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Performance tests of an abrasive cut-off systems for the finishing of high-precision casts

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Abstract

The paper summarizes the performance data of a newly designed and engineered grinding and cut-off system. The machine is used for separation of models manufactured by the investment casting method. The machine comprises the following units:
- base supporting other assemblies and elements: abrasive disc holder and drives; this solution enables an easy replacement and access to holding elements while a belt transmission allows the disc rpm to be varied,
- mechanism moving the spindle in the horizontal, hence the abrasive disc position with respect to the batch can be precisely controlled, depending on the cast position and their shape,
- holding and positioning-control of the batch to enable the fore and aft movements and rotations,
- guide systems ensuring the travel of the batch in the specified direction and adjusting the travel speed to the required cutting rate,
- centering, control, exhaust system, housing.

Extensive tests were performed, including the tests of operating parameters of abrasive discs depending on the cast material, cyclograms of the applied treatment are obtained accordingly.

Keywords: Casting separation; Finishing; High-precision casts

1. Introduction

Safe and efficient separation of casts from the runner system, free from noise and vibration, and at the same time the minimization of the left-over surface area on the cast is a major technological problem faced in the foundry plant in the cooperative “Armatura’. To solve the problem, the abrasive cut-off system was designed and engineered within the framework of the targeted research program ROW-II-232/2007 NOT.

This unit was designed for separating casts from the runner system. the number of casts in a batch ranges from 1 to 4 on the given level, there are 1-48 of them on 1-12 levels. The mass of the batch varies from 5 to 12 kg.

Reports available in literature [1-10] indicate that the widely used machines and automata cut off the casts while the rotating abrasive disc displaces in the vertical. Solutions include PMR-type manual cut-off machines (similar cut-off systems have been long used in the cooperative Armatura) and mechanized cut-off machines RASANT TM 400, TM 600, TM 800 (Universal Maschinen and Apparatebau GmbH & Co.KG) and TSF 500 (Reichmann & Sohn GmbH) [10]. Interesting solutions of manually or automatically controlled devices are offered by Struers Company [7, 10]. These are mostly hydraulic –powered facilities, incorporating batch holders, positioning tables, exhaust system, control systems and securing devices.

2. Technical specification of an abrasive cut-off machine

The cut-off machine PS 400 is intended for cutting of investment castings. The whole unit (the main gate with the supply gates and castings) are mounted horizontally in the holder unit (Fig 1). A three- clamp holder interacts with a securing bolt (a piston rod in the hydraulic cylinder).Two-way fixing allows the feed to be wholly secured. The holder assembly enables the batch rotation around the axis of the grip.

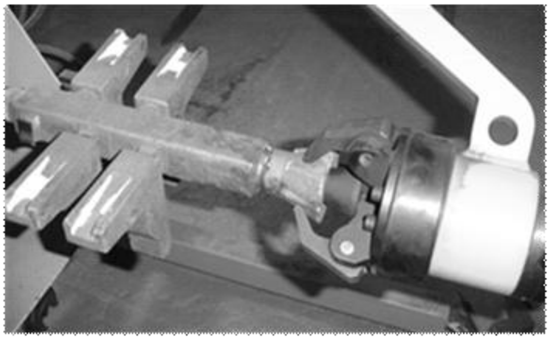

Fig 1. Castings in fixed position- general view

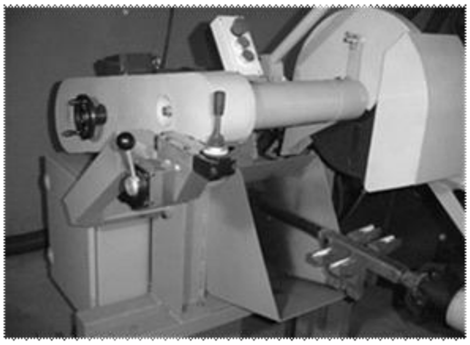

Fig 2. Abrasive cut-off machine- general view

Castings are sectioned manually, by swinging movements of the displacement lever in the vertical (Fig 2). The holder of an abrasive wheel is capable of horizontal displacement, so the castings can be sectioned on both sides of the main gate.

The abrasive cut-off machine PS 400 incorporates the base assembly (complete with vibro-isolation features), the drive unit (a 3-phase induction motor 7.5 kW, 2925 rpm), a belt transmission (transmission ratio ~1.6), a grip and a control unit.

The exhaust system interacts with an installation complete with pipes, filters and exhaust fans. The dust-removing unit in the cut-off machine can be connected to the in-house exhaust system.

The cut-off machine meets the work safety and environmental requirements set forth in the relevant EU standards [4.9].

3. Performance data

Tests were performed to determine the machining properties of the material in the applied treatment program and to obtain the relevant cyclograms.

The experimental set-up comprises an abrasive cut-off machine complete with a typical abrasive wheel, motor-driven (N=14 kW) and a fixing grip. The cutting unit- i.e. the lever supporting the abrasive disc and a counterbalance is positioned such that it remains immobile when the disc, ranging from 350-330 mm in diameter, moves closer to the element to be sectioned. During the test the lever end was loaded with a weight to induce the 25 kg pressure upon the disk (Test I, the resultant moment 13.75 daN x m) and 10kg pressure in Test II (resultant moment 5.5 daN xm). These are minimal values since during the cutting process the system loses the balanced position. At the moment the cutting process is over, the resultant moment increases to ~ 20 daN xm and ~12 daN x m, respectively. Measurements were taken with a dynamometer at the moment the specimen is cut.

The testing method was applied whereby the specimen with the cross-section 42 x 42 mm was sectioned at selected points along the runner length, the measured parameters included cutting time, hardness after cut and the abrasive disk diameter.

