ARCHIVES
of
FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 7
Issue 3/2007

83 – 86

17/3

Assessment of Systems for Mechanisation of Casting Production

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Received on: 24.04.2007; Approved for printing on: 27.04. 2007

Abstract

Using data on the world production of castings, the situation of foundry industry in Poland was evaluated with emphasis put on the productivity of domestic foundries. It has been observed that an increase of productivity requires a wide-scale mechanisation of the equipment used for casting production on modern foundry moulding lines. Modernisation of foundries is expected to help in creation of optimum conditions for casting production, satisfying all the requirements regarding quantity and quality of castings produced. Modern designs of moulding lines were described, including moulding machines and the related equipment.

Keywords: Flask moulding of castings, Moulding lines, Structure and equipment

1. Present state of the art

Manufacture of castings in sand moulds made from synthetic bentonite sands is nowadays the predominant process used in foundries, and it is anticipated that in the years to come this technoloqy will hold its leading position. In the world foundry practice, the share of this technology is now at a level of 65÷80% [1]. The main factor that decides about the unmatched competitiveness of this, on the other hand quite traditional, technology is, among others, the great progress in mechanisation and automation of the mould-making process, both flask and flaskless [2]. Complex mechanisation, automation and robotisation, effectively combined with microprocessor control, enables obtaining measurable technical effects, like increased output, higher dimensional accuracy and near-net shape of castings, improved casting surface quality, and also the possibility of shaping the structure and properties of cast materials and obtaining some substantial ecological effects in protection of natural environment, making the work in foundries safe and sane [3].

2. Characteristic of casting production

In 2004, the overall world production of castings in 38 countries was 80,75 mln tons. The leader in production of castings is China with its output covering almost 28% of the overall world production. The greatest casting producers in the world, i.e. China, USA, Russia, Japan and Germany, provide 65% of the overall world production volume. The share of Polish foundry industry is about 1%, with the total volume of 811 th tons of castings produced [4]. Basing on data collected from the 37 countries all over the world, the total number of foundries in 2004 was estimated at a number of about 34,3 thousand units. However, starting with the year 1995, this number is decreasing at a rate of 9%. The size of prodution falling to one foundry is from ~1,1 (India) to ~7,8 th tons/foundry/year (Germany); other tentative values are 5,2 (USA), 3,7 (Japan), 1,9 (China) and 1,8 th tons/foundry/year (Poland) [4].

According to the data given in [5], in Poland in 2004, the 390 operating foundries produced altogether 811,2 th. tons of castings, and in 2005 the volume of castings produced was 802 th. tons [6]. At the same time it has to be noted that in Poland foundries from the sector of medium and small enterprises (SME) make 94% of the total number of foundries. The productivity in domestic foundries is at a level of 30÷35 tons/employee/year.

The above value is, however, greatly differentiated and depends on the type of castings produced. And so, in foundries casting ferrous alloys it reaches 100÷150 tons/employee/year (in the case of ingot moulds it sometimes even exceeds 500), whereas in foundries of non-ferrous metals alloys it is 2,9÷44,9 t tons/employee/year; in foundries using the investment casting process, the productivity amounts to 1,6 tons/employee/year [7].

For comparison, the foundry industry in Japan boasts the productivity of 109,8 tons/employee/year [8]. In 1991, in Germany, 44,52 tons of iron and steel castings fell to one employee, and in 2001 this value reached 84,85 tons per employee [9]. In the USA, as early as in 1997, the productivity had already exceeded 65 tons/employee/year with production volume reaching 14,7 mln tons and 2950 foundries employing altogether the staff of 225 000 workers. In 94% of the American foundries the level of employment was < 250 persons, of which number 80% of foundries were employing <100 persons, and the remaining ones, i.e. 6%, had > 250 workers [10].

