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GRINDING AND POLISHIN OF CIRCULAR STAINLESS STEEL TUBES

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ABSTRACT
This paper describes the process of grinding and polishing of circular stainless steel tubes carried out by special centerless machines. It is a machine used for grinding and polishing of stainless steel tubes made by Surface Engineering, Italian company from Milan. The machine consists of four grinding and three polishing modules.
Keywords: centreless, grinding, tube

1. INTRODUCTION

Centreless grinding process differs from other cylindrical processes in that the workpiece is not mechanically constrained. On traditional old design machines, a workpiece is either held between centers or chucked and rotated against the faster spinning grinding wheel by an external motor usually located in a workhead. Parts made using a centreless process do not require center holes, drivers or workhead fixtures. Instead, the workpiece is supported on its own outer diameter by a workblade located between a high speed grinding wheel and a slower speed regulating wheel with a smaller diameter. Centreless grinding is proper for grinding cylindrical tubes and bullion.

2. CENTERLESS GRINDING

Grinding is one of the most significant production operations within final processing, for it provides:
- highly accurate proportions
- high quality of the processed surface

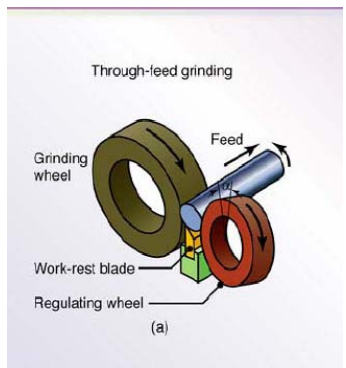

Figure 1. Schematic view of the mode of operation

Most commonly, grinding is subsequent to thermal treatment whereby it eliminates any defects caused by thermal deformations during the thermal treatment.
Centerless grinding makes it possible to quickly replace the processed parts with those to be processed. There are three main modes of centerless grinding:

1. Through-feed grinding
2. In-feed grinding
3. End-feed grinding.

Figure 1 shows the schematic view of through-feed grinding.
As the figure shows, grinding and regulating wheel rotate in the same direction, a work-rest blade being in between. When centerless grinding is concerned, regulating wheel is usually rotated for α angle that ranges from 0° to 8°. This provides the occurrence of workpiece horizontal velocity component, therefore the external mechanism for axial motion of the workpiece is needless. Owing to this axial motion, objects processed in such manner can have only circular cross-section which is constant along the whole workpiece.
During the grinding process, number of revolutions of regulating wheel is much smaller than the one of grinding wheel, and this difference regulates the number of revolutions of a workpiece and its axial motion. In order for this mode of operation to be feasible, the machine must be regulated by PLC controller whose role is to adjust both the number of revolutions and the workpiece force on grinding wheel.

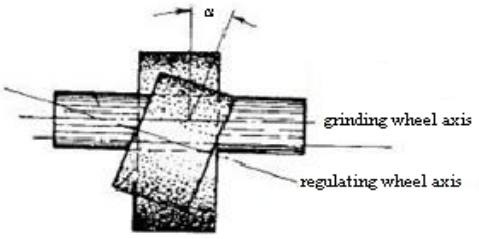

Figure 2. Schematic view of the mode of operation (side view)

During the process of centerless grinding, grinding wheel performs the main rotary motion. Secondary motion is performed by the regulating wheel, it is rotary and it provides longitudinal tube feed. The axis of grinding and regulating wheels can shift from 1 to 10 mm, as related to the axis of the workpiece. The feed of the workpiece can vary according to change in the dip angle α and periferal velocity of the regulating wheel.

$S_{workpiece} = V_r \cdot \sin\alpha = D_r \cdot \pi \cdot n_r \cdot \sin\alpha$ [mm/min], wherein:
$S_{workpiece}$– presents feed of the workpiece
V_r – periferal velocity of regulating wheel
α – dip angle of the regulating wheel in relation to grinding abrasive wheel
D_r – external diametar of the regulating wheel
n_r – number of revolutions of the regulating wheel

According to the diametar of the workpiece, two parameters of the operation mode are accepted: space between the grinding and regulating wheels, and change in the height of longitudinal work-rest blade. During the tube grinding process on the special centerless machine, grinding wheel is wrapped with changeable grinding (abrasive) band which is replaced after being worn out. Polishing process is similar in character to the grinding one, the only difference being that a special brush with a layer of polish pasta is used as a polishing tool in the former.

3. MACHINE FOR GRINDING AND POLISHING OF CIRCULAR STAINLESS STEEL TUBES

The machine is a product of the Italian company *Surface Engineering* from Milan, and it is the result of long time experience and cooperation with *Siemens* company. Figure 3 shows the entire machine.

The machine for grinding and polishing of stainless steel tubes comprises a set of several minor machines – modules. The total nominal output of the machine is 80kW and it requires constant water supply of 2 bars water pressure for its functioning. The total machine length is 21m and it functions with the assistance of a crane whose lifting capacity amounts to 10t. It is mounted in a machine hall, and its role is to transfer raw material (unmachined tubes) and ready made products.

The machine consists of an infeed, four grinding modules, three polishing modules and a part for authomatic packaging of machined tubes into polyethylene foil. The assembled machine is controled by PLC *Siemens* company. It is the machine construction that enables shutting down some of its parts (according to circumstances or due to a failure/maintenance), which provides maximum working efficiency of the machine.