Machining properties of cast steel L 20, L 600, L40H, LH 14 were tested using an ANDRE ABRASIVe disk (product code: 030074, symbol 41-350 x 3.5 x 3.5 95 A 24 BF-80 STANDARD, the SAIN-GOBAIN ABRASIVES disc (41-350 x 3.5 x 32 rpm 4370 A-24-T6 BF- 80 INOX) was utilized in testing of the cast steel LH 18 N9. The specimens were sectioned with abrasive wheels at 80 rpm. For each steel grade 20 cuts were performed in each loading cycle. For cognitive purposes, tests were run on aluminum and brass specimens. The average cutting times for the specimen 42 x 42 mm and the disk 350 x 3.5 x 32 are summarized in Table 1.

In terms of casting separation from runners, machining properties are associated with cutting ability. This property is chiefly controlled by the properties of machined material and of the abrasive disc.

Table 1.
Cutting times of specimen 42 x 42 mm

Material	Average cutting time for the specimen I and II, s	
L40H	5,86	7,81
LH14	7,23	10,01
LH18N9	7,42	11,69
L600	7,56	11,68
L20	9,39	18,70

In terms of casting separation from runners, machining properties are associated with cutting ability. This property is chiefly controlled by the properties of machined material and of the abrasive disc. Machining abilities in specified treatment conditions determine the efficiency and adequacy of the applied treatment. Machining abilities are determined by comparing the index expressed as $V_{mat}/V_{zuzycietarczy}$, where V_{mat} and $V_{zuztarczy}$ denote the volume of cut material and that of the worn disk, respectively. Selected results are summarized showing the cutting ability of the abrasive disk in relation to hardness HB on the cut – off surfaces (Fig 3).

The test program covered the treatment of castings by the abrasive disks 400 mm in diameter, rotating at 100 m/s. In these conditions the efficiency of the treatment would be improved. The cutting times are summarized in Table 2.

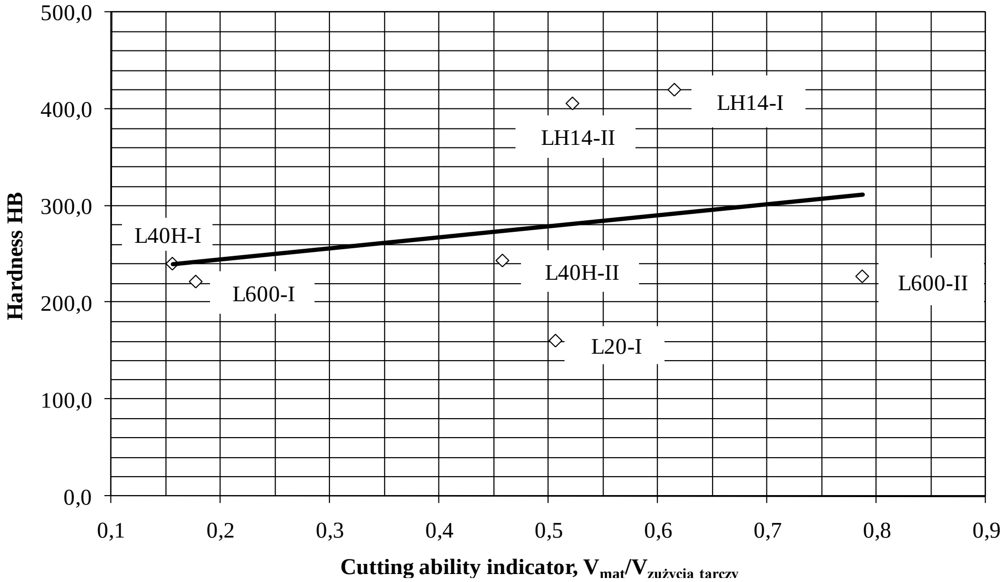

Fig 3. Cutting ability indicator

Table 2.
The cutting times

Operation	Block cast from 400 (the set of 5 casts weighing 11,8 kg	Lever cast from cast carbon L 270 480 in accordance with the standard PN ISO 3755 (the set of 8 casts weighing 11,8 kg	Mincer frame W 60 cast from LH 18 N9 (the set of 1 cast, weighing 8,2 kg
positioning and securing	10 s	10 s	10 s
cutting - off on one end of the runner gate	3 casings: 12,5 s (items)	4 casings: 17 s (4 items)	1 casting 3 supplying gates, 37 s
switching the cutting head to the opposite end of the runner gate	7 s	7 s	-
cutting - off on the opposite end of the runner gate	2 castings 20,5 s	4 castings 21 s (4 items)	-
removing the runner gate	3 s	3 s	3 s
Total:	**53 s**	**58 s**	**49 s**

4. Conclusions

The research project prompted the design, engineering and equipping of the laboratory set-up for separating the castings from the runners. The fundamental element is an abrasive cut-off machine PS 400 with the following parameters: abrasive wheel diameter Dt= 400 mm, disk rpm n= 4775 1/m, efficiency W= 30 sets per hour, dimensions: B x L x H = 1718 x 1050 x 1741 mm.
The holder assembly is designed for securing the casting sets to be made by the investment pattern method. It might be modified and adapted to runner systems in other casting methods.
Performance tests allow the reliable assessment of machining capability of abrasive disks, depending on the casting material. The methodology outlined in this studyenables the selection of an optimal abrasive wheel and of the parameters of the finishing treatment. It is revealed that the abrasive cut-off machine fitted with a disk 400 mm in diameter operating at 100 m/s provides excellent performance, approaching 60 sets per hour.
Performance tests were performed accordingly and a wide range of issues were addressed associated with the design, actual lay-out of the abrasive cutting off system, operating and environmental conditions. Laboratory test data are available to the interested specialists from foundry plants.

Acknowledgements

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