ATTAINMENT OF PROCESSED GRADIENT OF STRUCTURE ON PRESELECTED ZONES OF A PIECE BY SOME INTEGRATED SYSTEM WITH ELECTRON BEAM EQUIPMENT

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ABSTRACT: This paper presents the researches concerning attainment of processed gradient of structure on preselected zones of a piece, by electron beam equipment, using for heating, as thermal source, a concentrated beam produced by an electronic gun. These researches, concerning the achievement of a big gradient of the structure only on different zones of functional surfaces, were possible, for the first time in our country, because the implementation of new solutions and the integration of some modern systems in vacuum at $10^{-2}...10^{-4}$ torr, with equipment specialized in welding by electron beam. These researches, show a special interest because solve the problem of replacement of classical and expensive technologies, used now, with modern ones, using electron beam, more efficiently and economically, called by the author HARDENING [1, 2, 3], which beside the increase of resistance at wearing, obtained on the hardened surface, leads to the increase of resistance at endurance, on preselected zones of the piece.

KEY WORDS: DFE – hardening with electron beam, hardened spot, hardened tape, hardened structures, structure's high gradient, preselected zones.

1. INTRODUCTION

The use of electron beam in the field of hardening and processing by heat of surfaces is presented by the author in several papers [1, 2, 3]. Attainment of a processed gradient of the structure using an electron beam is made only in the mechanical stressed wearied zones and can be made as the last technological process even in zones that, by functional purposes, are embedded in resin or plastic material.

The process takes place without the surface deformation and additional costs and brings exceptional advantages opposite to classical technologies; such are classical hardening followed by the come-back of the whole piece and by the correction of deformations by expensive rectification processes. One can appreciate that the energy used for the application of the new solution is about 5% from the energy used in classical solutions.

2. STRUCTURE PROCESSED GRADIANT ON PRESELECTED ZONES

The high structure's gradient is obtained by hardening the zones preselected on the piece, using electron beam (DFE), a modern process that consists in hardening only of the zone exposed at mechanical stresses and especialy at the piece wear, been known that mostly the zone of hardening represents 10% of the total surface of the piece.

One can obtain hardened structures only at the preselected zones (fig. 1), programming and preselecting many zones in the same time (A_1, A_2), hard wearied stressed, from the piece (A_0) and overlapping tapes, in view to assure a good hardening uniformity in the material microstructure, with a quotient determinated by experiments, with a high precision, automatically, for hardening by one passing over with the electron beam, by only one clamping of the piece and by only one starting of the electron beam and at only one opening of the vacuum work room.

The prosess (fig.1) consists in :

- Bringing the „A_1 zone" in the field of hardening by FE, moving the table on the distance of maximum X_0= +and- 62,5 mm and Y_0= +and- 62,5 mm, controlling the table velocity (of the piece A_0);
- Hardening the „A_1 zone", by deflection of FE on the distances of maximum X= +and- 20 mm and Y= +and- 20 mm, controlling the FE velocity, next by the hardening of the "zone A_2".

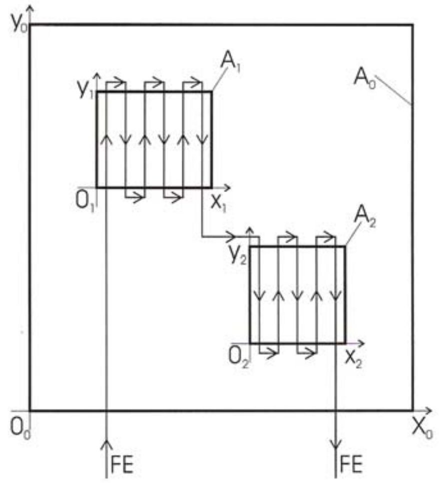


Fig. 1. Preselected zones, the areas A_1 and A_2 on the A_0 piece, hardened by FE

The hardness of many preselected zones higher than the hardness field with 40x40 mm maximum is made programming the multiple of „DFE zones" (40x40mm).

FE diameter and it's focalization are made controlling the focalization current by the computer together with the movement of the table on the direction Z=-50mm.

One can use two DFE methods:

- In FE tapes from a continuous distance (fig.2), without a good uniformity of the hardened tape between tapes;
- In Fe tapes continuous overlapped (fig. 4), with an overlapping quotient determinated by experiments, with a very good uniformity of hardened layer and between tapes.

