ABSTRACT: An apparatus for the continuous swaging of continuous workpieces in which at least two pairs of swaging units are provided, each of which defines an aligned path of travel for the workpiece. The first unit of each swaging unit pair has two opposed dies set 90° to the opposed dies of the second unit of each pair. Only the dies of one of the units is fully extended at any given time. The dies of each unit perform a pivotal movement which has a component in the workpiece-feeding direction along the feed path when the dies are extended. The second pair of swaging units operate at a higher speed than the preceding pair of units, however, the arrangement is such that velocity of the component of movement in the workpiece-feeding direction is substantially the same in all units.
APPARATUS FOR THE CONTINUOUS SWAGING OF CONTINUOUS WORKPIECES

This invention relates to apparatus for a continuous swaging of continuous workpieces, which apparatus consists of at least two swaging units, which are provided each with a pair of dies, which are driven by eccentric shafts, slidable in pivoted guides, arranged to blow toward each other and at the same time to perform a pivotal movement to the workpiece, and, as far as possible, controlled to perform successive individual blows.

An apparatus of this kind is already known. It has the advantage that the work of deformation is divided between at least two and preferably more swaging units, which are arranged in succession so that a relatively low power is required in each unit whereas a relatively large total reduction of the cross-sectional area of the workpiece can be achieved. The individual swaging units are relatively simple in construction and do workpiece require a complicated, time-consuming maintenance. It is a desirable to effect the total reduction in cross-sectional area by a plurality of steps because an excessive reduction in area in a single step could result in cracks on the surface of the workpiece. The pair of dies of at least one swaging unit are offset by an angle of 90° from the pairs of dies of the other unit so that an improper widening of the workpiece is avoided and square sections can be obtained.

Such apparatus can be used instead of a rolling mill train and requires much less power and prime cost than the latter.

In the known apparatus, the swaging units are properly controlled so that the pairs of dies always perform only individual blows and the elongation imparted to the workpiece by the blow in one unit will not be obstructed by a simultaneous blow of the pair of dies of another unit. On the other hand, all swaging units are alike and their eccentricity and are driven at the same speed so that all pairs of dies have the same blow frequency although they contact the workpiece at different times. In each die blow, it is required to displace material of the workpiece in an amount which is determined by the depth to which the dies penetrate into the workpiece, i.e., the reduction in area, and the length in which the workpiece is to be swaged.

As a result of the elongation of the workpiece, it is divided into two or more correspondingly smaller sections so that the work of deformation to be performed in the subsequent swelling units or pairs of swaging units is decreased and these units may have smaller dimensions and a lower power requirement. It would be obvious to increase not only the blow frequency of the pairs of dies but also the velocity at which they feed the workpiece, i.e., the velocity component of the dies in the direction of travel. A decrease in section of the workpiece, particularly because it is generally believed that the elongation of the workpiece results also in an increase of the feeding velocity of the workpiece as its cross-sectional area is reduced.

In connection with the invention it has been recognized, however, that owing to the wedge-like shape of the gap between the dies meeting each other the workpiece subjected to a blow of the dies is only partly elongated in the direction of travel and is mainly elongated in the opposite direction. During a die blow, the velocity of the portion of the workpiece which has not yet reached the dies is thus decreased and there is an increase in velocity only in that portion of the workpiece which has already moved beyond the respective pair of dies.

As soon as the dies release the workpiece, the same assumes an intermediate velocity, at which it moves freely until the next die blow. This intermediate velocity may be approximately constant so that the feeding velocity of the dies should be approximately uniform in spite of the different blow frequencies. Hence, if the blow frequency is increased from one swaging unit to the next or from one pair of swaging units to the next pair in that the speed of the associated eccentric shafts is increased, the eccentricity of the eccentric shafts or the leverage at the dies must be changed so that the dies feed the workpiece approximately at the same velocity in spite of the eccentric shafts.

If a relatively large number of swelling units are connected in a series, it may not be possible to perform only individual blows in succession but it may be necessary to cause the pairs of dies of two units to blow at the same time so that double blows are performed. In such an embodiment, the feeding velocity of the preceding one of said two pairs of dies which blow at the same time must be increased over the feeding velocity of the preceding one of said two pairs in that the eccentricity or the leverage at the dies is further changed so that the elongation of the workpiece in the direction of travel due to the blow of the preceding pair of dies will not be impeded by the simultaneous blow of the following pair of dies.