The studies on a future image of the American foundry industry in the scope of "Manufacturing Technologies" anticipate further systematic development of the sand moulding process, assuming that the following improvements are introduced: as regards foundry productivity - an increase by 15%; as regards the time assigned for designing of castings and development of technology for manufacture of both castings and the respective foundry tooling – average reduction by 50%, as regards energy consumption during casting process – reduction by 3÷5%; additionally it is assumed that new processes will be developed to enable manufacture of cast parts characterised by very high dimensional accuracy [11].

The data on the productivity indicate the need for modernising foundry operations, including complex mechanisation of the casting manufacturing process, basing on most modern designs of machines and equipment, wide-scale use of innovative solutions, introducing various integrated management systems and efficient marketing.

3. Mechanisation systems for foundries using the technology of sand moulds

The requirements imposed on domestic foundries mainly refer to the use of mechanised stands, posts and lines of casting fabrication (moulding lines) equipped with modern casting machines and equipment.

The share of the individual moulding technologies in production of castings and the structure of casting production using ferrous alloys are illustrated with the data compiled in table below [6].

Casting production in Poland in 2005 with breakdown into the type of the moulding process used				
Production technologies	grey and alloyed iron	ductile iron	malleable iron	cast steel
	%			
- sand moulds:				
moulding lines	25	66,3	19,5	3,8
machine moulding	16,3	15,2	20,5	30,7
hand moulding	33,4	17,5	-	63,9
- metal moulds:				
gravity die casting	8,9	-	-	-
centrifugal casting	16,1	-	-	-
-shell moulding:				
investment casting	-	-	-	1,6
- other processes:	0,3	-	-	-

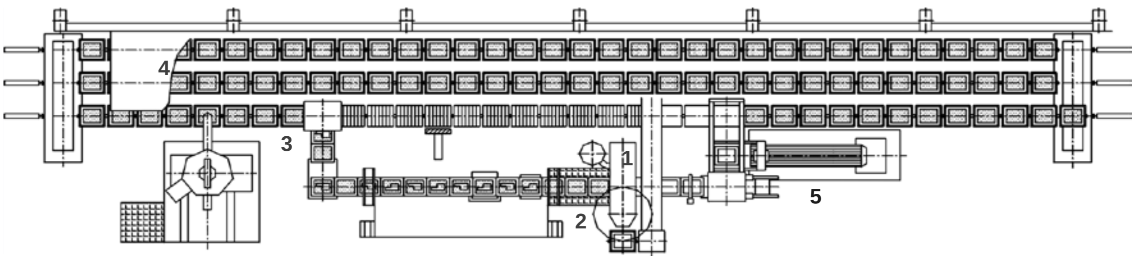

Fig.1. Schematic representation of a flask moulding line: 1- impulse-squeeze moulding machine, type FT, 2-sector of mould and core assembly, 3-sector of mould pouring, 4-sectors of casting cooling in moulds - holding area, 5-sector of casting knocking-out and sand separation [13]

From these data it follows that the manufacture of castings in machine-made moulds and on the automatic moulding lines is insufficient. Definitely, this state requires some improvevements, which mainly consist in installation of modern moulding facilities offered by both domestic and foreign producers.

The lines for casting manufacture are equipped with automatic equipment to make flaskless moulds (packets of compacted sand) and with aggregates and automatic devices for the manufacture of moulds in flasks.

The majority of automatic flaskless moulding lines operating in Poland are Disamatic, Disa-Forma, Match-Blomatic and Loramatic; sometimes moulding lines offered by other recognised world producers are used as well. Nevertheless, the lines for automatic flaskless moulding operating in Poland are in most cases obsolete. These are the lines which have been in operation since early 70-ties of the past century. Only few foundries have installed modern moulding lines according to the design solutions offered at present.

The situation is much better as regards mechanisation of casting production in flask moulds. The possibilities of an improvement in this respect are additionally backed up by the fact that the mechanised equipment for flask moulding posts and lines of casting manufacture is offered not only by foreign producers but also by the home companies. In numerous Polish foundries is at present effectively operating the moulding equipment made by companies like BKE-Engineering, DOZAMET and TECHNICAL with the site in Nowa Sól. The range of the offered equipment includes blow-and-squeeze moulding machines, type F-2 [12], and impulse-squeeze machines, types FI, FIP and FT [13].

