

NEW SOLUTION OF THE TECHNOLOGICAL PROCESS OF DISC BRAKES MACHINING

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Abstract: The constructional solutions of disc brakes were presented. Technological process of their carrying out in the large-lot production was discussed. The semi-automatic seat to mechanical treatment of disc brakes was characterized. Modification of technological process of disc brakes treatment was done. Machine cutting parameters were optimized and changes in NC programs for lathes and borers were implemented. An attempt of applying ceramic cutting plates with another optimization of machining parameters was made. Applied changes improved the efficiency without worsening the precision of work.

Key words: disc brake, technological process, CNC machines, modification, optimization.

1. INTRODUCTION

In the period from 1890 to 1895 Karl Benz, F. W. Lanchester, Albert de Dion and Georges Bouton constructed the first cars and put them on the market. In 1902, Lanchester submitted a patent application for the disk brake. At the same time, a considerable progress in the brake technology was made by Herbert Froad (Ferodo), who developed and patented the first modern abrasive materials. In 1922, Malcolm Loughead (Lockheed) replaced the mechanical control system with a hydraulic system. A considerable progress took place in 1953, when Dunlop equipped the *Jaguar XK 120* with disk brakes. A year later, in 1954, the first ventilated brake disks were implemented to the *Alfa Romeo* car. But it was not until 1963 that a big truck was equipped with Knorr disk brakes, and in 1969 this technology was applied for the first time in motorcycles [1, 2, 3].

Owing to the stability of operation, the cost of raw-materials and the ease of production, a material commonly used for brake disks is grey cast iron, where graphite occurs in the form of small lamellas that look in the cross-section like threads (graphite lamellar cast irons) [4]. Other materials are used in special applications. For example, materials based on carbon composites are used for the production of brake discs intended for racing cars and aircrafts.

In the casting process, moulds are of different complexity, depending on the piece to be manufactured and the required production cycle. However, all moulds are designed for group casting (Fig. 1).

Disc castings are much larger than the finished discs (Fig. 2). This is due to the fact that the uniform material of required technical characteristics, such as hardness, composition and structure only lies at a certain depth below the surface. The casting allowance ranges from 1,5 to 2 mm. This means that 25% of the casting material is removed during machining.

High-performance braking systems more and more commonly use ventilated brake discs. Essentially, they are made up of a double disc composed of two plates

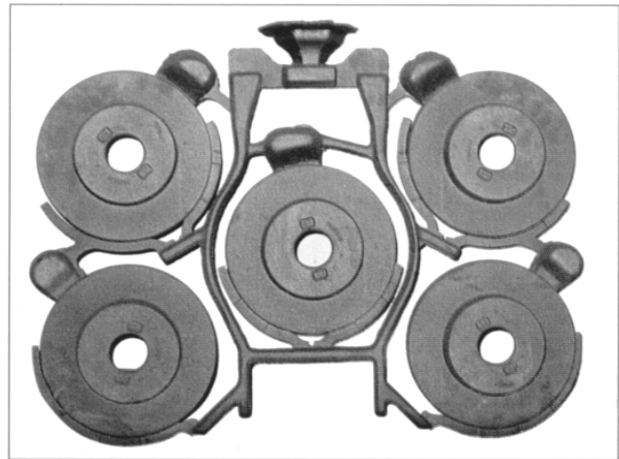


Fig. 1. Cluster casting of brake discs [1].



Fig. 2. Casts and final shape of brake discs [1].

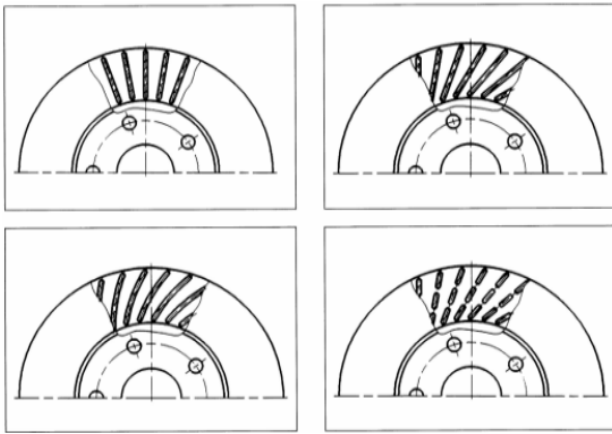


Fig. 3. Different shapes of blades of ventilated brake discs [1].

separated by metal bridges that connect both parts, while forming at the same time passages for the flow of air. Air flows between the two plates and takes away the thermal energy. The air circulation depends largely on the shape of internal bridges, which are called “blades” (Fig. 3).

2. MACHINING OF BRAKE DISCS

Demand for brake discs, in a global scale, reaches several hundred million units per year, thus their production is a large-lot one.

