GRINDING MACHINERY AND METHODS

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ABSTRACT

A grinding machine for grinding the external and internal surfaces of a workpiece, comprising a grinding wheel which is rotated about its axis and moved to simultaneously contact a first cutter wheel rotating about its axis and a workpiece rotating about its axis, such that the axis of the workpiece and the axis of the cutter wheel lie in substantially the same vertical plane and are spaced less than 180° from each other about the circumference of the first grinding wheel. The apparatus may also include a second grinding wheel which is adapted to be rotated and moved to operate on the internal surface of the workpiece or to contact a second cutter wheel.

7 Claims, 6 Drawing Figures
3,646,708

1 GRINDING MACHINERY AND METHODS

This application is a division of my application Ser. No. 607,957, filed Jan. 9, 1967 now U.S. Pat. No. 3,524,283.

This invention relates to grinding machinery for grinding surfaces of substantially cylindrical or substantially cylindrical hollow workpieces.

This invention is particularly useful for simultaneously forming grinding the inside diameter and the outside diameter of either inner race rings or outer race rings of ball bearings. However, this invention is not confined to grinding ball bearing rings since the disclosure herein is equally applicable to the grinding of cylindrical surfaces or rings for any purpose.

This invention also provides for truing or dressing the inside or outside diameter grinding means by cutter means positioned such that compensation need not be provided to take into account the material removed from the grinding means during truing.

In the past, the geometric relationship of the grinding wheel, the dressing means and the workpiece was such that extreme accuracy in truing feed movement was necessary to produce the correct work size. In prior art grinding and dressing machines in which dressing takes place on the opposite side of the grinding wheel from that used in grinding, it is also necessary to compensate for the material removed from the grinder by the dresser as well as to compensate for the thermal changes encountered in the operation of the machinery. These disadvantages of the prior art not only resulted in manufacturing quality control problems, but also increased the costs in operating such machines because of waste and setup time required.

In view of the foregoing, applicant has provided a new and improved grinding machine, which provides significant advantages over the prior art. Particularly, the geometric relationship of the grinding wheel, the dresser and the work are such that means for compensating for the material removed from the grinder during truing is no longer required. Additionally, the accuracy of the work is insured by utilizing the dresser or cutter to control the size of the workpiece being ground.

Accordingly, it is an object of this invention to provide a new and improved grinding machine and method for grinding the outside diameter of a substantially cylindrical workpiece.

Another object of this invention is to provide a new and improved grinding machine and method for grinding the outside diameter of a substantially cylindrical workpiece.

A further object of this invention is to provide a grinding machine in which the grinding wheel, a rotating dresser and the work are positioned in geometric relationship, such that the position of the dresser sets the work size.

Still other objects and advantages of the invention will in part be obvious and in part will be apparent from the specification.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others and the apparatus embodying features of construction, combination of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference is had to the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a top view of a grinding machine according to this invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a view similar to FIG. 3, showing the position of the parts of the machine in a different relationship than that shown in FIG. 3;

FIG. 5 is a schematic view taken along line 5—5 of FIG. 1;

and

FIG. 6 is an example shown schematically of means for controlling the hydraulic system according to the invention.

Referring now to FIGS. 1—5, there is shown according to the invention a frame 10 on which is mounted a headstock 11 driven by a motor 12 through a belt and pulley system generally shown at 13. A rotating spindle portion 14 of the headstock 11 supports a workpiece shown at 15, such as a ring for a ball bearing. A hydraulically actuated precision tool 16 is shown at 17. The pressure plate is controlled by pistons shown at 18 and 19. The plate 17 is mounted on antifriction bearings shown at 20 and is adapted by the action of pistons 18 and 19 to force the workpiece 15 against the spindle nose 14. There is also provided a hydraulic cylinder 23 for moving a tapered plunger 24 carried within the headstock spindle 14 for locating the work concentrically on the driving ring of the spindle prior to clamping by the pressure plate 17. The head of the plunger 24 enters the interior of the inner diameter portion of the workpiece and centers it, such that the pressure plate 17 may be used to clamp the workpiece against the spindle ring shown at 14a.

The workpiece 15 may be supplied to the grinding machine by an indexing plate which carries the workpieces from a feed chute to a position adjacent to the headstock driving ring and after they have been ground carries the finished rings to the discharge chute. The type of indexing plate which may be used is of the Geneva type which has been used in the past on machine tools and/or grinding machines. It will be understood that the workpiece may be inserted by hand, if desired.

