Flexible Superfinishing Modules used in SME (Small and Medium Enterprises)

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Abstract: - In the paper are presented some achievements regarding the uses of flexible superfinishing modules that can be used to obtain the surface finish requirements for the products in small and medium enterprises. These modules have a range of flexibility that make them to adapt to a large sort of products and to a great range shape and dimensions of workpieces.

Key-Words: - surface finish, accuracy, flexibility, modules, small enterprises

1 Introduction
Superfinishing is the process used for improvement of machined surfaces to make them more wear resistant. It was invented in 1934 by Chrysler Corporation and it took about 40 years before gaining widespread acceptance. During grinding, extreme heat and aggressive stock removal often alters microstructure and base metal hardness, which create slight dimensional and surface imperfections such as smeared peaks, waviness and chatter. Superfinishing, a low temperature, low stock removal process, improves part geometry and surface finish by removing the amorphous layer formed during the grinding process. In this process, the main aim is to remove the bunt out layer of the surface and to correct the inequalities in geometry. This leads to even distribution of the load. It is a slow speed abrasive machining process. Only a slight amount of stock is removed (2-30 μm), which represents the surface roughness [1].

It is not a dimension-changing process, but is mainly used for producing finished surfaces of superfine quality (Fig.1).
The abrasive is either aluminium oxide widely used for steel, or silicon carbide for finishing cast iron and non-ferrous metals. Superfinishing leaves a tightly controlled cross-hatch pattern which is attained by the interaction of three interrelated motions. These are: oscillation of the stone, rotary movement of the workpiece and pressure of the abrasive tool on the workpiece. Cutting fluids in superfinishing are light mineral oil or kerosene oil together with a heavier cutting oil [2].
The superfinishing process is shown in Fig.2.

Fig.1 Gradual improving a rough surface by superfinishing.

Fig.2 Principles of superfinishing process.

$P =$ contact pressure between stone and workpiece (0,5-4,0 kg/cm²);
\[ a = \text{amplitude of stone vibration} \quad \text{max. 6 mm}; \]
\[ f = \text{number of strokes per min (about 1000-1500 cycles/min)}; \]
\[ d = \text{diameter of workpiece [mm]}; \]
\[ n = \text{R.P.M of workpiece}; \]
\[ V_s = \text{traverse speed}; \]
\[ \tan \beta = \frac{\pi dn}{af}, \text{ as angle } \beta \text{ increases, the finish improves.} \]

If the workpiece is longer than the stone, then a traverse motion is also required parallel to the axis of workpiece \( (V_s) \).

2 Examples of flexible superfinishing modules
2.1 Superfinishing attachment
Superfinishing attachment used on a centre lathe is shown in Fig.3 [3]. Main parts and operating elements of superfinishing attachment are discussed below:

![Fig.3 Superfinishing attachment.](image)

where, 1 - support bar that is clamped into the tool holder; 2 – stone guide, an air cylinder with piston, to which the stone holder is fastened; 3 – stone holder, that is fastened in the piston rod of the stone guide; 4 – stroke regulation valve, which is for regulating the oscillation stroke; 5 – stroke valve indicator that is provided with a scale showing the amplitude of oscillations; 6 – starting device; 7 – pressure reducing button; 8 – stroke regulation valve. The oscillations of this assembly are pneumatically generated and also stone force on the part surface is pneumatically generated.

2.1.1 Superfinishing attachment mounted on a grinding machine
Superfinishing attachment that is shown in Fig.3 can be mounted on a lathe, on a milling machine, or on other universal machine tools. This feature of it make it to match on to the requirements of small and medium enterprises regarding the finishing operations for the workpieces in a small and medium number of items. In Fig.4 is shown a grinding machine where was mounted a superfinishing attachment instead of grinding wheel to can machining by superfinning a gear with two cylindrical surfaces symmetrical disposed.

![Fig.4 Superfinishing attachment on a grinding machine.](image)

This superfinishing attachment on a grinding machine is working in a truck factory and is able to work all the types of this kind of gears. There are seven types of these gears with the same shape but with different dimensions. Using this arrangement it is cheaper that to buy a new machine and was used an old grinding machine to hold the part and superfinishing attachment. Time of machining is 40 seconds and the roughness average obtained is \( R_a = 0.2 \, \mu \text{m} \).

2.1.2 Superfinishing attachment mounted on a lathe.
There are some superfinishing attachments that can be mounted on lathes. The parts can have different lengths or diameters and in Fig.5 are shown some types of workpieces which can be machined on this superfinishing attachment.

![Fig.5 Types of workpieces machined on a lathe by superfinning.](image)
In Fig. 6 is shown a superfinishing attachment mounted on a lathe where the oscillations are mechanically generated and the stones pressure on the part surface is pneumatically generated. In this example the workpiece is hold between centers and the superfinishing attachment which is mounted on the traverse carriage can have a longitudinal feed to can work all the length of the part being machined.

This type of device can work with two, four or six stone guides depending on the part length, or with different stone grades to reaches the roughness requirements.

2.2 Superfinishing equipment for machining internal surfaces

To machining internal surfaces of the workpieces are used different equipments depending on their size and shapes. In Fig. 7 is presented an example of using the superfinishing method to machining the internal surfaces of the gears.

