$2.6x10^{-4}$
Material	The constant bending moment beam theory		
	F[N]	F_m [mm]	ε[‰]
St37	0.85	0.81	$2.6x10^{-4}$
$Al_2 O_3$	1.37	0.80	$2.6x10^{-4}$
Si[100]	0.523	0.81	$2.6x10^{-4}$
Si[110]	0.677	0.80	$2.6x10^{-4}$
Si[111]	0.751	0.80	$2.6x10^{-4}$

Table 1: Force F, deflection F_m and elongation ε obtained by calculations made for those two methods

It can be observe that for the second method the forces needed to stress the beam are smaller than in first case and the deflection obtained is bigger and the elongations is the same in bought cases. Considering these arguments will be made a measurement and testing device using which will use a constant bending moment beam

2.4. The modernization stand

Having in observation the requirements from 2.1 paragraph for old stand and choosing the method constant bending moment beam theory in accordance with 2.3 paragraph was choose the followings equipments.

2.4.1. The electric motor

The motor utilization is a ultra-high-resolution DC-Mike Actuators type M-227. M-227 is a linear actuators providing linear motion up to 50mm with submicron resolution in a compact package. They consist of a micrometer with non rotating-tip, driven by a closed-loop DC-motor/gearhead combination with motor-shaft-mounted high-resolution encoder. The combination of an extremely low striction/friction construction and high-resolution encoder allows for a minimum incremental motion of 50 nanometers at speeds up to 1mm/sec.
Compare to conventional rotating-tip micrometer drives the non-rotating-tip design offers several advantages; it eliminates:

- Torque-induced stage platform tilt
- Sinusoidal motion errors
- Wear at the contact point
- Tip-angle-dependent wobbles

Figure 5 : M-227.50 high- resolution DC-Mike actuators and several tip options

The command of motor will be making through by microcontroller, the microcontroller for which obtained being The C-860 Mercury controller.

2.4.2. The microcontroller

The microcontroller is the C-860 Mercury controller. The Mercury is a miniaturized servo-controller for motion control in research and industrial applications. It provides a complete stand-alone control system for the smaller motors typically used in high-precision positioning systems in a very compact single package. The Mercury controller is the optimal solution for motion control application where a single axis precision positioned is to be controlled by a PC or PLC.
The unique Mercury concept combine s a high-performance motion controller and an integrated power amplifier in an extremely small package. Additional PWM control outputs allow the direct operation of any DC-motor-driven PI micro positioning system, even high-sped stages such as the M-500.

The Mercury controller employs a highly specialized processor providing high-performance PID motion control with many options for trajectory generation and filter settings. Position, velocity and other motion parameters can be change on the fly. For heightened system safety and performance, a second and independent processor handles all communication and command parsing activity.

Figure 6 : Mercury controller

2.4.3. The other equipments

The microcontroller was connected at the PC with Pentium processor. Was designed and realized the overhear system of stamps, adequately the constant bending moment beam method. Was choose and corresponding positioned the micro-limiters

3. TESTS AND EXPERIMENTATIONS

The tests were realized through designed the simple programs from PC used the graphical interface presented in figure 7.

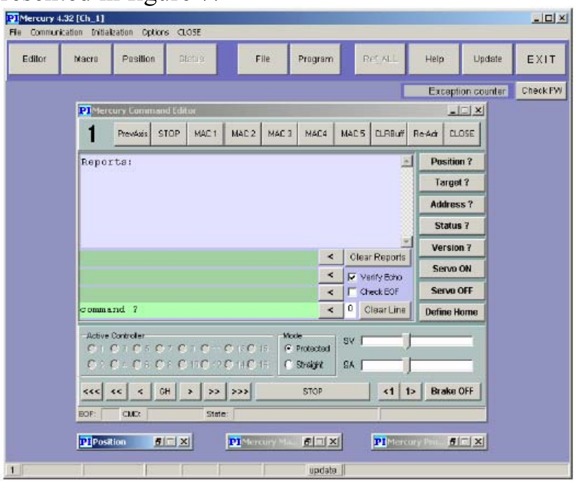

Figure 7 : Programmable graphical interface

An example of test program is presented following.
Exemple:"MR1000,WS100,WA500,MR-1000,WS100,WA1000,RP5"
In the example instructs the motor to move 1,000 encoder counts in the positive direction, wait in that position 500 milliseconds, return to the original position, wait 1 second and than repeat the sequence 5 times.

4. CONCLUSIONS

After the testing device was build and tested we could observe that it present the following advantages:
- the beams can be stress until the calculated brake point is reached;
- the results reproduction is possible;
- the measurements can be made for temperatures between -50 and +80°C;
- the beans can be replaced easy and quick;
- the actuate and results reading is making automatically;
- the stress can be produce and repeat continuously more then 4 billions time on the same beam to observe the material response to fatigue.

In figure 8 are shows the stand after the modernization

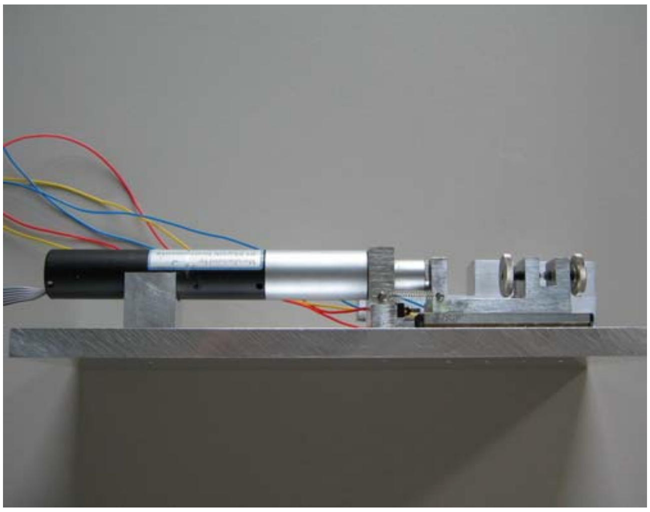

Figure 8 : The stand after the modernization

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[3] *** - *Hütte des Ingenieurs Taschenbuch Theoretische Grundlagen*, 28 Auflage Verlag von Wilhelm Ernst&Sohn-Berlin