THE MACHINING OF BRAKE DISCS

WOLNY, R. & RYGALLO, A.

Abstract: *In the paper constructional solutions of brake discs were presented. Technological process of their carrying out in the large-lot production was discussed. The semi-automatic seat to mechanical treatment of brake discs was characterized. The main goal of this paper was the modification and optimization of technological process of brake discs treatment. 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: *brake disc, technological process, CNC machine, modification, optimization*

Authors´ data: Dr. **Wolny**, R[yszard]; Dr. **Rygallo**, A[ndrzej], Czestochowa University of Technology, Dabrowskiego 69, 42-200 Czestochowa, Poland, rwolny@itm.pcz.pl, andryg@pro.onet.pl

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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 brake disc. At the same time, a considerable progress in the brake technology was made by Herbert Frood (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 brake discs. A year later, in 1954, the first ventilated brake disks were implemented to the *AlfaRomeo* 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 (Baker, 1986).

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). Other materials are used in special applications (Rhee et al, 1971).

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 (Pompon, 1998).

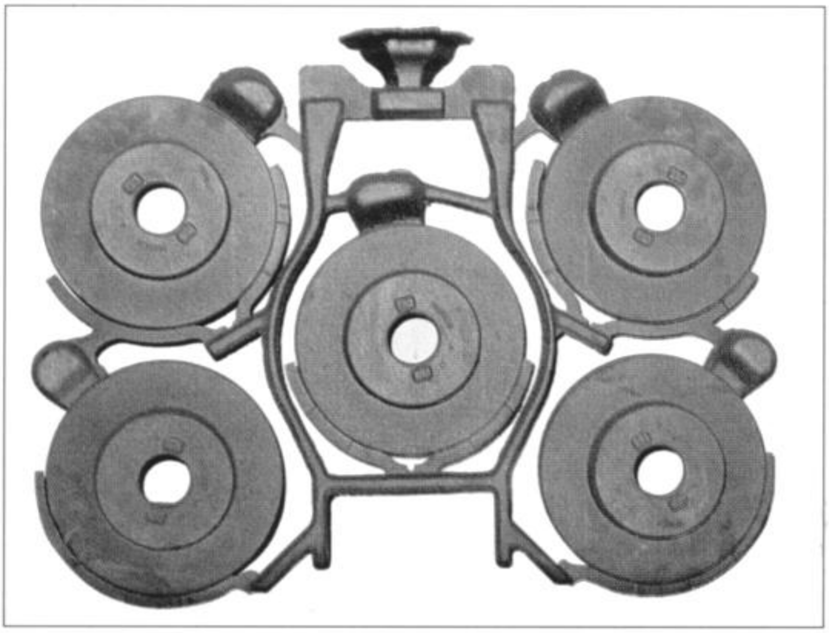


Fig. 1. Cluster casting of brake discs

Fig. 2. Casts and final shape of brake discs

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 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 (Harper, 1971). The air circulation depends largely on the shape of internal bridges, which are called “blades” (Fig. 3).