Most of the gears from the truck gear boxes need for the internal surfaces of the hub a high surface finish that can’t be obtained by grinding. After grinding is necessary to use the superfinishing equipment as is shown in Fig. 7.

The workpieces are hold in a special fixturing device on the pitch diameter by a ring with balls or pins that acts on the space teeth of the gear.

This kind of devices is able to hold spur gears and helical gears. For each type of gear is used a ring and a set of jaws which are grinding on internal surfaces to be concentric with the workpiece being machined.

Also to reduce the jaws number it is possible to make special jaws that are able to hold the workpiece by the two of their surfaces only by mounting them rotated with 180° on the chuck [4].

For each type of workpiece is used a superfinishing head with 3 stones radially disposed. The oscillations are mechanically generated and the machining time was about 30-40 seconds.

Sometimes the internal diameters of parts have small sizes, about 8-25 mm. For this kind of workpieces (Fig. 8) is necessary to use in small and medium enterprises and for small number of pieces other type of equipments.

This workpiece is a part from ignition equipment of the car engine and the internal surfaces has a diameter of 8 mm. To machining by superfinishing this type of workpiece was made an equipment that is presented in Fig. 9. In order to make this superfinishing operation in the Fig. 10 are shown two methods (I and II). One is with abrasive stone 15 fixed on the rod 16. The part has two motions, one of rotation and one is reciprocating with an amplitude size of 3-4 mm.
The abrasive stone exerts a force $F$ generated by a spring during the machining process.

Fig.9 Equipment to superfinishing internal surface of the cam.

In the second method illustrated in Fig.10 the part is fixed and all the motions are made by the tool system. These motions of the tool system are: rotation and reciprocating motion with amplitude $a = 3-5$ mm. The superfinishing operation is done with three abrasive stone with synthetic diamond symmetrical disposed.

Fig.10 Schematic illustration of superfinishing internal surface.

The internal rod 13 is acted pneumatically to can generated the pressure of abrasive stones on the internal surface of the part. Depending on the number of parts that are required was used one of these two methods. The best results were obtained with the method I [5].

2.3 Equipments to superfinishing flat surfaces

The quality of flat surfaces is a requirement of many workpieces as for gear pump pinions showed in Fig.11.

Fig.11 Gear pump pinion.

This type of workpiece has a high requirement regarding the cylindrical and flat surfaces. For achieving the quality of cylindrical surfaces it was used the superfinishing attachment showed in Fig.3. But to machining flat surfaces was designed an equipment presented in Fig.12.

Fig.12 Equipment to superfinishing flat surfaces for gear pump pinions.
This equipment is adaptable on an engine lathe mounted on the carriage. The presented method involves two working stations having the same construction. The only difference between them refers to the grit size used. For the first working station the grit size is 600 while for the second is 1200. The workpieces are fixed between centers with the centers 8. The rotary motion for the part is achieved by the following chain: lathe engine gears 11, cardan shaft 1, gear 3 that engages with the teeth of the workpiece. The cutting force is achieved by the means of the pneumatic engine 7 which has a longitudinal movement along the rods 6. In Fig.13 is shown the abrasive tool system.

![Fig.13 The abrasive tool system.](image)

The abrasive stones are fixed in the support 2 and the bolt 1. For each size of workpiece there is a type of abrasive stone that is fixed on the lever 5 of the pneumatic engine, in a square space that ensures a good position during the machining. The attachment system of the abrasive stone has two degrees of freedom, one of the turning of the lever 5 around the pin 10 and the other, given by the turning of the tool support in the lever 2. These two degrees of freedom provide a good position of the tool on the plane surfaces of the workpieces, which doesn’t depend on the accuracy of the workpieces placing between the lathe centers. In this case it is possible that the longitudinal position errors of the workpieces to be eliminated. In order to process another type of workpiece, it is only necessary to change the abrasive tool system and to make an axial adjustment, according to the length of the workpiece.

The machining time was about 35-45 seconds and the roughness average $R_a$ between 0,04 to 0,08 μm. This equipment was designed as an easy-to make equipment and it also has a great productivity.

3. Conclusions

For the small and medium enterprises where the production run is in small rates it is a problem to solve the requirements regarding the surface quality for a high range of sizes and types of workpieces which they produce. In this direction it is a good idea to use superfinishing attachments that can be mounted on the universal machine tools which exists regardless of their precision. Superfinishing attachment is used where cost-effective and rapid production methods for the fine-surface production are needed. Depending on the part count and size of the workpieces, the superfinishing attachment can easily retrofitted to a conventional grinding machine on lathe. The unit can also be integrated into a CNC system, through which the individual unit functions and process parameters can be controlled from the machine controls. Superfinishing method has a distinct advantage in improving surface finish compared with roller burnishing process, where if the peak-to-valley height is too great, the peaks can bend over and create a fish scale pattern. In addition, roller burnishing machines are very heavy, because they have to exert extremely high forces to the workpiece causing deformation. Superfinishing is a state of the art method for surface finishing in the micron range. A consistent, reproducible surface quality can be achieved and is possible to finish a great variety of materials and workpieces.

References:


