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The system of automation for controlled cooling of the shapes

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In this paper was described project of the automation system for controlled cooling of the shapes 200×200mm. Were showed arrangement of sensors, valves, algorithm of functioning, time dependence's and formulas describing using of the cooling medium.

1. INTRODUCTION

During the manufacturing process of production steel shapes, the one of the stage is a cooling. This stage determines structure properties of the shapes. To obtain products marked by suitable properties and to level thermal field in cross-section was prepared a special draft of summary controlled cooling area [1].

2. TECHNICAL SPECIFICATION

In Fig.2 was showed piping and instrument diagram of system. It is composed of 3 zones located behind rolling mill. Second zone is a zone of free air cooling, and first and third are zones of water-air spray. Total length of all zones: 18.0m

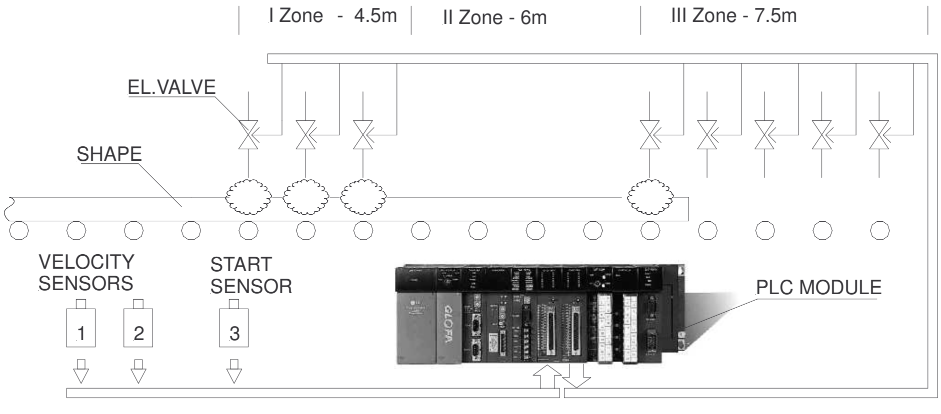

Figure1. The diagram of the controlled cooling installation (without scale)

[1] Draft for steel factory "Huta Bankowa" in Dąbrowa Górnicza.

Water-air zones consist of units. Length of one cooling unit: 1.5m. Each unit is composed of 6 lines cooling sprays supplied from water and compressed air systems through solenoid valves. Flow of the cooling medium, is controlled by the programmable logic controller, measuring velocity of the shapes and switching valves according to functioning algorithm. As PLC was expected GLOFA GM6 – one of the whole GMx family LG Industrial System company.

3. OPERATING ALGORITHM

After detection by sensor "VS1", shape's presence in cooling bed, starts realisation of algorithm presented in Fig.2. The velocity of the shapes is calculated on the ground of measured time of the shape motion and distance between two control optical sensors.

