13th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2009, Hammamet, Tunisia, 16-21 October 2009

MAGNETIC WARM FORMING

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ABSTRACT
The paper described of magnetic field near castings forming in flat carbon steel. Presents is self solution of forming tool employed of experiments about. The results certify aptitudes of employed behalf of introductions the work.
Keywords: experiment, forming, test, magnetic, sample

1. PRESENT KNOWLEDGE
Necessary quantum of energy has to be delivered for achieving of necessary particular material melting temperature. For casting and manufacturing is making use of liquid phase acquired by means of energy source (melting furnace). Falling temperature of cast is not using after casting, yet. Gain of casting and forging process is financial effect couched in reduction of costs. Not only single energy but also need for only one heating device.

At comparison of energy demand between heat treating furnace and foundry furnace is input power of both devices with price 0,198 € for 1 kW:
1 - foundry furnace K 360/12 - 100 kW, price 19,80 €,
2 - heat treating furnace VK 100S - 45 kW, price 8,91 €.

Economic expedience of solution results from this simple comparison. Especially if price of electrical energy is continue increasing. Single cast forming process is possible make in magnetic field. Experiments and theoretical analysis of processes is confirming positive effect.

2. EXPERIMENTAL PART
For experiments was made samples from low-carbon steel 12 020. Chemical composition of steel: *C* – 0,13 %, *Cr*- 0,20 % , *Mn*-0,70 %, *Ni* –max 0,25 %. Samples hardness was 66,05, 66,10, 66,90, 68,15 , 68,30 HRB. Roller series was cast to mould. After achieving of top forging temperature 1280º C started own forming. 10 samples was forming with application and 10 samples without application of magnetic field to lower forging temperature 750º C. Experiments scheme with application of magnetic field is on figure 1.

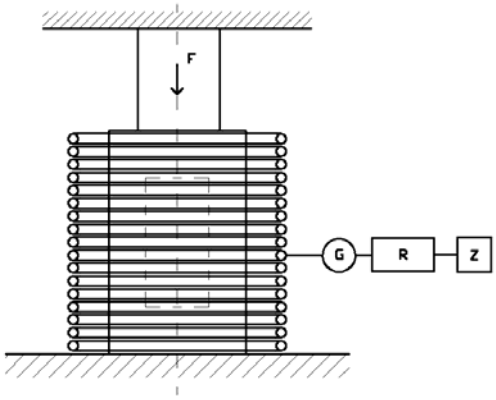

Figure 1. Experiments scheme with application of magnetic field

Principle: The work, which generator delivered to circuit from activation $t = 0$, $I = 0$, until to expected moment $t = t$, $I = I$, is: $A = \int_0^t \varepsilon' I dt = \int_0^t RI^2 dt + \int_0^t \left(LI \frac{dI}{dt} \right) dt$

$\acute{\varepsilon}$ - generator direct electromotive voltage, $\acute{\varepsilon} = RI + L\, dI / dt$.
On right side first item presenting Joule warm. Second item for $I = 0$, is presenting energy accumulated by induction L. Is it magnetic field energy and is valid:

$$E_m = \int_0^I LIdI = \frac{1}{2} LI^2 \qquad (1)$$

This energy is possible present by means of magnetic field vectors H, B. Is using of model example of toroid coil with flow I and with numbers of winding N. For total magnetic flow Φ in his winding is valid: $\Phi = LI = NBS$.
After substitution in LI to (1) with application of relation $H = NI / d = nI$ (where d = curve length $2\pi R$, n - winding intensity, $n = N/d$), from whom $I = Hd/ N$ will:
$E_m = ½\, L\, I^2 = ½\, \Phi I = ½\, HBSd = ½\, HB\tau$, where $\tau = Sd$ is toroid capacity.
Magnetic energy storage occur in circuit at flow enlarging and deliver it flow generator. [2]