There is shown at 30 a slide which carries a motor 31 for driving a spindle 32 carrying an inside diameter grinding wheel 33. The slide 30 is moved axially by the provision of a hydraulic cylinder 35 having a piston 36. By the action of the piston 36 the grinding wheel 33 may be moved axially with respect to the workpiece in order to position it for grinding the inside diameter of the workpiece 15. For positioning the grinding wheel 33 in the proper axial position relative to a rotating cutter or dressing wheel 39 the slide 30 is moved in the opposite direction. The dressing wheel 39 is also supported in a slide 40 and is movable by a handcrank 40a so that it may move inwardly or outwardly from the internal diameter grinding wheel 33. The dressing wheel 39 is driven by a motor 41 through a belt and pulley arrangement 41a. The belt is held taut by the provision of a spring-loaded mechanism shown at 42.

As may also be seen, the slide 30 is mounted on a second slideable member 45 which may be positioned by a handcrank 46, such that the grinding wheel 33 may be moved radially with respect to the workpiece 15 or radially with respect to the dressing wheel 39.

As may also be seen in FIGS. 1 and 2, a slide 50 is provided for supporting an external grinding wheel 51 which is driven by a motor 53 through a belt and pulley arrangement shown at 54. The slide 50 is arranged to be fed radially with respect to the work to provide infed for grinding the outside diameter of the workpiece 15. This is accomplished by the provision of a screw 55 which may be rotated manually.

As may be clearly seen in FIGS. 1 and 2, there is provided a truing wheel 60 mounted on a spindle 61 and driven through the belt and pulley arrangement 41a by the motor 41. The wheel 60 is preferably of diamond material and is mounted on a slide 65 which is also moved by an adjustable screw 66, such that it may be moved radially toward or away from the grinding wheel 51.

As may be more particularly seen in FIG. 5, the workpiece 15 and the dressing wheel 60 are positioned with respect to the circumference of the grinding wheel 51, such that they are both on the same side of grinding wheel 51. The axis of the supporting spindle for the workpiece, as well as the axis for the dressing wheel, lie preferably in the vertical plane and are separated by an arc of less than 180° and preferably less than an arc of 45°, along the outside circumference of grinding wheel 51.

In the preferred embodiment, the center of the work-holding spindle is preferably placed approximately 2 inches above the horizontal axis of the external grinding wheel 51, whereas the center of the rotating diamond cutter 60, used for truing
the external wheel 51, is placed an equal distance below the horizontal axis of the external grinding wheel 51. The axes of the work spindle and the rotating diamond cutter 60 spindle preferably are the same or radial and parallel to the axes of the grinding wheels 51 and 33. This particular geometric arrangement of components provides some unique advantages. It brings the outside diameter of the rotating diamond cutter 60 and the outside diameter of the finished workpiece in contact with the periphery of the external grinding wheel at the same time, regardless of the size of the grinding wheel. Thus the size of the outside diameter of the finished workpiece is controlled by the position of the rotating diamond cutter provided with outside diameter of the grinding wheel is advanced until it contacts the outside diameter of the cutter.

The preferred method for utilizing the outside diameter grinding wheel 51 is as follows. The external slide 50 and the wheel 51 are advanced to a fixed stop position. The fixed stop is provided by a stop shown at 70 which engages an adjustable stop member 71 supported on the slide 50. A series of workpieces are then ground, the exact number having been determined by experience to be a practical number of parts to grind before redressing the wheel. After the predetermined number of pieces has been ground, the stop member 71 is adjusted to allow the slide 50 to advance approximately an extra 0.001 inches on the next infed cycle. Near the end of this next infed cycle, when the first workpiece encountered has been ground to size, the outside diameter of the grinding wheel will contact the outside diameter of the rotating diamond cutter 60 and about 0.001 inches of grinding grit and bond will be removed from the outside diameter of the grinding wheel, thereby exposing a new layer of freshly dressed grinding crystals. No more material will be removed from the workpiece during the final 0.001 infed of the wheel 51. The machine will again be operated a predetermined number of grinding cycles and the wheel slide 50 will be permitted to advance to a new position by adjustment of stop 71 to redress the grinding wheel 51 on the next cycle. It should be noted that after the wheel 51 has been trued and the next workpiece is ground, the grinding wheel will just contact the cutter as it reaches the end of its stroke.