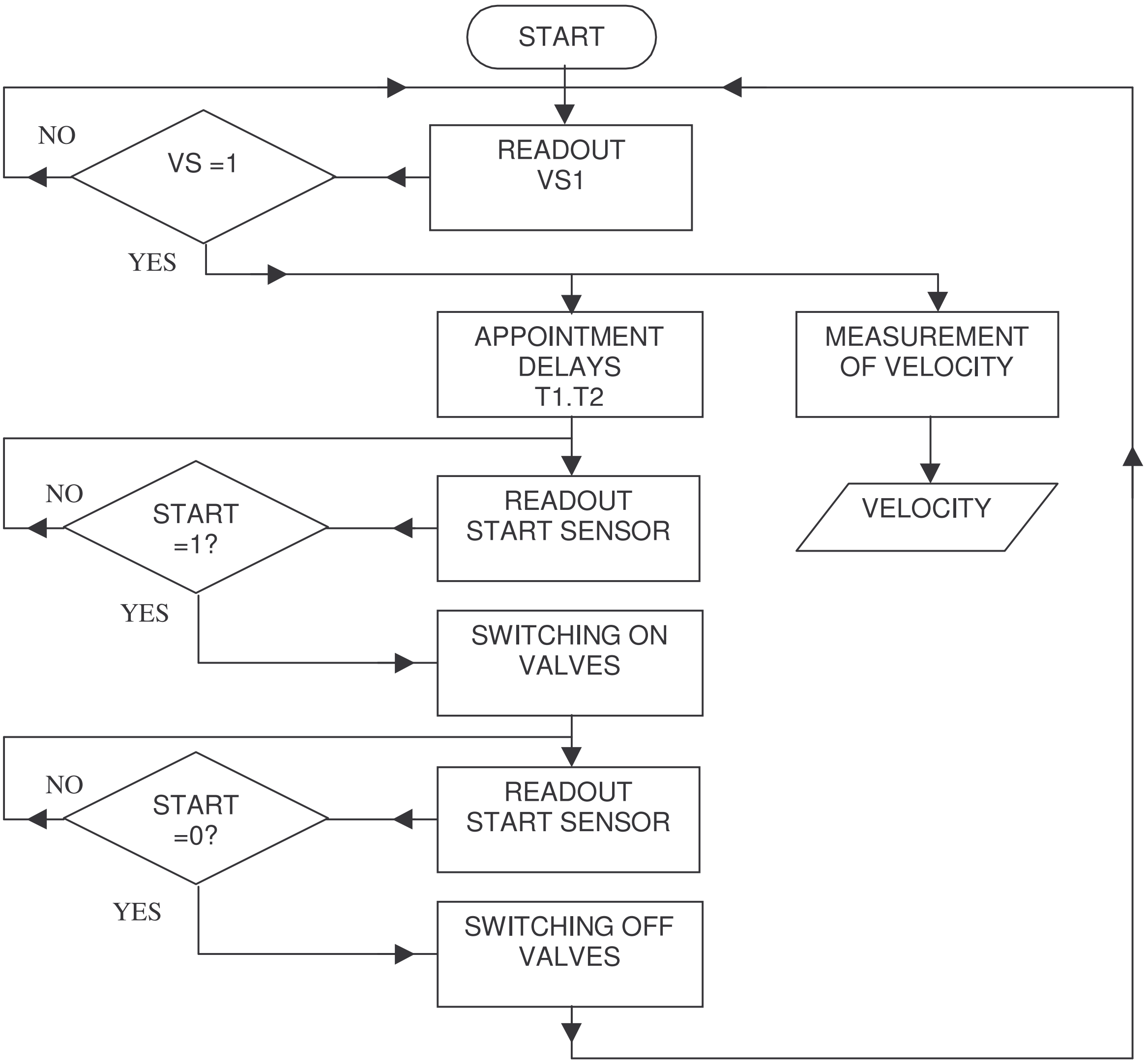

Figure 2. Operating algorithm of installation

After measurement of the shape's velocity, are determinate two times: T1 and T2. T1 – is the time of following switching of valves and T2 – time which shape needs for transition trough air cooling zone (Figure 2). Next, if the shape was detected by sensor "START", are successive set on electrical valves of cooling mediums - air and water. When the sensor "START" detectives the end of the shapes - the electrical valves, are successive set off, with appropriate times and whole process is repeating again.

This algorithm was written down in ladder diagram program by using GMWIN® software, working under operation system Windows 9x/2000. This software features virtual graphical real-time simulator, which lets check and watch the work of the program.

4. TIME DEPENDENCES

Successive interval times are function of the input Bool variables {VS1, VS2, START,}, from sensors and input constructional constants: l_m; length of the cooling unit l_u and l_{ac} - length of free air cooling zone.

