ABSTRACT
Method for forming a rod end having a rod portion and a substantially flat head portion formed at one end of said rod portion, the method comprising a cold forging process including a upsetting step for forming a pair of parallel flat surfaces of small area on parts of said head portion, and a finishing die forming step for forming the head portion into a desired shape.

1 Claim, 11 Drawing Figures
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ROD END COLD FORMING PROCESS

A rod end has been known as a mechanical element which is utilized to connect an axially reciprocating driving member with a swingable driven member for converting an axial movement of the driving member into a swinging movement of the swingable member. Thus, it generally comprises an elongated rod portion adapted to be connected at one end with said driving member, and a substantially flat head portion integrally formed at the other end of the rod portion. The head portion has a pair of parallel surfaces and a hole extending perpendicularly to the surfaces. The hole is adapted to receive a pivot pin for connecting the swingable member with the rod end. In this type of rod end, the head portion having a pin receiving hole is often subjected to a stress concentration and therefore it must have a substantial mechanical strength as compared with the rod portion.

Conventionally, a rod end of aforementioned type has been produced either by machining a steel rod of sufficient diameter into a desired configuration and thereafter drilling a pin receiving hole, or by forming a steel rod of relatively small diameter into a desired configuration through a single hot forging process and thereafter drilling a pin receiving hole. As will be apparent to those skilled in the art, the former method is disadvantageous in that, since fibers of the steel rod are cut during machining, the strength of the rod end, particularly that of the head portion is substantially decreased, and that it takes increased labor and time for manufacture resulting in an increased manufacturing cost. The latter method is advantageous over the former method in that the whole strength of the rod end can be increased. However, this method is not so effective to increase the strength of the head portion due to the fact that, during hot forging process, fibers of the steel rod are apt to be directed at the head portion radially with respect to the pin receiving hole which is to be drilled in later process, whereby the succeeding drilling will in effect cut the fibers at the area of the pin receiving hole. Moreover, since a hot forging process requires steps of heating, trimming and cleaning steps, the manufacturing cost is substantially increased.

Thus, a stronger and less expensive rod end has been desired.

The present invention has an object to provide a method for manufacturing a rod end of increased strength and precision with lower manufacturing cost.

According to the present invention, a rod end is formed from a steel rod through a cold forming process without cutting fibers therein, so that it is possible to obtain an extremely strong and durable rod end.

According to the present invention, a rod end is formed by a cold forging process including a special upsetting step which is peculiar to the present invention. Thus, the present invention provides a less expensive and a mechanically strong rod end. The upsetting step is effective to exclude any offset, misalignment and twist of the head portion with respect to the rod portion, so that it is possible to obtain a rod end of a high precision.

The present invention is characterized by a cold forming process including a special upsetting step which is effective to exclude any offset, misalignment and twist of the head portion with respect to the rod portion. Generally, in a conventional process it is very difficult to produce a precise element such as a rod end which has an elongated rod portion and a substantially flat head portion integrally formed therewith, through a cold forming, because a twist, misalignment or offset is apt to be produced between the head portion and the rod portion. For this reason, a rod end has not been produced by a cold forging process.

The inventor conceived a novel method which could overcome the aforementioned disadvantages of prior art, and succeeded to produce a rod end through a cold forging process with a high precision.

Novel features of the present invention which are set forth in the appended claims will be more clearly understood from the following descriptions of preferred embodiments which are shown in the accompanying drawings:

FIG. 1 is a front view of a conventional rod end; FIG. 2 is a side view thereof;
FIG. 3 is a front view of a rod end manufactured by machining a steel rod and specifically showing the direction of fibers in the rod end;
FIG. 4 is a front view similar to FIG. 3 but showing a rod end manufactured by a hot forging process;
FIG. 5 is a diagrammatical view of a steel rod blank which is being extruded in the forward direction in a pretreating step of a method in accordance with the present invention;
FIG. 6 is a diagrammatical view of a workpiece having a rod portion formed by the extruding process shown in FIG. 5;
FIG. 7 is a vertical sectional view of an apparatus utilized in the upsetting process of the present invention;
FIG. 8 is a sectional view taken along the line VIII—VIII in FIG. 7;
FIG. 9 is a view of a workpiece having a barrel shaped head portion made by the upsetting apparatus shown in FIG. 7;
FIG. 10 is a vertical sectional view of an apparatus utilized in the die forging process of the present invention; and,
FIG. 11 is a view of a rod end made by the die forging apparatus of FIG. 10 and particularly showing direction of fibers in the rod end.

In FIGS. 1 and 2 show a typical example of a rod end which is generally designated by the reference numeral 1 and which may be manufactured by the method of the present invention. As is well known, the rod end 1 comprises a rod portion 1A adapted to be directly connected to an axially reciprocating driving member (not shown) and a head portion 1B integrally formed with the rod portion 1A. The head portion 1B is of a substantially disc shape having a pair of parallel surfaces 1C and 1D and is provided with a hole 1E extending perpendicularly to the longitudinal axis of the rod portion 1A as well as to the parallel surfaces 1C and 1D on the head portion 1B. If the rod end 1 of this type is manufactured from a steel rod blank such as by machining or hot die forging, the aforementioned disadvantages have been encountered. In a rod end machined from a steel rod blank, fibers in the blank are cut at the head portion 1B as shown in FIG. 3 so that the head portion 1B becomes substantially weak as compared with the rod portion 1A. Further, the drilled hole 1E in the head portion 1B additionally cuts the fi-
bers into short lengths decreasing the strength of the head portion 1B.

In a rod end manufactured by a hot die forging process, fibers $f$ in the blank are directed substantially radially with respect to the drilled hole 1E at the head portion 1B as shown in FIG. 4, so that the fibers $f$ are cut by the hole into short lengths reducing the strength of the head portion.

The inventor succeeded in overcoming the above disadvantages of the conventional methods and has provided a rod end of substantial strength by a cold forging process including a particular upsetting step.

The method of the present invention comprises steps which will be described with reference to FIGS. 5 through 11. In FIG. 5, a rod blank of a predetermined length of a uniform diameter is axially extruded to form an end portion of reduced diameter which constitutes the rod portion of a rod end. For this purpose, a die 10 as shown in FIG. 5 is used.

As shown in FIG. 5, the die 10 has an inlet hole 11 of a diameter substantially equal to the diameter of the steel rod blank W and a forming hole 12 co-axially aligned and connected through a conical portion 13 with the hole 11.

The steel rod blank W cut into a predetermined length is subjected to annealing, barrel finishing, cleaning by acid and lubricating treatments, and thereafter inserted into the inlet hole 11 of the die 10. In the first step of the present invention an ejector or a knock out element 14 is inserted from bottom into the forming hole 12 through a predetermined depth and a punch 15 is forced into the inlet hole 11 so as to extrude the lower end of the blank W into the forming hole 12 until the extruded end of the rod portion 1A (refer to FIGS. 1 and 2) abuts the upper end of the ejector 14. Thereafter, the punch 15 is retracted upwardly and the knock out element 14 is quickly moved upwardly to eject the workpiece W having a rod portion WA from the die 10.

The workpiece W thus formed with the rod portion in the first step WA is then subjected to an upsetting operation. This operation is carried out as the second step of the present invention by the apparatus shown in FIGS. 7 and 8.

The apparatus includes a die 20 having an upwardly extending guiding recess 21 of a flat rectangular cross-section, a semi-cylindrical upsetting recess 22 formed at the bottom portion 21A of the guide recess 21, and a hole 23 opening to the upsetting recess 22 and extending therefrom vertically downwardly. The guide recess 21 comprises a space of a rectangular cross-section defined by pairs of opposed vertical sidewalls 21a, 21b, 21c and 21d which primarily serve to guide an upper die or a punch 24. The pair of opposed sidewalls 21c and 21d further serve an important part in the process of the present invention, as will become apparent.

The upsetting recess 22 is formed at the bottom 21A of the guide recess 21 and has a semi-cylindrical surface 22c extending perpendicularly to the sidewalls 21c and 21d. The opposite ends of the recess 22 are closed by the sidewalls 21c and 21d. Thus, the upsetting recess 22 has a pair of end surfaces 22a and 22b which are in vertical alignment with the side walls 21c and 21d of the guide recess 21.

Both the guide recess 21 and the upsetting recess 22 are symmetrical with respect to the axis of the hole 23, so that each of the sidewalls 21c and 21d and of the end surfaces 22a and 22b is at the same distance from the axis of the hole 23. This means that the head portion of the rod end can have a symmetrical configuration with respect to the axis of the rod portion WA which is formed in the preceding process.

The characteristic feature of the present invention resides in the upsetting process which (the second step) is performed by the die 20 having the construction shown in FIGS. 7 and 8.

The die 20 used in the method of the present invention has a upsetting recess 22 comprising a semi-cylindrical recess which is closed at the opposite ends by a pair of vertical walls 21c and 21d, the distance (r) between the vertical walls or the length of the semi-cylindrical surface being smaller than two times the radius $r$ of the cylindrical surface 22c. The radius $r$ of the cylindrical surface 22c is slightly smaller than the radius of the head portion of the rod end being made, and the length $r$ is substantially greater than the thickness of the head portion of the rod end.

The punch 24 adapted to cooperate with the die 20 has a rectangular cross-section so that it is complementary with the shape of the guide recess 21, and is formed at its lower end surface with a semi-cylindrical recess 25 which is to be disposed with an opposed relationship to the upsetting recess 22 of the die 20.

When the punch 24 is lowered until its lower surface abuts the bottom surface 2A of the guide recess in the die 20, the recesses 22 and 25 define a cylindrical cavity of a volume greater than the volume of the head portion of the final product.

The blank W having a rod portion formed in the preceding extruding process is then subjected to an upsetting process in which a preforming of the head portion of the rod end is performed. In this process, the rod portion WA of the blank W is inserted into the hole 23 of the die 20 so that the lower end of the rod portion WA is supported by the upper end of an ejector or a knock out element 26 which is inserted from bottom into the hole 23. Thereafter, the punch 24 is driven downwardly so as to upset the head portion WB of the blank W.

In this instance, if the volume of the head portion WB of the blank were the same as that of the cylindrical or disc-shaped cavity defined by the recess 25 of the punch 24 and the recess 22 of the die 20, the head portion WB of the blank W would be formed into a configuration exactly identical to the shape of the cavity, however, in an actual practice, it would be difficult to form steel rod blanks of varying diameters in this manner. Further, in order to perform a precise forming, it is necessary to additionally provide a die forging process following the upsetting process. Therefore, it is not essential to form the head portion of the blank into an exact cylindrical or disc-shaped configuration in this upsetting process. Thus, in the following descriptions, it is assumed that the volume of the head portion WB of the blank after forming of the rod portion is slightly smaller than the cavity defined by the recesses 22 and 25 in the die 20 and the punch 24.

Since the head portion WB of the blank W is smaller than the cavity defined by the recesses 22 and 25, when the punch 24 is driven downwardly to deform the head portion WB of the blank W, the material of the head portion is caused to flow at the lower side along the part cylindrical surface 22c of the recess 22 in the die
20 to form a part cylindrical surface WC and at the upper side along the upsetting recess 25 in the punch 24 to form a part cylindrical surface WD (refer to FIG. 9).

However, since the head portion WB is smaller than the cavity defined by the swaging recesses 22 and 25 in the die 20 and the punch 24, the material of the head portion does not completely fill the cavity, so that the head portion WB is formed to an irregular shape as shown in FIG. 9.

In this process, since each of the semi-cylindrical upsetting recesses 22 and 25 in the die 20 and the punch 24, respectively, has the length z which is smaller than two times the radius of its cylindrical surface, the material in the head portion is first caused to flow, as the punch 24 is driven downwardly, toward the vertical walls 21c and 21d and thereafter along the walls.

It should be noted that, after the upsetting process, the workpiece is formed with a pair of parallel flat surfaces WE on its head portion WB by the portions of the vertical walls 21c and 21d in the upsetting recesses of the die 20 and the punch 24, as clearly shown in FIG. 9. The axial extent L of the parallel flat surfaces WE is substantially two times the radius of the upsetting recess in the die 20 or the punch 24. The provision of the flat surface WE makes it possible to produce a rod end of extremely high precision by the succeeding die forging process.

FIG. 10 shows a die forging process in which the upset workpiece W as shown in FIG. 9 is forged while being supported horizontally.

As in a conventional method, this process which is the third step of the present invention employs a pair of upper and lower dies 31 and 32 which have cavities 30 complementary to the configuration of the final product. One of the dies is secured to the upper bolster of a press (not shown) and the other to the lower bolster. Each of the dies has a circular head forming recess 30a which extends vertically for receiving the head portion WB of the workpiece W, and a rod forming recess 30b which extends horizontally for receiving the rod portion WA of the workpiece W. A vertically extending circular hole 33 is formed in each of the dies and in communication with the head forming recess 30a. In each of the holes 33, there is slidable received a rod or punching element 34 which is movable independently from other parts of the dies. The punching elements 34 can be adjusted by means not shown in the drawings so that they can take predetermined positions with respect to the mating surfaces 31a and 32a of the dies.