This system of controlling work size by proper placement of the wheel truing means has been accomplished herein by the use of a rotating dresser 60 engaging a rotating grinding wheel 51, said dresser and wheel rotating in opposite directions and the provision of a workpiece-holding spindle which rotates the workpiece 15 in the opposite direction to the rotation of the wheel 51. In order to dress or true the internal grinding wheel 33, it is withdrawn by the movement of the slide 30, such that it is directly opposite the dressing wheel 39. Thereafter, the slide 40 positions the dressing wheel 39 to engage the grinding wheel 33. Additionally, by the provision of a fixed stop 81 and a mating adjustable stop 82 mounted on the screw 46, the grinding wheel may be fed into the work to a fixed position during the grinding operation or into the cutter 39 to the same fixed stop in final position for wheel truing or dressing. In practice, when the grinding wheel 33 is to be trued, stop 81 controlling the final infed position of the internal grinding wheel 33 is preferably adjusted approximately 0.001 inches by adjustment of movable stop 82 with respect to the fixed stop 81. In this manner the cutter 39 will remove approximately 0.001 inches from the outside radius of the grinding wheel 33 and the axis of the grinding wheel and its spindle will occupy a new position during both grinding and truing, which is removed from its previous position by the aforementioned 0.001 inches of feed. However, the working surface of the wheel will be in exactly the same position while grinding the next series of workpieces as it was before being trued or dressed.

As may be seen in FIG. 3, the inside diameter grinding wheel 33 and the outside diameter grinding wheel 51 are positioned to engage the workpiece 15. FIG. 4 shows the inside diameter grinding wheel 33 axially moved to engage the dressing wheel 39 and the grinding wheel 51 is moved radially as the workpiece 15 is removed and replaced by the next workpiece within the spindle and pressure plate arrangement. Referring now to FIG. 6, there is shown in schematic form an arrangement which may be used for operating the hydraulic cylinders 18, 19, 23 and 25. At 90 there is provided a source of fluid which is pumped to a cylinder 91 by a pump 92. The flow of fluid into the cylinder is controlled by a valve 94 having a movable spool 95 which is responsive to the position of a cam follower 96 and a cam 97. By the use of a plurality of cams, the movements of the slides controlled by cylinders 18, 19, 23 and 35, may be controlled in a predetermined sequence. It should be understood that other hydraulic control systems well known in the prior art could also be used to control the aforementioned cylinders.

It will thus be seen that the objects set forth above, among others, have been accomplished by the invention described herein in which the manner and method of making the invention may best be understood when the following claims are considered in connection with the accompanying drawings.

What is claimed is:
1. A grinding machine comprising a grinding wheel, a cutter wheel, and means for supporting a workpiece for rotation about an axis, the axis of rotation of the grinding wheel, the cutter wheel and the means for supporting the workpiece all lying in parallel horizontal planes and the axis of rotation of the cutter wheel and the means for supporting a workpiece lying in substantially the same vertical plane, said vertical plane passing through the horizontal plane of the axis of the grinding wheel and offset from the axis of the grinding wheel, means for positioning the grinding wheel in a single direction to engage both the cutter wheel and the workpiece supported by said means.
2. In a grinding machine comprising a grinding wheel, means for rotating the grinding wheel about its axis, a cutter wheel, means for rotating the cutter wheel about its axis, first means for supporting and rotating a grinding wheel and said first means spaced less than 180° apart from each other being the circumference of said grinding wheel, and means for positioning the grinding wheel in a single direction to engage both the cutter wheel and the workpiece.
3. In a machine according to claim 2, including stop means for setting the position of said grinding wheel with respect to said cutter wheel and said first means.
4. In a machine according to claim 2, wherein said cutter wheel axis and the axis of rotation of said first means are equidistant from a plane passing through the axis of rotation of said grinding wheel.
5. The method of grinding the outside diameter of a plurality of cylindrical workpieces with a rotating grinding wheel which is trued by a rotating cutter wheel, said workpieces and said cutter wheel positioned with respect to the grinding wheel such that when the grinding wheel is moved in a single direction it may engage both the cutter wheel and the workpiece, which comprises rotating the workpiece and advancing the grinding wheel in a single direction to engage the workpiece and then the cutter wheel, whereby the grinding wheel grinds the workpiece and is then trued by the cutter wheel.
6. The method according to claim 5, in which the advance of the grinding wheel is stopped after it has traveled a predetermined distance toward the cutter wheel.
5. A grinding machine for grinding the surface of a workpiece, comprising a first grinding wheel, first means for rotating said first grinding wheel, a first cutter wheel, second means for rotating and moving said cutter wheel, third means for supporting said workpiece, fourth means for moving said first grinding wheel independently of said second and third means, such that its axis lies in substantially the same horizontal plane during said movement so as to be capable of simultaneously engaging said first cutter wheel and said workpiece, wherein said workpiece and said first cutter wheel are positioned at less than a 180° angle about said first grinding wheel whereby their axes lie in substantially the same vertical plane, and further including stop means for setting the position of said first grinding wheel with respect to said first cutter wheel and said third means.
It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Title Page, under the heading "Related U.S. Application Data", "607,957" should read -- 607,956 --; Column 1, line 3, "607,957" should read -- 607,956 --.

Signed and sealed this 4th day of July 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCALK
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