The output variables are operation states of electrical valves {EV1 .... EV8}. Particular delay times of closure t_{EVx} each valves except EV1, also depend on states of previous valves. Closure times in first zone are function:

$$t_{EV1} = f(START)$$
$$t_{EV2} = f(EV1, v_s, l_u) \quad (1)$$
$$t_{EV3} = f(EV2, v_s, l_u)$$

Visible on diagram offset between time of closure 3 and 4 unit, illustrates second zone of free air cooling and is caused by time of the shape transition trough this zone.
After taking into consideration length of the air cooling zone, times of closure valves in third zone are function:

$$t_{EV4} = f(EV3, v_s, l_u, l_{ac}) \quad (2)$$
....
$$t_{EV8} = (EV7, v_s, l_u, l_{ac})$$

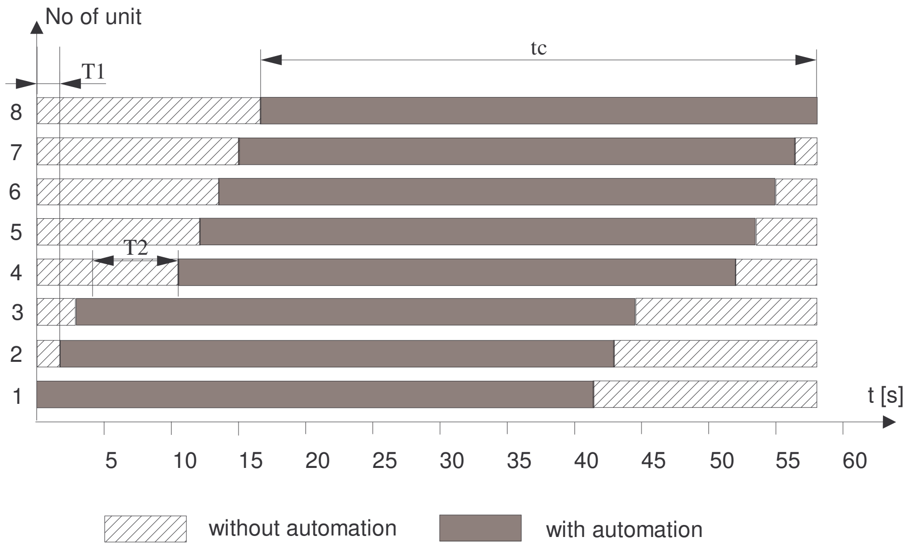

Figure 3. Time dependence's at velocity of shape; $v_s = 1^m/_s$

5. CONSUMPTION OF THE COOLING MEDIUM

In case of simply system of automation type: on - off, the time t_c of cooling is describing by formula (l_c *– length of cooling zone;* l_s *– length of shapes;* v_s *–velocity of shape*):

$$t_c = \frac{l_c + l_s}{v_s} \tag{3}$$

Then, the consumption Q_w of the cooling medium (water or air) per one cycle for *n*- cooling units is describing by formula (φ_i *consumption of cooling medium per unit*):

$$Q_W = \sum_{i=1}^{n} \varphi_i t_c \tag{4}$$

Assuming that $\varphi_1 = \varphi_2 = ... = \varphi_i$ and substituting (3):

$$Q_W = \frac{n\varphi}{v_s}(l_c + l_s) \tag{5}$$

Use the system of automation let it increase using of cooling medium, because every cooling unit operating only when in field of action is the cooled shape. In this case, the worktime of every unit per one cycle:

$$t_c = \frac{l_s}{v_s} \tag{6}$$

similarly as formula (4), consumption of cooling medium is describing by formula :

$$Q_A = \frac{n\varphi}{v_s} l_s \tag{7}$$

Ratio Q_W to Q_A characterises reduction of use cooling medium. From relationship (8) follows that reduction ratio *k* depends on l_s and l_c. and for l_s = 40m and l_c =18 equals 1.45 and increases when length of cooling shapes' decreases.

$$k = \frac{Q_W}{Q_A} = \frac{l_c + l_s}{l_s} = \left(1 + \frac{l_c}{l_s}\right) \tag{8}$$

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