Each of the dies 31 and 32 is provided with a groove 35 around the periphery of the forming recess 30a for allowing excess material to flow thereinto to form a flash. Further, each die is formed with a projection 36 at the junction between the head forming recess 30a and the rod forming recess 30b for forming a neck between the head and the rod portions of the workpiece W. The rod forming recess 30b is designed as being longer than the rod portion of the workpiece W in order to allow axial elongation of the rod portion during forging operation.

In operation, the punches 34 are positioned at predetermined level with respect to the related mating surfaces 31a and 32a in accordance with the thickness of the head portion of the workpiece and, thereafter, a preformed workpiece W as shown in FIG. 9 is placed on the lower die 32. As previously described, the workpiece W has a head portion WB having part cylindrical end surfaces WD and WC and a pair of parallel flat side surfaces WE, so that the head portion WB of the workpiece W can be stably placed in the head forming recess 30a of the lower die 32. It should be noted that the parallel flat side surfaces WE on the head portion WB are effective to have the workpiece W supported horizontally with the rod portion WA lifted apart from the forming recess 30b.

After the workpiece W is placed on the lower die 32 as explained above, the press is operated to drive the upper die 31 downwardly onto the workpiece W. The head portion WB of the workpiece W is constrained at its outer periphery, particularly at the part-cylindrical end surfaces WD and WC from expanding radially outwardly by the head forming recesses 30a in the upper and lower dies 31 and 32, while it is compressed by the punches 34 acting on the flat surfaces WE. The fibers (f) of the material in the head portion, which are oriented in the circumferential direction during the previous upsetting process, are now displaced outwardly maintaining their orientation when the head portion is compressed (FIG. 11). Thus, it is possible to completely eliminate the disadvantages of conventional methods in that the strength of the head portion is decreased.

This forging process effectively finishes the barrel shaped head portion of the workpiece W into a complete disc shape and, at the same time, forms a neck portion 1F at the junction between the head portion 1B and the rod portion 1A by the forming projections 36 in the dies.

The excess material of the head portion is allowed to flow into the gutters 35 to form flashes which are thereafter removed by any suitable known method. In this manner, a rod 1E as shown in FIGS. 1 and 2 can be obtained. Thus rod end thus formed is then drilled to form a pin receiving hole 1E which extends perpendicularly to the flat surfaces of the head portion 1B. The hole 1E is used to receive a pivot pin for connecting the rod end to a swinging member when it is in use.

The advantages of the present invention can be summarized as follows:

1. Since all steps are performed under room temperature, it is possible to obtain a rod end of high strength with less expensive manufacturing cost.
2. Since the head portion of the rod end is preformed by a upsetting step, fibers in the material of the head portion are oriented circumferentially, so that they are not cut by a pin receiving hole which is drilled in the head portion at the final step of the manufacturing process. Thus, it is possible to obtain a rod end of high strength.
3. The upsetting process is effective to produce a rod end of high precision since a pair of parallel flat surfaces formed by the upsetting in the head portion of the workpiece are utilized for precisely positioning the workpiece in the succeeding die forging process, so that it is possible to prevent any twist, misalignment and offset of the head portion with respect to the rod portion.

The present invention has thus been described with reference to a preferred embodiment shown in the accompanying drawings, however, it should particularly be noted that the invention is not limited to the details of the illustrated structure but various changes or modi-
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ifications may be made without departing from the scope of the appended claims.

I claim:

1. A method of manufacturing a rod end having a head portion and a rod portion comprising:
   a. first, partially forming said rod portion by extruding a stock rod of larger diameter through a die hole;
   b. secondly, axially compressing the portion not previously extruded into a die to form said head portion with a pair of semi-cylindrical surfaces which

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have their diameters approximately perpendicular to the rod axis and at the same time forming a pair of parallel flat surfaces each being parallel to the rod axis;

c. thirdly, finishing said head portion by pressing said flat surfaces in a die cavity having a pair of head forming recesses corresponding to the contour of the desired finished shape of said head portion while using said flat surfaces as a reference surface.

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