

[54] **PROCESS FOR SURFACE FINISHING OF METALS**

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References Cited

UNITED STATES PATENTS

3,055,102 9/1962 Shaw et al. 29/DIG. 11

3,157,093 11/1964 Shaw et al. 29/557 X
3,168,004 2/1965 Zavodny, Jr. et al. 90/24
3,430,477 3/1969 Breyer 72/275

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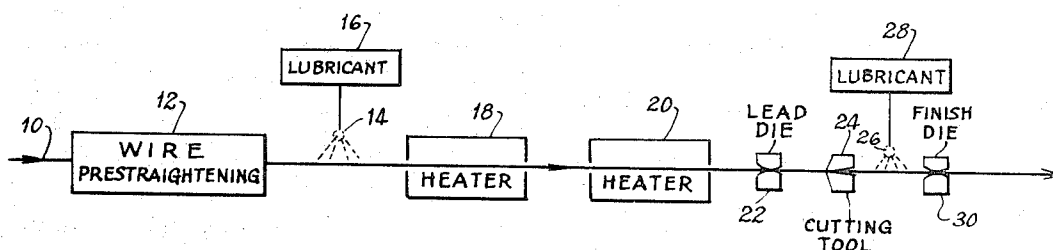
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[57]

ABSTRACT

A process for the surface finishing of metal in which a metal workpiece of repeating cross-section coated with a lubricant and heated at an elevated temperature is passed through a tandem assembly of a lead die, a cutting tool to remove surface metal, and a finish die to provide a finished workpiece having improved surface characteristics and improved mechanical and physical properties.

