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(54) APPARATUS FOR COLD DRAWING ELONGATED MATERIAL, PARTICULARLY FOR DRAWING-DOWN STEEL TUBE IN SEVERAL STAGES

(71) We, BENTELER-WERKE AG, WERKE NEUHAUS, of 4794 Schloss Neuhaus, Federal Republic of Germany, a joint stock company organised under the Laws of the Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for cold drawing elongated material, particularly of drawing-down steel tube in several stages.

When elongated materials, such as wire or a tube material, are drawn through a drawing die, a lubricant film must be interposed between the material and the drawing die in order to produce a good surface finish on the drawn material and to avoid metal transfer and cold welds.

The lubricant film is formed by using oils and greases of suitable consistency and composition. These are usually applied to the surface of the material that is to be drawn after the prior application of a bonding agent.

In the majority of drawing operations performed in practice dry and viscous friction is always present and even hard metal dies are liable to collect cold welds which must be removed by costly dressing off operations. Moreover, cold welds have the disagreeable property of being responsible for lasting dimensional changes of the dies which therefore become prematurely useless and cause stoppages in the progress of the work.

In order to eliminate dry friction and the resultant premature wear of the tools it is already known in apparatus of the contemplated kind to build up sufficient hydrodynamic lubricant pressure for perfect lubrication.

This can be achieved by the provision of a static tube in which the material prior to passing through the die frictionally entrains the lubricant and hydrodynamically builds up a high pressure. The entrainment of the lubricant by the material in the clearance gap depends upon a number of controllable factors and may be sufficient to generate pressures inside the die which are capable of entirely eliminating direct mechanical contact, i.e. of maintaining perfect lubrication during the process of drawing.

In order to provide hydrodynamic lubrication during the draft so that there is no contact between the drawn material and the die the lubricant pressure must be built up in a manner depending upon the physical properties of the drawn material. Besides other factors, such as surface roughness and the like, the pressure of the lubricant film will depend more particularly upon the drawing speed, the effective length of the static tube, the magnitude of the clearance gap between the material and the internal surface of the static tube, and the viscosity of the lubricant which itself varies with temperature and pressure.

In order to maintain hydrodynamic lubrication throughout the draft it is therefore a matter of importance that the pressure of the lubricant should be kept constant at the required level whilst drawing proceeds.

The observance of this condition is particularly difficult when drawing down in several stages, particularly tubes, because the stages differ not only with respect to drawing speed, but also because conditions fluctuate in either direction when the plant is started up and when it slows down.

In practice it is also difficult in non-stop working to maintain an exactly constant speed draft. This is partly due to the drawn material tending to build up longitudinal oscillations.

If during a draft the lubricant pressure becomes too high the tube may be deformed and the tube wall give way. This results in the immediate collapse of lubricant pressure and the appearance of a mixture of dry and viscous friction between tube and die. In multiple draft plant for drawing down tubes which in any event travel at very high speeds during the final drawing stages the drawing operation will in such an event come to an immediate end, frequently leading to the destruction of the plant.

On the other hand, if the lubricant pressure is too low from the start, then no full hydrodynamic lubrication will be achieved and both dry and viscous boundary friction will occur.

As the material enters the static tube the lubricant which is continuously supplied at the entry end of the static tube is entrained by surface friction and carried into the clearance gap between the travelling material and the static tube. The deformational work in the die and the friction between the travelling material and the lubricant generate heat which reduces the viscosity of the lubricant just before it enters the die. This naturally also causes a corresponding change in lubricant pressure.

As it is impossible during the actual draft to vary the width of the clearance gap between the material and the static tube and the drawing speed is required to remain as constant as possible after starting up, the possibilities of controlling the pressure of the lubricant film in the direction of keeping it constant whilst drawing is in progress are strictly limited.

It has already been proposed to control the lubricant pressure indirectly by cooling the die or the dieholder as well as the static tube and possibly the lubricant itself with a view to keeping the pressure constant. However, the necessary means are expensive and not sufficiently flexible, or rather too delicate, reliably to control the wide variation in conditions during the starting up stage, particularly when drawing down tubes in several stages.

It is the object of the present invention to improve the contemplated drawing apparatus, more particularly though not exclusively with regard to its flexible adaptation to all the above-described conditions by regulating the hydrodynamic build-up of lubricant pressure during operation and particularly during the starting up stage in multistage plant to comply with existing pressure requirements, irrespectively of or in addition to other means of regulation, such as those afforded by cooling of the die or of the lubricant.

Accordingly, the invention provides apparatus for cold drawing elongated material, for example for drawing down steel tube in several stages, the apparatus comprising a drawing die, a static tube disposed on the entry side of the drawing die for enclosing a portion of the elongated material as it enters the die, and means for supplying lubricant at the end of the static tube remote from the die, the static tube being arranged to enclose a portion of the elongated material equal in length to several times its outside diameter and to leave an intervening clearance gap in which pressure is hydrodynamically built up in the lubricant as it enters the die, in which apparatus means are provided for varying the effective length of the static tube over which the hydrodynamic build-up of pressure in the lubricant takes place and thereby regulating and keeping constant the hydrodynamically built up pressure of the lubricant.

Variation of the effective length of the static tube has the major advantage that this length can be reduced in the starting up stage of the plant when the lubricant is still relatively cold and when the full length of the static tube would lead to an excessively high pressure of the lubricant film. Not until higher drawing speeds have been reached and drawing has continued for some time will the effective length of the static tube be progressively increased to prevent the temperature rise and the consequent fall in viscosity of the lubricant from unduly reducing the pressure of the lubricant film. Naturally, it will also be possible, during continuous operation, to compensate for wider fluctuations of lubricant pressure by adjusting the effective length of the static tube, so that substantially standardised static tubes can be used for all the stages of a multistage tube drawing plant, since the changed conditions which arise in consecutive stages, for instance regarding drawing speed and reduction and consequent differences in the required lubricant film pressure can be indirectly compensated by adjustment of the effective length of the several static tubes.

In a particularly simple and therefore preferred embodiment of the invention the static tube contains a plurality of axially spaced openings which communicate with the clearance gap inside the static tube, the ends of some or all of the openings on the outside of the static tube being closable by valve means.

Although the shape of the openings is optional, they should preferably be radial bores and the valve means may then be manually or automatically operable seated cone or ball valves.

For opening and closing the seated cone or ball valves adjusting screws may be used in which case the chambers containing the valve cones or balls and the adjusting screws which directly make contact with the valve cones or balls may be located in an outer tube which closely surrounds the static tube.

In another advantageous embodiment of the invention the openings distributed along the length of the static tube are peripherally relatively staggered and the valve means are constituted by a sleeve valve which surrounds the static tube inside an outer tube provided with a lubricant outlet bore, and which is movable in relation to the static tube.

This arrangement has the advantage over the first hereinabove described embodiment that it permits the effective length of the static tube to be changed in small consecutive steps. Like the first described embodiment it can be automatically operated for instance by reference to pressure or temperature as the controlling parameters.

Preferably the sleeve valve is rotatable about the static tube and provided with an elongated longitudinal port which by rotation of the sleeve valve is adapted to cover or uncover one or several or all of the openings progressively and to connect them to the lubricant outlet bore in the outer tube. In such a case the outer tube and the sleeve valve may be connected together for common rotation and jointly adjustable to a desired angular position.

Conveniently the inner end of the lubricant outlet bore in the outer tube registers with the elongated longitudinal port in the sleeve valve. In order to ensure that a selected position is retained the outer tube and the sleeve valve may be located in their selected angular positions on the static tube by the engagement of a spring-loaded ball with recesses.

Furthermore, the effective length of the static tube established by the progressive covering or uncovering of the radial openings in the static tube by the elongated longitudinal port of the sleeve valve may be conveniently indicated by an index mark on a ring rotatably copued to the static tube and cooperating with a scale graduation on the outer tube.

It is also desirable that an entire assembly of die, dieholder, static tube together with the slide valve and the outer tube is rotatable in fixed bearings about the elongated material, particularly tube material, that is being drawn and for such purpose coupled to a drive means which imparts slow rotation thereto during the draft.

Two embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a longitudinal section of a drawing die and a static tube containing radial bores which can be closed by ball valves and

Fig. 2 is a similar view of a drawing die and a static tube according to another embodiment, wherein the radial bores are relatively peripherally staggered and can be closed by a rotary sleeve valve.

Referring to Fig. 1, an elongated material in the form of a tube 1 is in course of being pulled through a drawing die 2 in a bushing 3 inserted in a dieholder 4. There is further provided a static tube 5.

It will be understood from Fig. 1 as well as from Fig. 2 that the static tube 5 is many times longer than the outside diameter of the tube 1. The end of the static tube 5 facing the drawing die 2 is formed with a larger diameter flange 6. The outer face of the flange 6 bears on a sealing ring 7 which itself backs on the die 2. The back of the flange 6 of the static tube 5 facing away from the die 2 abuts a threaded plug 8 which engages the dieholder 4 and thus permits the several parts to be held together in a tight sealing mutual contact.