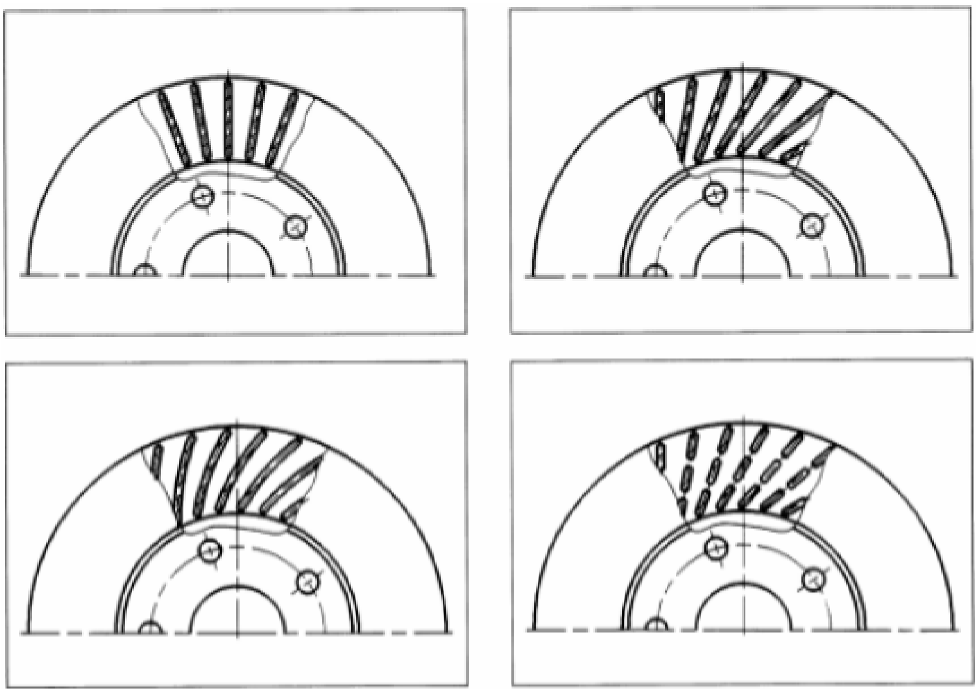


Fig. 3. Different shapes of blades of ventilated brake discs

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 twelfth thousand discs a day in a three-shift system, with hundred twenty type-sizes a month, intended both for new cars and for servicing purposes is presented.

Basic disc-shaping operations (Fig. 4) 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.