14 Claims, 2 Drawing Figures



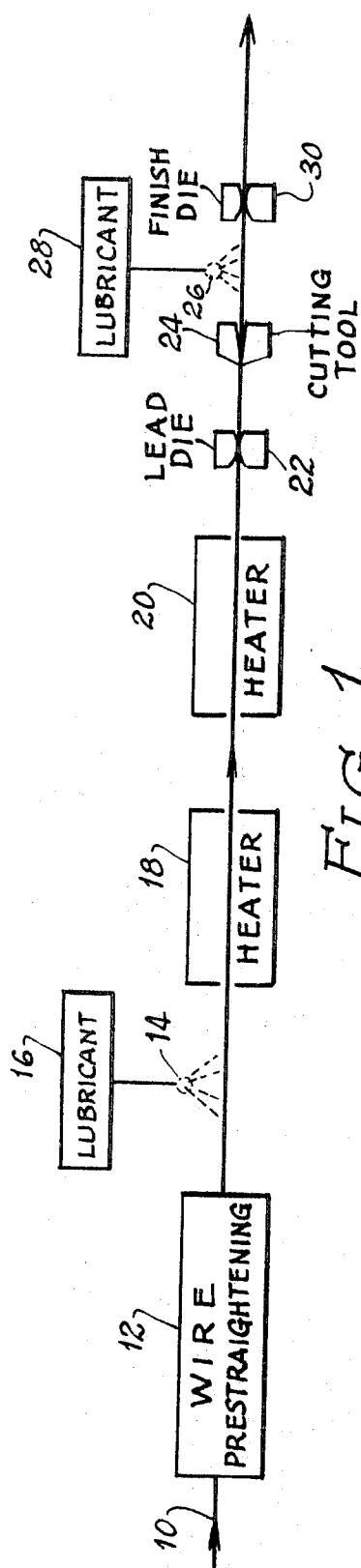


FIG. 1

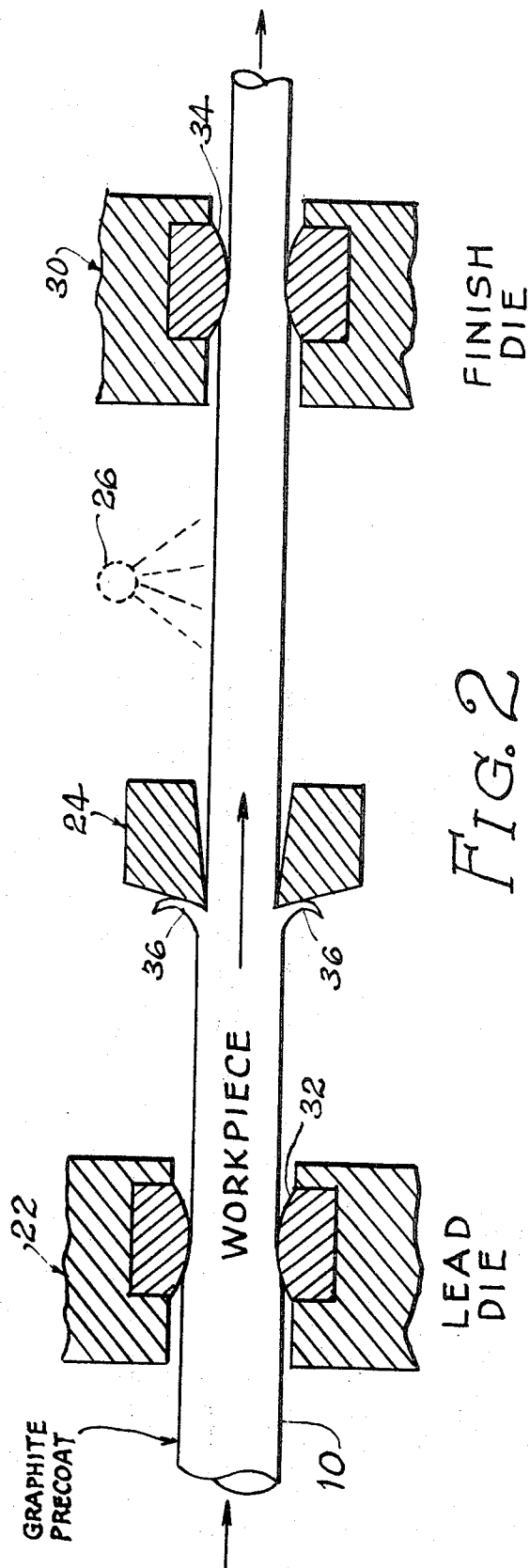


FIG. 2

PROCESS FOR SURFACE FINISHING OF METALS

This invention relates to the cold finishing of metals, and more particularly, to the simultaneous surface removal and warm or hot drawing of wire, bars, rods and like metal structures of repeating cross-section in long lengths.

In many cold finishing processes, it is desirable to remove unwanted metal from the surface of the workpiece prior to processing of the workpiece in a cold finishing operation.

The tandem arrangement of a lead die, cutter and the finish die as described by Shaw in U.S. Pat. No. 3,157,093 has some desirable characteristics. However, it has been found that with a great number of metals, as represented by hot rolled carbon and alloy steels, tool steels, and/or any strain-hardened metals, the material being removed by the cutter builds up on the cutting edge and this built-up edge replaces the tool as the cutter of the material. The built-up edge represents workpiece material that has become strain hardened by the work performed in the removal of the chip. The built-up edge appears to become welded to the cutting edge in such a manner that it is the built-up edge that does the shaving of the softer workpiece material. Because of the built-up edge formation on the cutting edge, it is difficult to hold dimensional stability of the workpiece. In addition, pieces of the built-up edge will periodically leave the cutter and remain welded onto the workpiece surface. As a result, an undesirable product having poor surface finish and poor dimensional characteristics is often obtained both before and after the workpiece is drawn through the subsequent drawing die. Furthermore, the welded pieces of the built-up edge which periodically leave the cutter can cause failure of the subsequent drawing die.

This problem has been faced by Zavodny et al. in U.S. Pat. No. 3,168,004. Zavodny used heat to soften the metal in order to avoid or minimize the strain hardness which otherwise is normally introduced into the metal being removed by the cutting operation. However, the metal removal process as described by Zavodny et al. in U.S. Pat. No. 3,168,004 employs only one tool, a cutter. In actual operation, the hot roll workpiece is passed through the cutter without any additional support from draw dies in front of or in back of the cutter. Furthermore, the workpiece is normally hot roll material with non-symmetric cross-section (due to hot mill tolerances, hot roll is normally out-of-round) which requires that a non-uniform depth of cut be taken in order to remove all of the surface defects that may be present in the hot roll material. All of these factors, i.e. lack of additional support of the workpiece, non-uniform depth of cut and non-uniform cutting forces, leave room for further improvement in the stability of the process, cutter life and off-center cutting condition.