Between the internal surface of the static tube 5 and the external surface of the tube 1 that is being drawn a narrow clearance gap 9 is allowed to remain. As the tube 1 is pulled though the die 2 it frictionally entrains a lubricant and, provided an appropriate drawing speed is maintained, a hydrodynamic build-up of pressure to the level required for perfect lubrication will result.

Externally the static tube 5 is surrounded by an outer tube 10. Both tubes 5 and 10 are firmly connected to each other for common rotation in the event of a rotary drive imparting slow rotation to them during the draft.

Moreover, as shown in Fig. 1, the static tube 5 is provided with two radial bores 11 and 11*a* which are longitudinally spaced and communicate with the narrow clearance gap 9 inside the static tube 5. Externally the bores 11, 11*a* can be closed by balls 12 and 12*a* which function in the manner of seated ball valves. It is self-evident that instead of seated ball valves also seated cone valves may be used.

For opening and closing these valves manually operable adjusting screws 13 and 13*a* are provided which are adapted directly to press the balls 12 and 12*a* into their seats. When the screws 13 and 13*a* are slackened off the balls 12 and 12*a* will be lifted off their seats by the lubricant pressure and permit surplus lubricant to escape through annular chambers 14 and 14*a* and lubricant outlet openings 15 and 15*a* to the outside.

When the apparatus is started up and the lubricant is still cold both the valve screws 13 and 13*a* are slackened off so that the effective length of the static tube 5 over which the hydrodynamic build-up of pressure occurs is correspondingly reduced. At higher drawings speeds and after a longer period of operation the effective length of the static tube 5 is increased in steps by first tightening the valve screw 13*a* and later the valve screw 13 to prevent the lubricant pressure from becoming too low as the temperature rises. The viscosity loss of the lubricant is thus compensated and the working pressure of the lubricant substantially maintained.

When the apparatus slows down to a stop the converse procedure can be adopted, whereas undesirable fluctuations of lubricant pressure during operation can be compensated by changing the effective length of the static tube accordingly.

Whereas for reasons of simplicity the embodiment in Fig. 1 is shown to be provided with only two axially spaced radial bores controlled by seated ball valves and adjusting screws, a larger number of such radial bores and valve means will be distributed along the length of the static tube in actual practice to enable the conditions in the static tube to be more finely adapted to existing conditions.

In the embodiment according to Fig. 2 the static tube 5 is arranged in a sleeve valve 16 which can be rotated on the static tube, and which contains a port *16a* in the form of an axial slot. Radial bores 17 are spaced along the length of the static tube. These are relatively angularly staggered in the circumferential direction of the static tube. Consequently rotation of the sleeve valve 16 and its port *16a* about the static tube 5 will cause the sleeve valve consecutively to cover one radial bore 17 after another at its outer end and the effective length of the static tube will thus be progressively increased.

The lubricant escaping through the port *16a* can drain away to the outside through a radial bore 18 in an outer tube 19. In Fig. 2 the position of this lubricant drainage bore 18 is actually shown at right angles to its true position which is directly above the port *16a* of the sleeve valve 16.

The sleeve valve 16 and the outer tube 19 are firmly connected together for common rotation. Preferably the outer tube 19 can be shrunk on the sleeve valve 16. In order to lock the outer tube and the sleeve valve on the static tube 5 in a selected position a ball 20 is adapted to engage recesses provided in the peripheral surface of the static tube 5 at appropriate angular intervals. The ball is loaded by a compression spring 21 precompressed by a grub screw 22.

The recesses which are engageable by the ball 20 are angularly relatively spaced around the periphery of the static tube at the same angular intervals as those at which consecutive radial bores 17 in the static tube are peripherally staggered.

In order to permit the existing angular position of the sleeve valve 16 and hence the effective length of the static tube to be checked, a ring 24 bearing an index mark on its peripheral edge is rotatably rigidly coupled to the static tube 5 by a radial pin 23. The index mark cooperates with a suitable graduated scale on the peripheral surface of a wide flange at the end of the outer tube 19 and permits the angular position of the static tube in relation to the sleeve valve and the outer tube and hence the adjusted effective length of the static tube to be directly read.

It will also be understood from Fig. 2 that the die as well as the dieholder and the static tube are rotatably mounted. Whereas the bearing at the dieholder end 4 is not shown, the fixed bearing box for the static tube 5 at the other end is marked 25. This also contains a fixed connection 26 for the supply of the lubricant which can thus directly enter the clearance gap 9 between the static tube 5 and the tube 1 through an annular groove 27 and radial bores 28.

29 is a retaning disc and 30 a locking ring for axially locating the rotating parts.

The drive which rotates the die, dieholder and static tube at a slow speed of revolution during the draft is not shown in Fig. 2.