The example of a flask moulding line operating at present in production of castings is shown on a schematic diagram in Figure 1.

The presented moulding line is assigned for manufacture of castings by moulding in flasks of dimensions 630×500×150/150 mm (length×width×height of drag/height of cope - internal dimensions). The drags and copes are made alternately on an impulse-squeeze moulding machine, type FT 65.

The above described moulding line is consistent with the world trends as regards its design and equipment [15,16]. At present, foundrymen definitely prefer the designs provided with sectors for cooling of castings in moulds (these are the, so called, holding areas) instead of a closed loop available on trolley conveyors. Design solutions of this type ensure greater flexibility of connection between the moulding sector and the sectors of pouring and cooling. The transport system in the holding area consists of foundry conveyors, and it includes a railway track, trolleys for moulds, and a transfer table. Foundry conveyors can operate in an automatic cycle. The trolley drive systems are operated by hydraulic servo-motors. The transfer tables are operated by hydraulic rotary motors. The coupling necessary for conveyor movement in an automatic production cycle is achieved by control systems equipped with a PLC programmer.

The principal technical solutions used in modern moulding lines include, first of all, the machines for two-step mould compaction. First, the compaction of the sand is by blowing and shooting, by impulse and air jet flow, or by other related techniques [17]. After initial compaction, the sand is additionally squeezed, usually by means of the squeeze plates - flat, shaped, or of multi-piston design. Application of these techniques enables obtaining the required uniform sand compaction. Another benefit are the very advantageous indeces of energy consumption. The respective table gives the values of the demand for a unit compressed air volume and specific energy consumption in sand compaction by squeezing, shooting combined with squeezing, and impulse and air jet flow compaction.

Summary

Basing on the data regarding world production of castings, the situation of the domestic foundries has been outlined, with attention focussed on the productivity values. An improvement in this respect can be obtained using on a wider scale the systems of the mechanised production of castings. The potential that the foundry modernisation holds has practically no limits due to, among others, a rich offer submitted by the producers of moulding machines and equipment as well as complex installations of the entire moulding lines.

The offered equipment ensures better technical flexibility. It also gives the possibility of quick "rearrangements" when changing the assortment of castings produced and/or making intricate moulds and castings with large number of cores. The equipment used on these lines can also be used under the conditions of small-lot production owing to the application of segment pattern plates.

The, preferred at present, structure of moulding lines and of the respective equipment is meant to satisfy the required values imposed by the criteria of a technical assessment of these lines, i.e. the productivity, sand compaction degree and quality, failure-free operation, degree of automatisation, and moulding line compactness or a degree of its structure development. The system of the holding areas enables obtaining a wide range of the cooling times.

The indices of the technical assessment, including the productivity of moulding lines, depend, first of all, on the production cycle of moulding equipment, which is composed of a number of different operations repeated periodically. The way in which these operations are performed is strictly connected with the way in which the individual assemblies and structures have been designed, since this is the factor which, in turn, determines the layout of components and relations that exist between them and that are characteristic of each type of the equipment. The offered solutions of the domestic moulding machines are characterised by high production capacity; they are operating against the principle of impulse-squeeze technique of compaction of the synthetic sands bonded with bentonite.

The problem that the domestic foundries are currently facing is the small number of new investments. In Poland, at present, are operating the lines with automatic systems produced in early 70-ties of the past century. The potentials that these lines offer are far from the present expectations. The specifications of the equipment used by foreign foundries often state that full exchange of the moulding machines and equipment in foundries should be done as frequently as every 5 years [20]. This policy of modernisation of the foundries enables introducing modern solutions to the mechanisation systems and obtaining the leading position among foundry producers.

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Elaborated under research and development study no. 10.10.170.