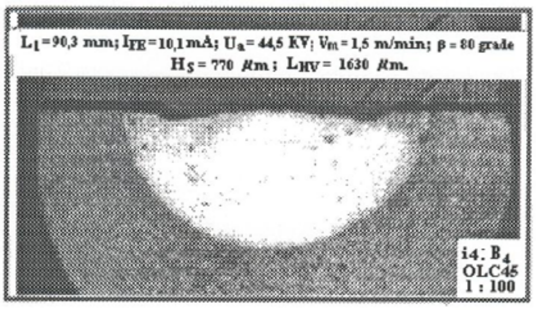


Fig. 2. The hardened spot in tapes of FE at a continuous distance, for OLC45

In the previously researches [1,2,3] we demonstrated the following:

- *the hardened spot:*:

- Is symmetrical beside the FE axe on the piece surface;
- One cans approximate an ellipse during one passing of FE, fig. 2.

- *the hardness in the hardened spot:*:

- is variable comparative of the point on the OX and OZ directions;
- is constant on OY direction, when FE go forward;
- marks a slap growing concerning the uncured core, fig. 3.

Results obtained: for the OLC45 steel, one has obtained hardness (HV) of 900...1100 40gf/30 beside the uncured core of 340 40gf/30 and a depth (Hs) of 20...800 μm.

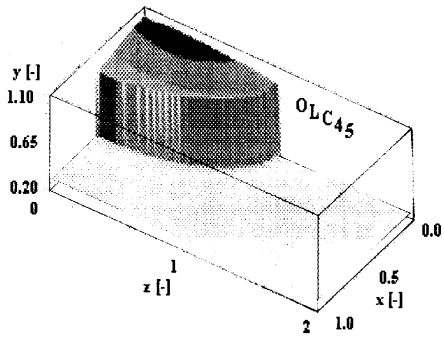


Fig. 3. Spatial distribution of hardness by colors, for OLC45.

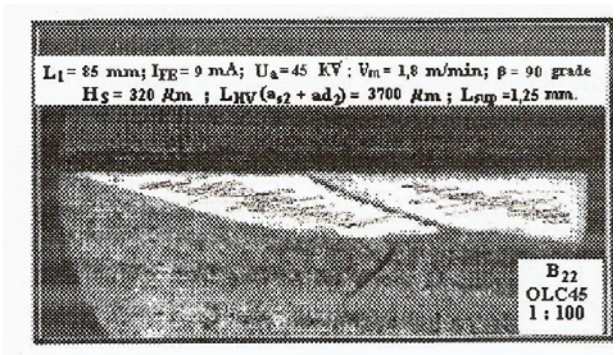


Fig. 4. Hardened tapes with FE overlapped for L_{sup}=1,25mm, and OLC45

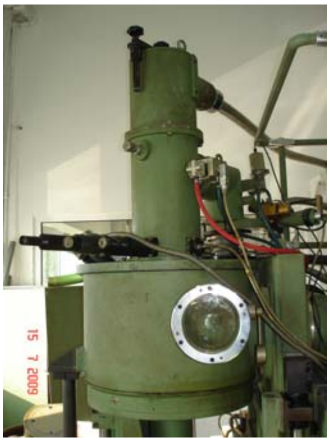
3. THE ELECTRON BEAM HARDENING EQUIPMENT

The FE hardening equipment, fig. 5, is a Steigerwald – Germany device, used especially for welding disk armatures of electrical motor type ICPE - 1978, with U_a= 72 KV and I_{FE}= 50 mA, at which one has adapted new functions in view to been used for hardness by electron beam on preselected zones of pieces.

The electronic gun is type triode with focalization at distance, with a 10^{-4}...10^{-6} torr vacuum. It is the main equipment building block, assuring the main following functions:

electron beam generation, building-up, focalization and direction.

The work chamber has a 10^{-2} torr vacuum, a circular shape, is opening in its lower part by an elevator and has a 528 mm inner diameter and a 400 mm height.



4. Fig. 5. The electron beam hardening equipment in the projected position of gun against the chamber

5. INTEGRATION OF SOME NEW SOLUTIONS AND MODERN SYSTEMS ON THE WELDING EQUIPMENT

In view to obtain hardened structures on preselected zones and microzones of piece using electron beam (item 2), the FE welding equipment was adapted and new functions were added as follow:

4.1. Displace of electronic gun in the axe of vacuumed work chamber

The position of gun of FE welding equipment was with 87 mm lower, beside the interior border of work chamber, causing a limitation of the equipment using. The gun was replaced on the work chamber axe (fig. 5), by designing the chamber overhead plate to integrate the three axes positional system and its functions.