3. TESTING

Device construction for pressure test

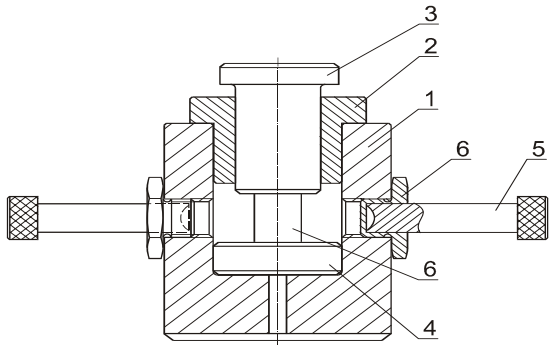

Figure 2. Testing device and scheme - second variant

For test execution was necessary made testing device by next steps. Device consists of these bodies: body pos. 1, where is working box. To box are putting round metal samples. Second part is top punch pos. 3, this is pressing on sample along direct axis. Top punch is steering in bronze case pos. 2.
Sample is in cave located on plate pos. 4, which is hardened on 60HRC and edged. Body is olted down on baseplate. Along direct axis of body is drilling breather hole necessary for assembly of plate. In the event of pressing in liquid environment is here screwed barrier.
Experiment was made by described device. Conditions of experiment: machine - shredder, tool - pressing device. 10+10 pieces of round samples was pressed. Dimensions of samples Ø 18x21 mm. Reduction was choices to maximum 30%. On fig. 3 are samples after accomplishment of tests. In tablets 1and 2 are experiment results.

Figure 3. samples after accomplished tests at different reductions

Table 1. Measured test values - samples without application of electromagnetism

forming power (kN)	*temperature (° C)*	*heigth (mm)*	*buckling (mm)*	*Reduction (%)*
6	840	20,2	19,2	8,2
7	840	19,7	19,7	10,5
9	900	19,2	20,0	12,72
10	900	18,4	21,0	16,36
11	900	17,0	22,0	22,72
11	900	16,8	22,2	23,63
11	900	16,4	22,5	25,45
11	900	15,8	23,0	28,18
11	900	15,5	24,2	29,54
11	900	15,5	24,4	29,55

Table 2. Measured test values - samples with application electromagnetism

forming power (kN)	*temperature (° C)*	*heigth (mm)*	*buckling (mm)*	*Reduction (%)*
6	900	19,2	20,2	12,72
7	900	18,7	20,7	15,00
9	900	17,2	22,0	21,81
10	900	16,4	22,7	25,45
11	900	16,0	23,0	27,27
11	900	15,8	23,2	28,18
11	900	15,4	24,5	30,00
11	900	15,6	24,3	29,1
11	900	15,3	24,6	30,45
11	900	15,4	24,4	29,1

Temperatures of process are above Curie temperature. It means that after application heating intensity with low value how is Curie temperature is possible expect bigger effect of magnetic field on forming process. The goals were done. Device construction was presented and suitability of solution was attested in laboratory conditions.

Determination of strain resistance
Test is near to static ramming is possible make evaluation according to simple terms:

$$A = K_s \; V \ln h_0 / h_1 = K_s \; V \varphi \qquad (J) \qquad (2)$$

where: A - forming work, needing to sample forming,
K_s - middle forming resistance (MPa),
V - capacity of pressing sample (cm^3),
h_0 - starting height of pressing sample (mm),
h_1 - sample height after pressing (mm),
φ - logarithmical degree of forming.

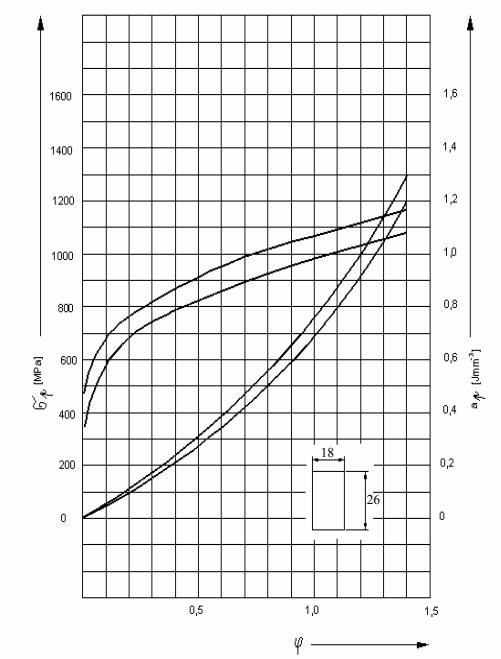

Figure 4. Curves of deformation resistances of testing steel

On figure 4 are showed of forming resistance relations from logarithmic degree of deformation for simple phases of testing for steel 12 020. Measured values are middle values of fifth measuring.

4. CONCLUSION

In paper was showed real possibilities of physical knowledge application to production process. And verification of device for forming process influence by magnetic field in laboratory conditions. It was successfully done.

The paper was elaborated in frame of project VEGA 1/4100/07

5. REFERENCES

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