A technological process of brake discs manufacture in a modern factory producing 12 thousand discs a day in a three-shift system, with 120 type-sizes a month, intended both for new cars and for servicing purposes is presented.

Basic disc-shaping operations are performed semi-automatic machining groups composed of numerically-controlled turning lathes and CNC drilling machines interconnected with transfer lines.

Turning operations are carried out on PCC job turning lathes manufactured by PITLER. These are two-chamber machines designed for dry machining, with a mobile electro-spindle of a vertical axis of rotation. The power of an AC motor incorporated in the electro-spindle is 72 kW, with a rotational speed range of 11.2 - 5400 min^{-1} and a maximum spindle torque of 860 Nm, whereas the allowable diameter of workpieces is 380 mm.

Positioned on a cross slide, the electro-spindle performs longitudinal (Z axis) movements within a range of 290 mm at a feed speed of 0 – 24 000 mm/min, and transverse (X axis) movements within a range of 1160 mm at a feed speed of 0 – 40 000 mm/min.

The turning lathes are equipped with a turret of a horizontal axis of rotation with eight $\varnothing 50$ mm cylindrical tool sockets. The turret is controlled, as an auxiliary lathe axis, by a SINUMERIK 840C/840D control system.

Table 1

Specification of basic operations

Operation	Operation description	Stand
10	Shot blasting	Shot-blasting machine
20	Self-inspection, supervision inspection	Shot-blasting machine
30	Preliminary turning	CNC turning lathe
40	Intermediate turning	CNC turning lathe
50	Final turning	CNC turning lathe
60	Self-inspection, supervision inspection	Inspection & measurement stand
70	Drilling	CNC drilling machine
80	Self-inspection, supervision inspection	Inspection & measurement stand
90	Inter-operation preservation	Preservation stand
100	Balancing	Balancing machine
110	Self-inspection, supervision inspection	Inspection & measurement stand
120	Inter-operation preservation	Preservation stand
130	Marking	Marking machine
140	Self-inspection, supervision inspection	Inspection & measurement stand
150	Automatic inspection	Inspection & measurement stand
160	Degreasing, phosphatizing	Degreasing line
170	Self-inspection, supervision inspection	Inspection & measurement stand
180	Anticorrosive protection	Anticorrosive protection line
190	Self-inspection, supervision inspection	Inspection & measurement stand
200	Packaging	Packaging stand
210	Final inspection	Final inspection stand