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

Tab. 1. Specification of basic operations

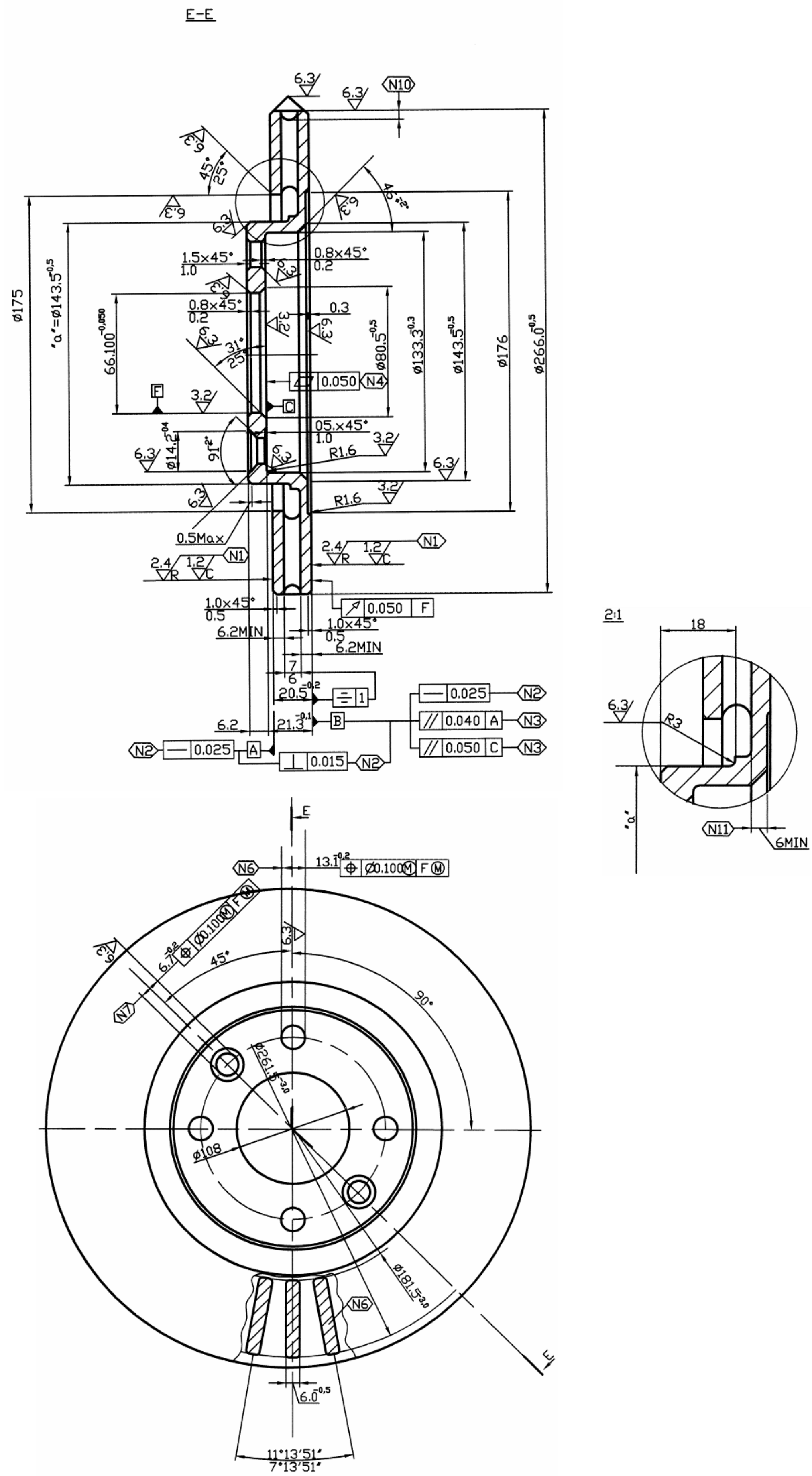
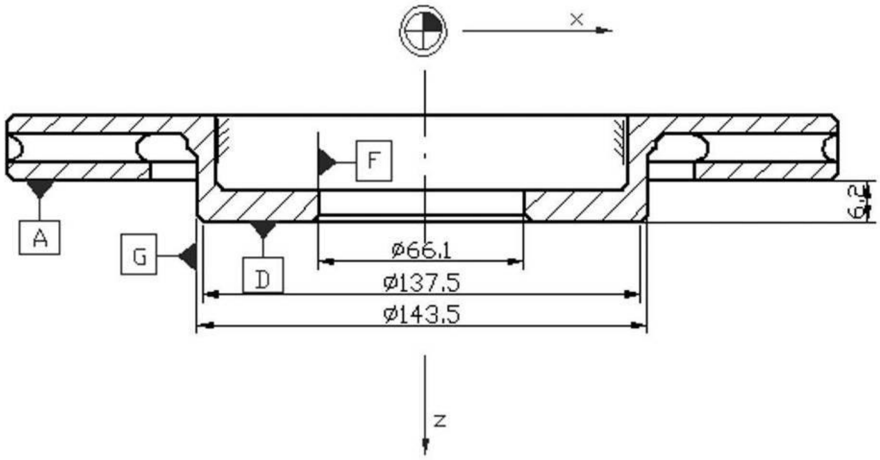
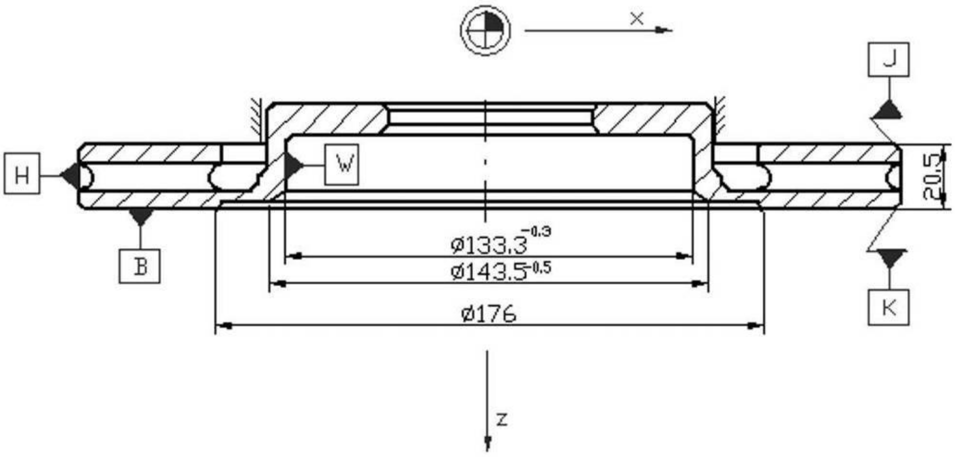