It is accordingly an object of the present invention to provide a process for metal finishing which is capable of the removal of undesirable surface imperfections of wires, bars, rods and the like while simultaneously improving the physical and mechanical properties of such workpieces.

It is a related object of the invention to provide a metal finishing process for the removal of surface imperfections which is capable of providing improved

cutting stability and uniformity and improved surface finish with closer tolerances and minimum scrap.

It is a further object of the invention to provide a process for metal finishing in which the cutter life is significantly improved.

These and other objects and advantages of the invention will appear more fully hereinafter and, for purposes of illustration and not of limitation, an embodiment of the invention is shown in the accompanying drawings in which:

FIG. 1 is a schematic illustration of the process of the invention; and

FIG. 2 is a schematic detailed view of the tools used in the process illustrated in FIG. 1.

The concepts of the present invention reside in a process for metal finishing in which a wire, bar, coil, rod or similar elongated workpiece of repeating cross-section coated with a lubricant and heated is subjected to simultaneous warm or hot drawing and metal removal operations. The working and metal removal are carried out by passing the hot, lubricated workpiece through a lead or draw die which serves to round or size the hot or warm workpiece to guide and support the workpiece, and to impart improved physical and mechanical properties to the workpiece.

After passage through the lead die, the workpiece is passed through a cutting or shaving tool which circumscribes the workpiece to effect removal of surface metal to eliminate surface imperfections. After passage through the cutting tool, the workpiece is again coated with a lubricant and passed through a finishing die to size and polish the workpiece.

It has been found that workpieces processed in accordance with the practice of the invention have substantially improved surface finishes as well as improved mechanical and physical properties. In addition, the stability and uniformity of the cutting or shaving operation is substantially improved, with essentially no off-center cutting, to provide closer tolerances, improved tool life and minimum scrap.

Referring now to the drawings, there is shown in FIG. 1 a schematic diagram illustrating the process of the invention as applied in the processing of wire, it being understood that other metal workpiece having a repeating cross-section are similarly processed. A wire 10 from a spool or the like (not shown in the drawing) is first passed through a prestraightener, if desired, and is then coated with the lubricant, as by spraying with a nozzle 14 connected to a source of lubricant 16.

The lubricant found to provide best results in the practice of the present invention for processing steel is a dispersion of graphite in water or other suitable liquid medium. The lubricant is applied in an amount sufficient to form a coating on the workpiece 10.

Following application of the lubricant, the workpiece is heated to an elevated temperature to remove the water or other inert liquid medium of the lubricant to form a fine graphite lubricant coating on the workpiece and to elevate the temperature of the workpiece to the initial working temperature. The workpiece is normally heated to a temperature in excess of 250° F. but below the lower critical temperature of the metal for steel workpieces. As will be appreciated by those skilled in the art, the sequence of lubrication and heating shown in FIG. 1 can be reversed with the step of heating followed by lubrication to produce a hot, lubricant-coated workpiece.

Thereafter, the warm or hot wire having the fine graphite coating on the surface is passed through the lead die 22 which can be a conventional die formed of a support and a nib 32. As indicated above, the lead die 22 not only supports the workpiece for subsequent processing, but also serves to round and size the warm or hot workpiece and impart desirable properties to the workpiece.

Rounding and sizing of the workpiece is advantageous for at least two reasons. First, because all commercial hot-rolled rod or wire exhibit some out-of-roundness and because the surface defects are most frequently located on the workpiece about the periphery of the cross-section, rounding and sizing minimize the scrap generated and insure removal of all defects. For example, if a workpiece had an oval or elliptical cross-section, without rounding and sizing the cutting or shaving tool would have to be dimensioned to remove the necessary amount of metal from the minor axis of the ellipse, thereby resulting in the removal of excess metal from the major axis of the workpiece and excess scrap.

Secondly, it has been found that rounding and sizing provides improved tool life of the cutting or shaving tool. Because the feed affects tool life, control in the depth of cut results in uniform wear on the circumference of the cutting or shaving tool and substantially minimizes premature failure of the cutting tool due to non-uniform loading of the cutting tool.

It has been found that the guiding function of the lead die insures that, once the workpiece is round, surface removal by the cutting or shaving tool occurs coaxially with the workpiece, thereby providing more complete surface defect elimination. In addition to its function as a guide, the lead die also serves to remove kinks and sharp bends from the workpiece by reason of the working of the metal workpiece in the die and the tension exerted on the workpiece by the die.