4.2. Video monitoring process

On the overhead plate of work chamber was designed and placed and additional view finder for monitoring the evolution of the FE hardening process through a video connected with a computer.

4.3. Integration of xyz motion systems at the command and xy control focalization-deflection

The command systems necessary at FE processing equipment are related to the focalization deflection and 3D position checking of the processing piece.

The command focalization system involves the control of FE motion following Oz axe, perpendicular to the xOy process plan (fig. 6), while the command of deflection system involves the control of FE motion in xOy plan, following xy and circle directions, keeping the constructive limits of FE device (fig.6).

In addition, the command of bringing and position systems of the piece processed is necessary to cover the whole field of motion (ahead and/or rotation) in the vacuum obtained conditions to:

- Translation on longitudinal x direction;
- Translation on transversal y direction;
- Translation on vertical z direction;
- Universal rotation (plate with special bits).

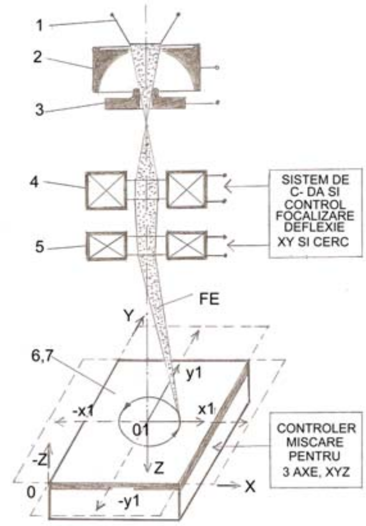


Fig. 6. Focalization and deflection schema – alternate focalized and xy deviated beam and circle and position system on three axes xyz, with: 1 - termoemitiv cathode; 2 - command electrode (Wehnelt); 3 - acceleration anode;

4 - focalization coils; 5- deflection coils;

6 - piece; 7- position three axes system

a) xy deflection and focalization of electron beam - Beam Trek controller, operates from telecommand and viewing on the display. The scanning position and amplitude is shown in fig. 7 and concern the clamping of electricity limits. For example, at a 100% position or amplitude corresponds the maximum, and at a -100% ones, corresponds the minimum for the respective deflexion axe.

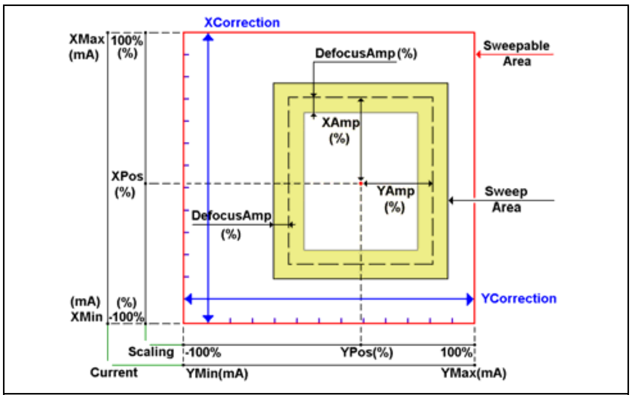


Fig. 7. Scanning position and amplitude of the electron beam

The area where the scanning takes place can be collimated on the main screen, fig. 8, the central zone been colorized in red shades (strong energy) or blue (weak energy), function of the time passed away in the respective sector by the electron beam. The data are collected directly from electrical sensors; this device has in the same time a diagnosis roll.

Fig. 8. Viewing on the main screen of the area where the screening takes place

- **Deflection type Lissajous** – the electron beam is deviated independently on each axe (X, respectively Y) by a kind of wave specific (standard or specified by the user in 32 points). The frequency for the deflection is specified by X frequency, respectively Y frequency (0.1-100Hz). Fig. 9 shows the menu as well as the result of such a deflection picked up by a digital oscilloscope.
- **Deflection type Spirala** – the electron beam is deviated in spiral, using shape of waves defined at Lissajous for X axa, respectively Y, but adding a 90 degrees phase difference between them (so sine becomes cosine and by composing this functions results a circle). When the amplitude of wave of variation of the radius is invariable (32 equal points) one will obtain a circle (if the wave's shapes on X and Y are sine), a rhomb (if the wave's shapes on X and Y are triangles), or a square (if the wave's shapes on X and Y are rectangular), fig. 10.

If the pulsation frequency (fp) is lower than circulation frequency (e.g. fc = 5 * fp), then a spiral direction will be generated. In this case the radius variation shape must not be constant.

In fig.11 is shown an example of scanning in spiral mode by variation of the radius which doesn't touch the centre, fig.11a (spiral with cold centre), while in fig.11b, this one uses a profile that draws nearer the centre (spiral with warm centre).