The infeed is on the tube entrance into the machine, and it provides the entrance of the tubes 100mm – 6000mm long. Most commonly, 6000mm long tubes are utilized. The infeed is completely automatized and its maximum load is 2t, wherein the number of tubes it can receive depends on the diameters and thickness. The diameter of tubes varies between 10mm and 220mm.

Figure 3. The entire machine for grinding and polishing of circular stainless steel tubes

The grinding modules ST 220 (Figures 4 and 5) are the first in the technological procedure of pipe grinding and polishing. All the grinding modules are identical, however the power within particular

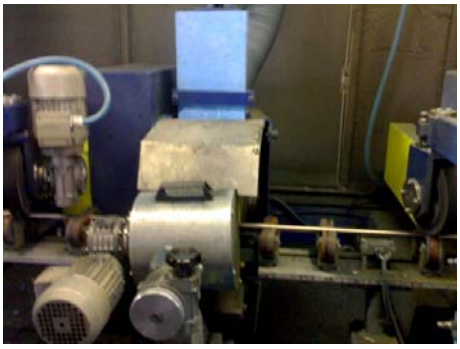

Figure 4. Interior of the ST220 module

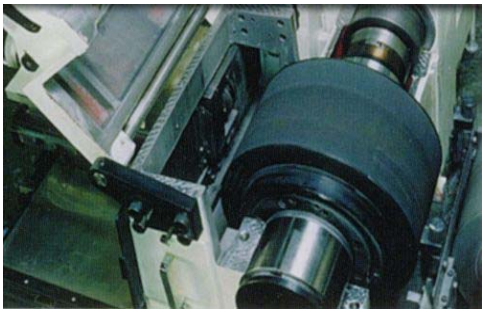

Figure 5. Grinding wheel inside the grinding module

modules varies, i.e. 17kW, 13kW, 10kW and 7kW. The first grinding module exerts the greatest power. Each of the modules may vary in the number of revolutions of the grinding wheel, within the range of 1500o/min to 3000o/min, which is governed by the PLC. The fineness of the abrasive bands of the grinding wheels also varies among modules. The fineness of the abrasive band of the first module is the lowest (400), and it grows with bands that follow, i.e. 600, 800 and 1000.
Artificial materials, such as aluminium oxide, silicon carbide, cubic boron nitride and diamond are most commonly used for the production of grinding (abrasive) bands. For the different purposes, the ST 220 uses CBN (cubic boron nitride) and PCD (artificial diamond)-based bands produced by *Klingspor*.

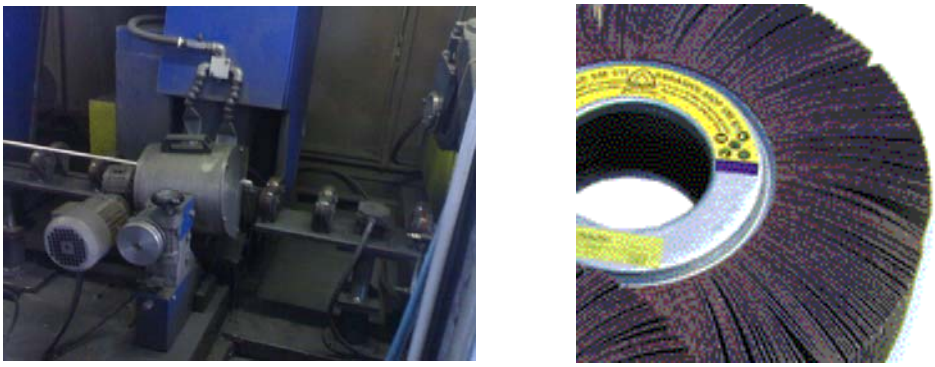

Figure 6. Interior of the PT 150 module (left)and polishing brushes (right)

Having being worked in grinding modules, tubes enter the polishing modules, the PT 150 type (Fig. 6). All the modules are identical, nonetheless they exhibit different power, i.e. 7kW, 5kW and 3kW. Within each module, polishing brushes can have different number of revolutions (100 o/min – 300 o/min), which is regulated by the PLC. The fineness of the polish paste in each of the modules is 1200, 1400 and 1600. Brushes and pastes are combined, depending on quality requirements (high, moderate or low pipe finish).
Subsequent to the above phase, tubes are automatically placed into a special carrier. They are then transferred by an automatic packaging machine into the 70μm thick polyethylene foil, whereupon these are considered as final products. The entire process of tube engineering can include finishing of maxiumum 25 tubes per hour, whereby the actual speed is approximately 10 tubes per hour, since the speed of the process depends on quality requirements. The materials used in the process (grinding bands, polishing brushes and polish pastes) are produced by the *Klingspor* and *3M*.

4.CONSLUSION

The paper presents the process of grinding and polishing of 6000 mm long stainless steel tubes worked on a special machine produced by the company *Surface Engineering* from Milan. This process is carried out on a complex machine comprising four grinding and three polishing modules. Each of the modules ensures higher quality of the processed surface. Depending on quality requirements, some of the modules can be excluded.
This is the latest method of tube processing. It is highly productive, and it ensures high quality and accuracy of the processed surface.

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