The lead die also serves to impart improved mechanical and physical properties to the workpiece by the plastic deformation of the workpiece in the die.

After passage through the lead die, the warm or hot workpiece is then advanced through a cutting or shaving tool 24 which operates to remove undesirable surface defects, such as seams, laps, slivers and decarburization from the workpiece. As is shown more clearly in FIG. 2 of the drawing, the cutting tool 24 completely encircles the workpiece for removal of a surface layer or chip 36 from the workpiece.

It is important to the practice of the present invention that the temperature of the workpiece, or at least the metal to be removed be at a temperature above 250°F but below the lower critical temperature of the metal for steel workpieces, and that the temperature of the metal to be removed be near or within the hot working temperature during removal of the metal to prevent or minimize the build-up of strain hardened metal on the shaving edge of the cutting or shaving tool. The additional heat required to raise the metal being removed to a temperature near or preferably within the hot working region of the metal is conveniently supplied by the work performed during removal of surface metal from the workpiece.

As will be appreciated by those skilled in the art, the heat build-up supplied by work performed depends upon the linear rate at which the workpiece is advanced through the shaving tool. Depending upon the

amount of heat supplied by the heating means 18 and 20, it has been found that linear speeds of 10 to 350 feet/minute are sufficient to provide the necessary heat to raise the temperature of the metal being removed hear or within the working region for the metal.

The geometry of the cutting or shaving tool is important. For best results, use is preferably made of a tool having a rake angle of +20° to -20° and a clearance angle of +15° to -15°.

After passage through the cutting tool 24, the workpiece 10 is again sprayed with a graphite-water dispersion lubricant by way of sprayer 26 to again coat the surface of the workpiece with graphite. Because the workpiece is at an elevated temperature, the workpiece is again coated with fine graphite which serves as a lubricant during subsequent processing. Application of the lubricant to the workpiece immediately after passage through the cutting tool 24 also serves to cool the workpiece and substantially eliminate undesirable oxide formation on the surface of the workpiece which would otherwise form as a result of the high temperature of the workpiece.

The workpiece having the thin graphite coating thereon is then passed through a finish die which serves to guide the workpiece, size and polish the workpiece and impart the finish properties to the workpiece. The guiding function is similar to that of the lead die. Thus, the lead and finish dies support the workpiece such that it is maintained coaxial with the cutting tool to insure a uniform depth of cut and an improved tool life.

The finish die is a reduction die and imparts the dimensions of the final product. The finish die also serves to polish the workpiece and contributes to the working of the heated workpiece to provide an increase in mechanical and physical properties, such as tensile strength, yield strength and hardness.

The foregoing tools can be conveniently mounted on a suitable holding fixture for attachment to a wire drawing block, a drawbench or the like. It is important that proper spacing be maintained between (a) the lead die 22 and the cutting tool 24, and (b) the cutting tool 24 and the finish die 30. As will be appreciated by those skilled in the art, the precise distances depend on the grade, size and percent reduction of each tool. For most applications, a distance of 2 to 30 inches between the lead die and the cutting tool, and a distance of 2 to 30 inches between the cutting tool and the finish die, provide the best results.

The concepts of the present invention are applicable to a variety of metals, and particularly strain hardened steels such as hot rolled carbon steels, hot rolled alloy steels, tool steels and the like. It has been found that the process of the invention is particularly well suited for the finishing of patent wire to provide a significantly improved surface finish.

Having described the basic concepts of the invention, reference is made to the following example which is provided by way of illustration, and not of limitation, of the practice of the invention.

EXAMPLE

This example illustrates the surface finishing of C-1041 steel cold heading wire in accordance with the process described in this invention.

