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A characteristic of design solutions for flask moulding lines

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Abstract

Moulding machines used in manufacture of moulds from synthetic bentonite sands constitute basic equipment of mechanised stands, work centres, and production lines. In the present article, a short characteristic of this equipment was given, basing on the generally accepted criteria of classification taking into consideration novel design solutions and principles of cooperation between individual sub-assemblies. Moulding equipment offered by domestic producers was described with emphasis put on models representative of the distinguished classes and groups.

Keywords: Mechanisation and automation of foundry processes, flask moulding lines, moulding equipment, classification, operating cycle

1. Introduction

The principle of operation of modern foundry mould-making machines using synthetic sands with bentonite is a two-stage compacting with final squeezing of the sand. The initial sand compaction is mainly obtained by application of the following techniques: blowing, suction, stream ejecting, vibrations, and slinging of sand batches. Combined techniques are also used, e.g. gravity pouring with vibrations, blowing/shooting into a space under negative pressure, etc. Final sand compaction is achieved by squeezing the sand with pressure comprised in a range of medium and high values (0.3÷10 MPa). High squeezing forces with reduced overall dimensions of the equipment are possible by application of the hydraulic-driven squeeze system..

2. Classification of moulding machines

The main criteria on which the classification and evaluation of moulding equipment is based include, first of all, the duration of the manufacturing cycle, which consists of a number of operations performed in sequence. The mode in which these operations are performed is dictated by the design of individual sub-assemblies and by their structure, both determining the outlay of components as well as their mutual operating relations, typical of a given equipment. The duration of the cycle determines the output of equipment and the working cycle of other installations operating on individual work stands, work centres and lines. The criteria differ according to the adopted technique of sand feeding, the technique of preliminary compaction and squeezing, the type of the squeeze head used on a given machine, the type of the separating mechanism and of its drive, and the number of different positions during moulding operation [1÷3].

Taking the above into consideration, the moulding machines were divided into III classes, and within each class into groups [4,5]. The distinguishing features are: the number of posts (positions), an outlay of the operating sub-assemblies (sand feeding, compaction, separation), the technique of pattern plates replacement within one pattern equipment and within different pattern equipments when the assortment of produced castings is changed.

Class I includes single-stand (single-post) moulding machines. Feeding of sand, its preliminary and final compaction in a flask resting motionless in one working position require a movement of the sand feeding device and squeeze head assembly (Fig.1).

As regards the outlay of sub-assemblies operating in single-post units, 4 groups were distinguished. The solutions applied most frequently in industrial practice are those which allow for the feeder and squeeze head unit to be placed on a trolley or on movable deflected pillars – the equipment of type I.1b and designs with stationary (immobile) units - the equipment of type I.4. A good example of the design I.1b is an AGF jolt-squeeze moulding aggregate made by DOZAMET Nowa Sól [7].

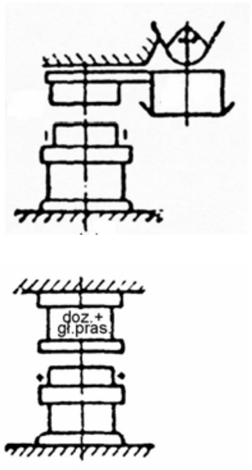

Fig.1. Principle of operation of moulding machines included in group I.1b and I.4

The time of the operating cycle necessary to make one half mould on the moulding machine in group I b is:

$$t_{c(pf)} = \sum t_{wyk} + \sum t_{s\_pf} + 2 \times t_{d\_p} \qquad (1)$$

where: t_{wyk} - the time of main technological operations (sand feeding, compaction, separation) and of auxiliary operations ((locking of pattern plate and flask in position, cleaning of pattern plate, etc.),

t_{s_pf} - the time of feeding empty flasks and receiving ready half moulds,

t_{d_p} the time of the trolley travel with the feeding and squeeze units,

The time of the operating cycle necessary to make one half mould on the moulding machine in group I.4 is:

$$t_{c(pf)} = \sum t_{wyk} + \sum t_{s\_pf} \qquad (2)$$

So, in the description of equipment from class I a characteristic feature will be the time of the movement of the feeding and squeeze units. In the description of equipment from class II this feature will be the parameters of the pattern plate movement to take successive positions. In equipment from class III the important feature will be proper outlay of the successive operations on the successive work posts and the time required for replacement (transport) of pattern plates between these posts.

A characteristic feature of the equipment included in group I.4. is that both the feeder and the squeeze head are stationary (motionless). This solution is possible only when the blowing technique with after-squeezing is applied. The blowing (shooting) holes are placed in the squeeze plate. A representative of this group of equipment are shooter-presses: F-2 (BKEngineering) [6] and SP-4 (TECHNICAL) [7].

The equipment included in class I enables upper and lower half moulds to be made alternately. The pattern plates are placed on a trolley and travel in line, crosswise to the movement which handles the flasks (an example is AGF), or - alternatively - rotary tables with seats for pattern plates are used, e.g. F-2 shooter-press.

Classes II and III (Fig. 2) include the equipment in which the operation of making one half mould is running on two or more work posts cooperating with the unit which handles pattern plates in straight or circular line (the shuttle-type or carroussel-type equipment).

The greatest practical importance have only the two-post machines. Larger number of working positions makes the design more complicated and requires complex and hence massive structures.

In equipment from class II, the operations are successively performed on two posts (two positions). The separate, stationary work posts of the sand feeder and squeeze head are successively taken by pattern plates bearing flasks with tops fixed on them. In the 3 groups distinguished within class II, practical solutions refer to group 2, according to a schematic diagram presented in Fig.2. Class II includes a FIP – 108 impulse-squeeze moulding machine made by DOZAMET Nowa Sól [7]

The time of the operating cycle necessary to make one half mould on the moulding machine in group II. 2 and III.2 is:

$$t_{c(pf)} = \frac{\sum t_{wyk} + \sum t_{s\_pf}}{2} + t_m \qquad (3)$$

where t_m - the time it takes for the pattern plate with a flask to travel from one post to another.

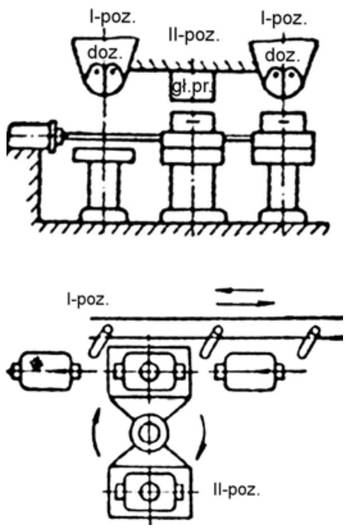

Fig.2. Principle of operation of moulding machines included in group II.2 and III.2

Class III includes equipment with *j* number of positions in an amount of ≥ 2 which serve for simultaneous execution of operations using minimum two pattern plates. These are the multi-position machines of carroussel- and streamline-type. Within class III, 3 groups of equipment differing in design of the flask feeding and half mould receiving system were distinguished. Machines from group 2 in this class are characteristic with this that the operations of flask feeding and half moulds receiving are carried out on the same post (in the same position). Between these two operations, other intermediate operations are executed. When all the operations are completed, the carroussel rotates. For example, using two-plate pattern equipment, upper and lower half moulds can be made on two posts simultaneously. An example of these machines are the moulding machines from series FT-65 to FT 108 made by TECHNICAL [6].

The equipment of type III.2 is the one most commonly used on foundry stands, work centres and lines (Fig. 2).

The relationships presented in Fig 1,2 determining the duration of half mould making cycle show differences resulting from the adopted design solution of sub-assemblies and a mode of their cooperation.

Depending on the design and structure, $\sum t_{d\_p}$ and $\sum t_m$ assume different values. Knowing that the share of $\sum t_{d\_p}$ in the operating cycle of a single-post machine is 15÷20%, and the share of $\sum t_m$ in the operating cycle of a multi-post machine is 20÷25%, and that, additionally, the majority of the examined machines are used with flasks of the 0,2÷0,6 m^2 surface and have the time $t_{c(pf)}$=12÷15 s, it follows that shortening the cycle by 1 second, due to e.g. reduced number of the handling operations, will increase the machine output by 7÷8%, while the cycle shortened by 2 seconds will increase the output by 13÷17%.

Any increase in the established minimum time will decrease the output of the equipment. For example, if the replacement of a set of pattern plates takes the time longer, in respect of the predetermined time t_m, by a value Δt_m, this will be reflected in the performance of the equipment. At present, castings of one type are made in mass production very rarely. The portfolio of orders forces frequent changes in the assortment of produced castings, which makes frequent changes of the pattern equipment necessary. In this case, reducing to minimum the time loss Δt_m means making the replacement of pattern plates strictly as preset, which gives Δt_m=0. If this condition is not satisfied, the degree of the effective utilisation of the machine capacity will be [4,5]:

$$\eta_m = \frac{t_c}{t_c + \dfrac{m_j \times \Delta t_m}{n_{śr}}} \tag{4}$$

where: m_j - the number of pattern plates used simultaneously on *j* number of the work posts,

$n_{śr}$ - average number of moulds in a lot;

$$n_{śr} = \sum_{i=1}^{r} n_i / s \tag{5}$$

s - the number of lots.

The values of the coefficient η_m calculated from the above relationship (for m_j=2), are graphically presented in Fig. 3, according to an average size of the produced moulds (castings).

3. Summary

At present, the share of moulding lines with one automatic moulding machine making alternately both half moulds with replacement of pattern plates in every cycle amounts to about 82%. Therefore the problem of the proper choice of moulding equipment is very important and requires multi-aspect analysis.

The systematic presentation of design solutions developed for the moulding equipment and presented in this paper as well as some formulae regarding the operating cycle should help in critical assessment of an equipment of this type. The classification criteria discussed here and the description of the adopted design solutions enable practical assessment of the production capacity of the moulding equipment, also in the aspect of easy modifications to be introduced to this pattern equipment later.

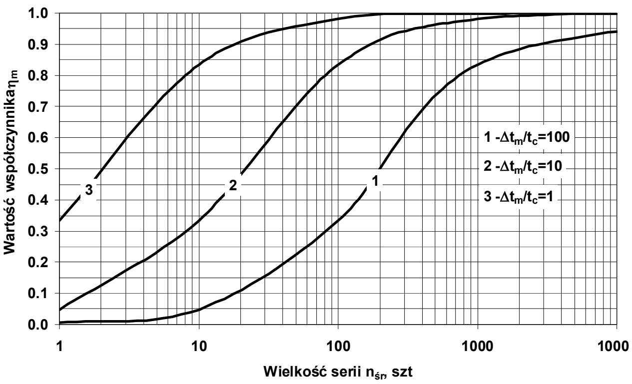

Fig. 3. Drop in production capacity vs duration and frequency of pattern equipment replacement

The assortment of domestic products described in this paper indicates the possibility of choosing from a wide range of the equipment developed by Polish producers. All classes of machines are offered to compact the synthetic sands wirh bentonite by blow-squeeze and impulse-squeeze technique. The equipment satisfies the requirements of the occupational safety regulations. It ensures, moreover, high accuracy in reproduction of complex patterns and high degree of sand compaction which, combined with its uniform distribution, gives moulds of satisfactory dimensional accuracy.

When the moulding machine is assessed for its applicability to a given purpose, special attention should be drawn to the design solutions which will enable pattern equipment to be replaced in a time preset for the individual operations, remembering that any deviation from this time will have a significant effect on production output.

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