- **Deflection defined User** – the electron beam follows a path defined by points (maximum 250), spending round each point a certain time defined independently (haft from the previous point and haft to the next point), fig. 12.
- **Defocus option**

This option is used to defocus the electron beam directly from deflection. This process supra imposes over the current model scanned, a circle usually with a higher frequency and with an amplitude defined by the user. In fig. 13 one can observes the menu associated with Defocus option as well as the result of a circle deflection with the variable energy of the sectors and the Defocus option activated.

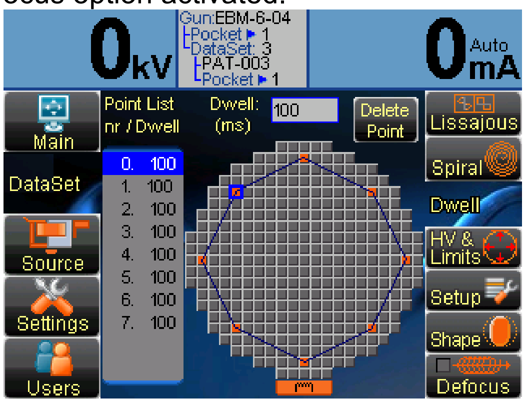


Fig. 12. Deflection defined User – by points

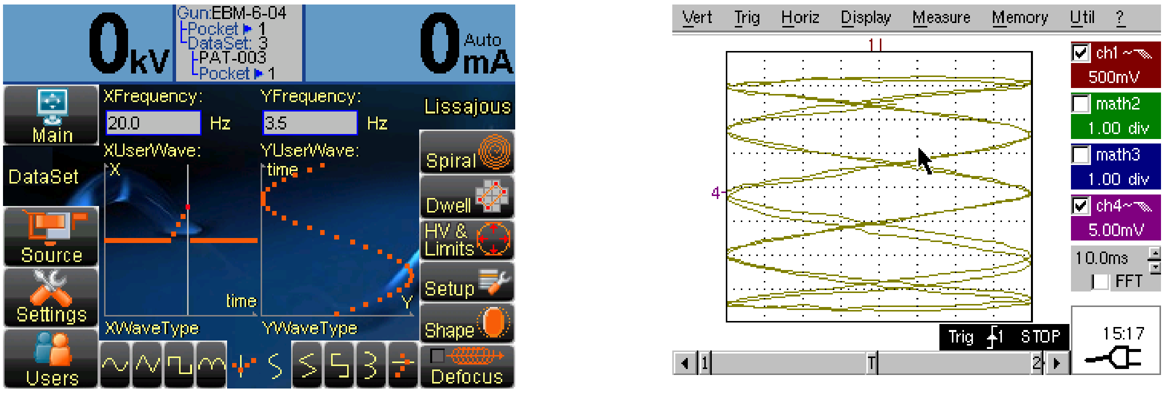


Fig. 9. The menu and the result of a Lissajous deflection

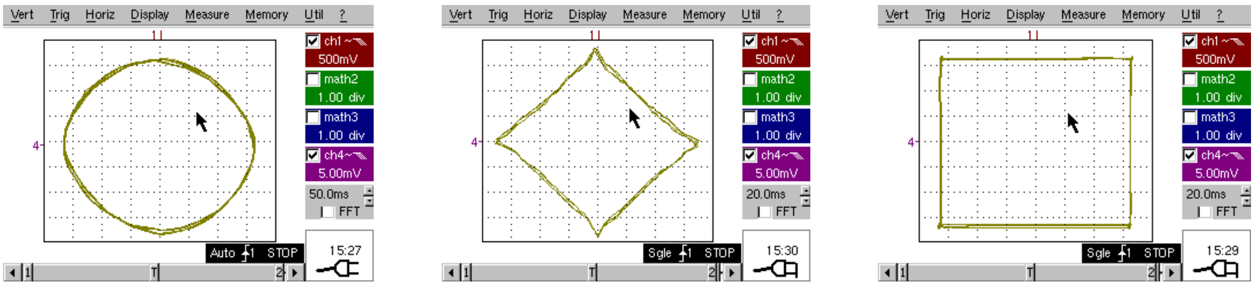
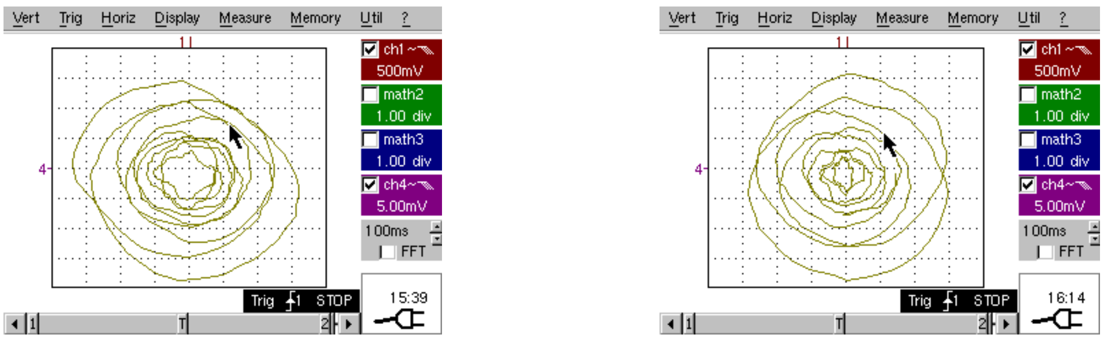