One coil of hot rolled wire (Heat No. 60L424) was employed. This coil had a diameter of 7/16 inch (0.431

inch $\pm 10 \times 10^{-3}$) and the following chemical analysis: (%)

C	Mg	P	S	Si	Cr	Ni
0.36	1.5	0.012	0.021	0.19	0.10	0.10

Inspection of this coil revealed that it had maximum partial decarburization of 0.003 inches, intermittent seams less than 0.004 inches in depth and the following mechanical properties:

Tensile	Yield	Elongation	Red. of Area
105,000 psi	59,000 psi	27.5%	66%

This sample was coated with water-graphite lubricant prior to passage through a pair of induction heating coils as shown in FIG. 1. During heating the water evaporated, leaving a fine graphite coating on the workpiece. The graphite coated wire is then passed through a tandem assembly of a lead die, a cutter and finish die (see FIG. 1) at a speed of 120 feet per minute at a temperature of $800^{\circ}\text{F} \pm 25^{\circ}\text{F}$. The cutting tool had a 5° rake angle and a 5° clearance angle. The die sizes were as follows:

Lead die	0.405/.406
Cutter	0.391/.392
Finish die	0.374/.375

The finished product had the following characteristics:

Seams and Decarburization	None
Finish Size	0.375 $\pm$ 0.000
Hardness	- 0.002
Microfinish	30 to 32 Rc
	Less than 15 μ -inches

This coil broached normally and the finished product was free of surface defects such as barber-poling and tearing or fish scaling. The mechanical properties were as follows:

Tensile	Yield	Elongation	Red. of Area
151,000 psi	128,000 psi	7%	42%

In addition, the workpieces treated in accordance with the present invention have been found to have improved formability. Formability can be determined by subjecting a sample of the treated workpiece to compression whereby the formability can be expressed as the ratio of the initial height of the sample to the final height of the sample.

While not equivalent to the practice of the invention as described above, it has been found that it is possible, and sometimes desirable, to employ the cutting tool used in the practice of the invention in combination with one of a lead die or a finish die. In the practice of this concept the die through which the workpiece is advanced is either in advance of or subsequent to the cutting tool, and serves to work the workpiece and impart thereto improved mechanical and physical properties, and serves to guide the workpiece for advancement through the cutting tool.

Whether the die precedes or follows the cutting tool, it is preferable to apply lubricant to the workpiece before passage through the cutting tool as illustrated in FIG. 1.

It will be apparent that various changes and modifications can be made in the details of procedure and use without departing from the spirit of the invention, especially as defined in the following claims.

We claim:

1. A process for the surface finishing of metals comprising the steps of passing a metal workpiece of repeating cross-section coated with a lubricant and heated to a temperature in excess of 250°F through a first die to size and work the workpiece, passing the workpiece through a cutting tool to effect removal of surface metal from the workpiece with the temperature of the metal being removed being near the hot work region of the metal, applying a lubricant to the workpiece to form a coating thereon, and passing the workpiece through a second die to work the workpiece, with the first and second dies and the cutting tool being in axial alignment.
2. A process as defined in claim 1 wherein the lubricant is graphite.
3. A process as defined in claim 1 wherein the lubricant is a suspension of graphite in water.
4. A process as defined in claim 1 wherein the workpiece is heated to a temperature above 250°F but below the critical temperature.
5. A process as defined in claim 1 wherein the workpiece is passed through the cutter at a rate sufficient to raise the temperature of the metal being removed to a temperature within the hot working region of the metal.
6. A process as defined in claim 1 wherein the workpiece is processed at a rate of 10 to 350 feet per minute.
7. A process as defined in claim 1 wherein the cutting tool has a rake angle of $+20^{\circ}$ to -20° and a clearance angle of $+15^{\circ}$ to -15° .
8. A process as defined in claim 1 wherein the first die is spaced from the cutting tool by 2 to 30 inches.
9. A process as defined in claim 1 wherein the second die is spaced from the cutting tool by a distance of 2 to 30 inches.
10. A process as defined in claim 1 wherein the workpiece is a strain hardenable steel.
11. In a process for the surface finishing of metal wherein a metal workpiece of repeating cross-section heated to a temperature of at least 250°F and coated with a lubricant is passed through a cutting tool to remove surface metal, the improvement comprising passing the workpiece through at least one of a lead die preceding the cutting tool and a finish die following the cutting tool to work the metal and support the workpiece as it is passed through the cutting tool.
12. A process as defined in claim 11, wherein the metal is steel.
13. A process as defined in claim 11, wherein the lubricant is graphite.
14. A process as defined in claim 11, wherein the workpiece is passed through the cutting tool at a rate sufficient to raise the temperature of the metal being removed to a temperature within the hot working region of the metal.

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