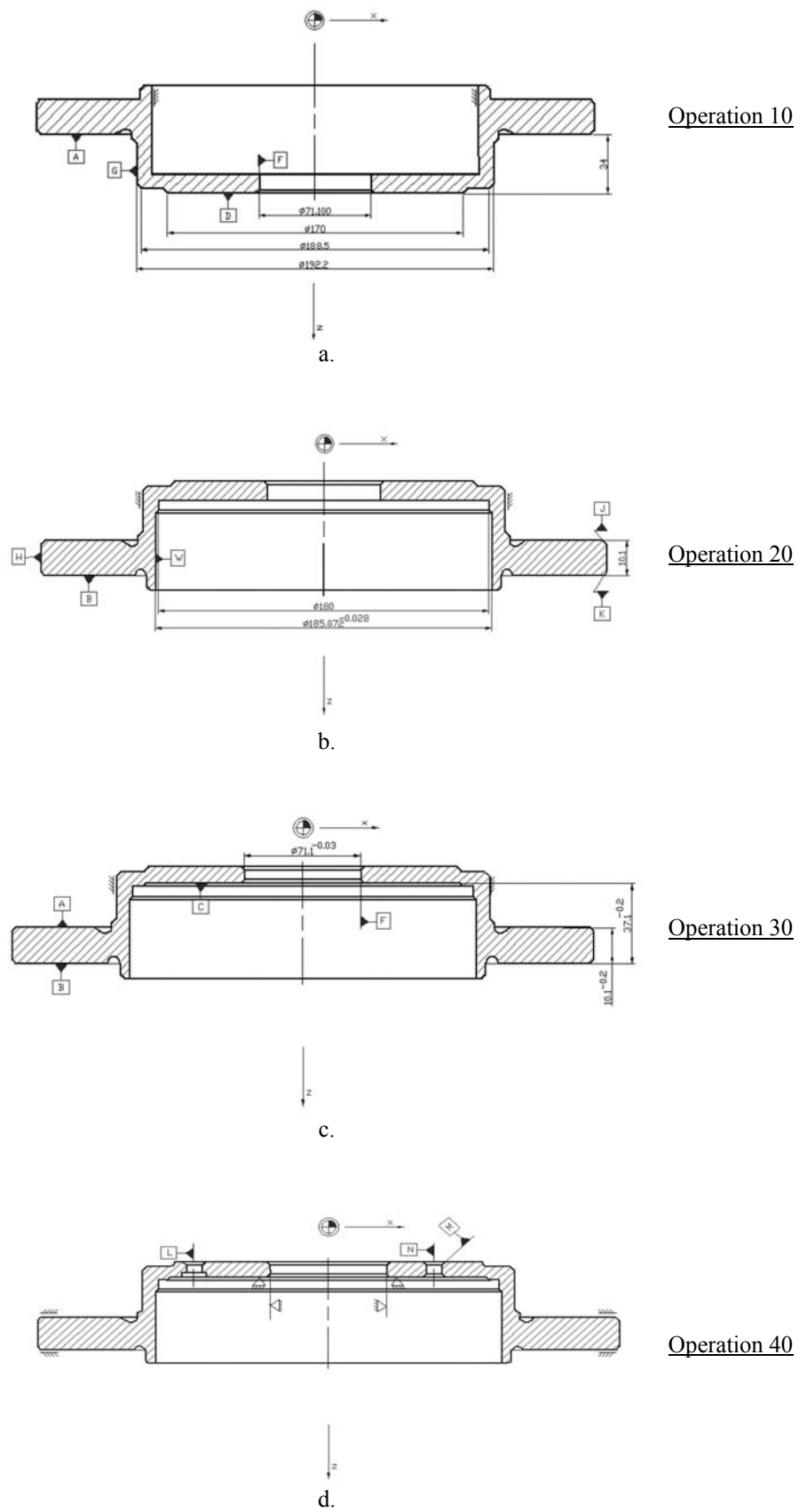


Fig. 4. The brake disc, the designation of surfaces machined, the system of axes and the characteristic points of four operations.

Specification of four operations and treatments included in the technological process of brake disc machining

Operation	Operation description	Stand
10	1. Coarse machining of surfaces A and D. 2. Turning of bevel (on surface G) + outer diameter of bell G. 3. Finish turning of channel between surface A – G. 4. Turning of bevel (at hole F) + coarse turning of hole F + finishing of face D.	T18
20	1. Finish turning of outer diameter H. 2. Turning of bevel J, K + coarse turning of surface B. 3. Finish turning of bell inner diameter W.	T19
30	1. Turning of hole F + bevel (at hole F) + finish turning of plane of contact C. 2. Coarse sizing of surface A-B. 3. Finish sizing of surface A-B.	T20
40	1. Drilling L and N on surfaces D and C. 2. Beveling M and counterboring on surfaces D and C.	Drilling machine

Drilling operations in the brake discs technological process are performed on very high-performance CNC drilling machines manufactured by CHIRON.

Both the job turning lathes and the drilling machines are designed to operate with transfer lines and robots.

The specification of basic operations of the brake discs technological process is shown in Table 1.

3. MODIFICATION OF THE TECHNOLOGICAL PROCESS

A modification to the technological process of brake disc machining was made [5]. The main purpose of the modification was to increase the productivity by changing machining parameters for three turning operations and one drilling operation (Fig. 4; Table 2) and by using tools with ceramic plates.

The machining parameters for sintered carbide tools ranged within $v_c = 200-700$ m/min and $f = 0.2 - 0.6$ mm/rev, respectively. Some of those parameters were maximal on account of the capabilities of the control systems. As a result of the modification the time of machining a brake disc was shortened by 20% on the average.

The application of ceramic plates increased the productivity by reducing the frequency of their replacement, while meeting the quality requirements for the brake discs [6].

4. CONCLUSIONS

High demand for brake discs has caused the development of production of a new generation of numerically controlled job turning lathes. Both the equipment and the tooling systems applied enable machining with high cutting parameters, which guarantees a high quality of product.

The changes applied to the technological process of brake discs significantly increased the productivity with maintenance of the precision of execution.

REFERENCES

- [1] *Podręcznik tarczy hamulcowej* (1998). (Textbook of disc brake). Brembo SpA.
- [2] Harper G. A. (1971). *A history of brakes and friction materials*, IMechE.
- [3] Baker A. K. (1986). *Vehicle braking*. Pentech Press, Londres, Plymouth.
- [4] Rhee S. K., Ducharme R. T., Spurgeon W. M. (1971). *Characterization of cast iron friction surfaces*, S.A.E. Lexington Avenue, New York, No 720056.
- [5] Podmagórski M. (2003). *Proces technologiczny tarcz hamulcowych wraz z programem na OSN* (Technological process of disc brakes with the program on CNC machine tools), Praca dyplomowa, ITMiAP Politechniki Częstochowskiej, Częstochowa.
- [6] Wolny R., Rygałło A. (2006). *Proces technologiczny obróbki tarcz hamulcowych*. (Technological process of disc brakes treatment), International Conference „Production Engineering”, Centrum Zaawansowanych Systemów Produkcyjnych, Instytut Budowy Maszyn i Automatykacji Politechniki Wrocławskiej, Oficyna Wydawnicza Politechniki Wrocławskiej, ISBN 83-7085-989-5, Wrocław.

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