The operation and effect of the sleeve valve 16 and its port *16a* which can be rotated on the static tube 5 in relation to the radial bores 17 is analogous to that of the method of control described with reference to Fig. 1. The effective length of the static tube can be changed automatically by relative rotation between static tube and sleeve valve respectively outer tube by reference to pressure and/or temperature as the controlling parameters.

WHAT WE CLAIM IS:—

1. Apparatus for cold drawing elongated material, for example for drawing-down steel tube in several stages, the apparatus comprising a drawing die, a static tube disposed on the entry side of the drawing die for enclosing a portion of the elongated material as it enters the die, and means for supplying lubricant at the end of the static tube remote from the die, the static tube being arranged to enclose a portion of the elongated material equal in length to several times its outside diameter and to leave an intervening clearance gap in which pressure is hydrodynamically built up in the lubricant as it enters the die, in which apparatus means are provided for varying the effective length of the static tube over which the hydrodynamic build-up of pressure in the lubricant takes place and thereby regulating and keeping constant the hydrodynamically built up pressure of the lubricant.

2. Apparatus according to Claim 1, comprising a static tube containing a plurality of axially spaced openings which communicate with the clearance gap inside the static tube, the ends of some or all of the openings on the outside of the static tube being closable by valve means.

3. Apparatus according to Claim 2, wherein the openings are radial bores and the valve means are manually or automatically operable seated cone or ball valves.

4. Apparatus according to Claim 3, wherein the seated cone or ball valves can be opened or closed by adjusting screws.

5. Apparatus according to Claim 4, wherein chambers containing the valve cones or balls as well as the adjusting screws which bear directly on the valve cones or balls are located in an outer tube which closely surrounds the static tube.

6. Apparatus according to Claim 2, wherein the openings distributed along the length of the static tube are peripherally relatively staggered and the valve means are constituted by a sleeve valve which surrounds the static tube inside an outer tube provided with a lubricant outlet bore, and which is movable in relation to the static tube.

7. Apparatus according to Claim 6, wherein the sleeve valve is rotatable about the static tube and provided with an elongated longitudinal port which by rotation of the sleeve valve is adapted to cover or uncover one or several or all of the openings progressively and to connect them to the lubricant outlet bore in the outer tube.

8. Apparatus according to Claim 7, wherein the outer tube and the sleeve valve are connected together for common rotation about the static tube and are jointly adjustable.

9. Apparatus according to Claim 8, wherein the inner end of the lubricant outlet bore in the outer tube registers with the elongated longitudinal port in the sleeve valve.

10. Apparatus according to any one of Claims 7 to 9, wherein the outer tube and the sleeve valve are located in their selected angular positions on the static tube by the engagement of a spring-loaded ball with recesses.

11. Apparatus according to any one of Claims 7 to 10, wherein the effective length of the static tube due to progressive covering or uncovering of the radial openings in the static tube by the elongated longitudinal port in the sleeve valve is indicated by an index mark on a ring rotatably coupled to the static tube and cooperating with a graduated scale on the outer tube.

12. Apparatus according to any one of claims 7 to 11, wherein an entire assembly of die, dieholder, static tube, slide valve and outer tube is rotatable about the elongated material, particularly a tube, that is being drawn through the die.

13. Apparatus according to Claim 12, wherein fixed bearing boxes for rotatably mounting the assembly are provided, one of the bearing boxes is located at the end of the static tube remote from the die and constitutes at the same time a connection for the introduction of the lubricant in said bearing, and the rotatably mounted assembly is connectable to drive means for driving the entire assembly.

14. Apparatus for cold drawing elongated material, particularly for drawing down steel tubes in several stages, substantially as herein described with reference to and as illustrated by the accompanying drawings.

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1564971 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

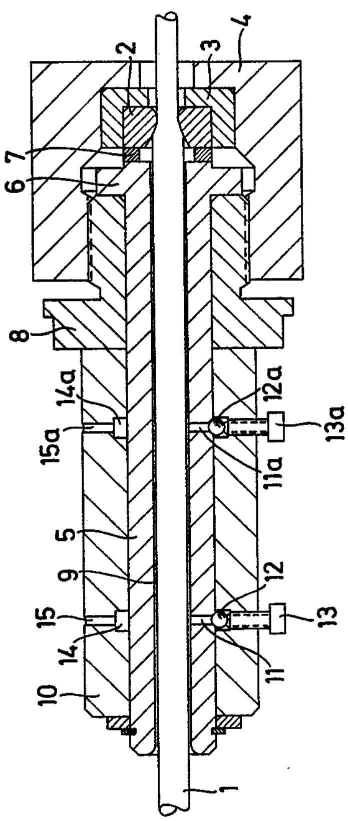

FIG. 1

FIG. 2