Fig. 10. Exemples of scaning in Spirala mode



a. b.

Fig. 11. Scanning in spiral mode by variation of the radius

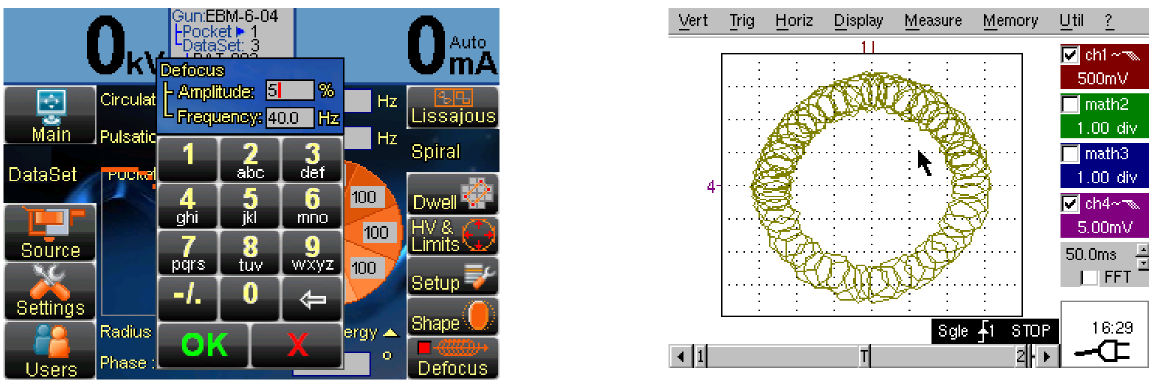


Fig. 13. The menu and the result in Defocus option

b) System of positioning on three axes functional to operate in conditions of low vacuum (10-12 barr) contains:

- Mechanical system with three translation axes droved with a transformation system for the motion type bolt and nut with nuts pretensioned to assumpt the clearance with the following characteristics: stroke axe x – 125mm; y – 125mm; z – 50mm; positioning precision 0,05mm.

- The additional rotation axe with step by step engine and universal plate with special bits with 70mm diameter;
- Motion controller for 3 axes, max. 1,5A with interface on parallel port that will permit the command simultaneous of 3 axes designed in the following two types: boarding xy + z; boarding xy + universal rotation;
- Windows software for motion control on the parallel port; PC command system, that allows programming the motions of table's axes xyz in G standard code for CNC equipments and others 2D standard formats (HPGL); includes the board for video acquisitions.

6. CONCLUSIONS

a) Researches concerning the attainment of a high gradient of structure only on different zones of functional surfaces were possible for the first time in our country, because new solutions were deployed and modern systems in vacuum at 10^{-2} barr were incorporated on equipment specialized on electron beam welding.
b) One can obtain hardened structures only on preselected zones (fig. 1), by programming and preselecting in the same time many zones (A_1, A_2), hard wearied stressed, from the piece (A_0) and overlapping tapes, in view to assure a good hardening uniformity in the material microstructure, with a quotient determinated by experiments, with a high precision, automatically, for hardening by one passing over with the electron beam, by only one clamping of the piece and by only one starting of the electron beam and at only one opening of the vacuum work room.
c) On Steigerwald equipment, modified for selecting zones of piece for processing, using integrated systems and leaded by computer, one can perform other processes by electron beam for:
- welding with electron beam on preselected zones and on varies path;
- lithografy by direct writing (marking, engraving, inscription), on 0,2 to 1,2 mm channels width (characters) and 0,2 to 1,5 m depth.

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