Fig. 4. The ventilated brake disc

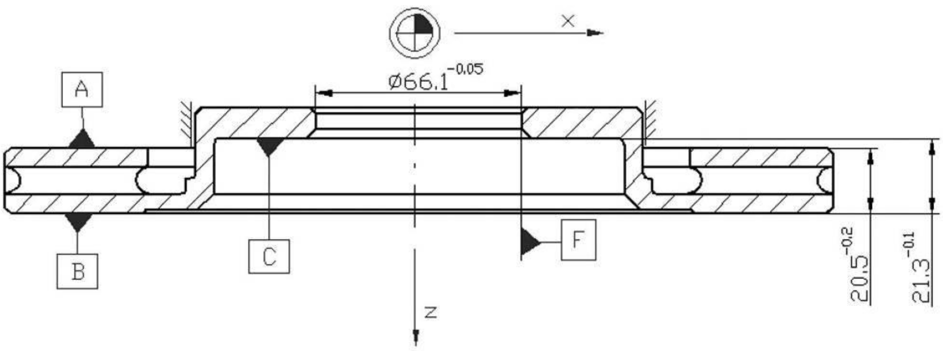
Operation 10



Operation 20



Operation 30



Operation 40

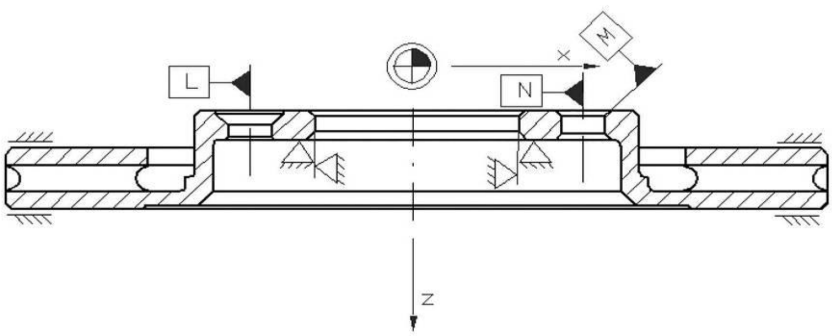


Fig. 5. The ventilated brake disc, the designation of surfaces machined, the system of axes and the characteristic points of four operations

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 work piece 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 - 24000 mm/min, and transverse (X axis) movements within a range of 1160 mm at a feed speed of 0 - 40000 mm/min.
The turning lathes are equipped with a turret of a horizontal axis of rotation with eight ø50 mm cylindrical tool sockets. The turret is controlled, as an auxiliary lathe axis, by a SINUMERIK 840C/840D control system.

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.

For all operations machine cutting parameters were optimized and changes in NC programs for lathes and borers.

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

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

Tab. 2. Specification of four operations and treatments included in the technological process of ventilated brake discs machining

3. Modification of the technological process

A modification to the technological process of ventilated brake disc machining (Fig. 4) was made (Podmagorski, 2003). The main purpose of the modification was to increase the productivity by changing machining parameters for three turning operations and one drilling operation (Fig. 5; Tab. 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 (Wolny & Rygallo, 2006).
The application of ceramic plates increased the productivity by reducing the frequency of their replacement, while meeting the quality requirements for the brake discs (Wolny & Rygallo, 2008).

4. Conclusion

The aim of this paper was achieved. Machine cutting parameters were optimized and changes in NC programs for lathes and borers were implemented. The result of the modification was the time of machining a brake discs shortened, average by 20%. The changes applied to the technological process of brake discs significantly increased the productivity with maintenance of the precision of execution.

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