It is not essential to change the blow frequency of the dies in adaptation to the elongation of the workpiece from one unit to another; this change may also be effected in larger stages from one pair of units to another.

In another embodiment of the invention, the two eccentric shafts of each swelling unit are separately driven by two synchronized motors. It will be desirable that both motors are provided for all swaging units, these motors are preferably disposed at the delivery end of the apparatus, and the motors drive the eccentric shafts of the individual swelling units or pairs of units by transmission units which are connected in series. Hence, the driving torque which is required is divided between two motors so that the prime cost is reduced, particularly with large units. Nevertheless, the two dies of each pair blow at the same time because the two motors are electrically or mechanically synchronized. Whereas the motors are common to all swaging units, they need not be designed for a higher torque because only individual blows are performed, as a rule, so that only the pair of dies of one unit performs work of deformation at a time whereas the pairs of dies of the remaining units do not contact the workpiece or have been retracted from the workpiece. The provision of the two motors at the delivery end of the apparatus is desirable because the eccentric shafts having the highest speed can then be driven by the transmission unit which is nearest to the motor whereas the eccentric shafts having lower speeds are driven by subsequent transmission units so that there is a speed reduction from each traction unit to the next. The offset arrangement of the shafts in the various transmission units involves an offset arrangement of the shafts which con-
nect these units; the latter offset arrangement may also be utilized to improve the overall arrangement because the dimensions of the swaging units or pairs thereof decrease in the direction of travel of the workpiece.

For the swaging of square-section workpieces, an apparatus having a simple and appropriate design will be obtained if two swaging units, in which the pairs of dies are offset in known manner by an angle of 90°, are directly flanged together to form each pair of swaging units and bevel gear units are alternately provided to transmit a drive from the common transmission unit to the eccentric shafts. If it is desired to swage rectangular-section workpieces, it will not be required to arrange the pairs of dies of the swaging units at an angle.

The subject matter of the invention is shown by way of example in the accompanying drawing.

FIGS. 1 and 2 are, respectively, a side elevation and end elevation showing a pair of swaging units, which are swaged together.

FIGS. 3 and 4 are transverse sectional views taken on lines III–III of FIG. 1 and lines IV–IV of FIG. 3, respectively. FIG. 3 is a showing which is rotated through 45° in FIG. 1.

FIG. 4 is a diagram illustrating the sequence of blows in a four-unit apparatus.

FIGS. 6 and 7 are, respectively, a side elevation and a top plan view showing diagrammatically an apparatus consisting of three pairs of swaging units.

Each swaging unit A–F comprises a pair of dies 1, which are driven by eccentric shafts 2 and slideable in pivoted sliding guides B. The dies 1 blow toward the other and during each blow perform a pivotal motion in the direction of travel of the workpiece to the feed area. This direction is indicated by arrows. In each of the pairs of swaging units A, B or C, D and E, the two pairs of dies 1 are offset by an angle of 90°. Two units of each of the pairs are directly flanged together. Each pair of swaging units forms an assembly which is held between two supports 4. The two eccentric shafts 2 associated with each pair of dies 1 and included in each swaging unit are separately driven. Two common motors 8 (FIG. 7) are provided for all swaging units A–F and are electrically or mechanically synchronized. These motors A–F are disposed at the delivery end of the apparatus and drive the eccentric shafts 2 of the swaging units by transmission units 5, which are connected in series. Because the pairs of dies of the swaging units of each pair are offset by an angle of 90°, drive is transmitted to the eccentric shafts 2 from the common transmission units 6 in alternation by a straight drive unit 7 and a bevel gear unit B. It is apparent from FIGS. 6 and 7 that the two swaging units C, D are smaller than the units A, B and the swaging units E, F are smaller than the swaging units C, D.

The eccentric shafts 2 associated with the upper dies 1 are eccentrically mounted in respective adjusting housings 9. Owing to this eccentric mounting, the adjusting housing 9 tends to rotate in response to the reaction to the swaging force. This rotation is prevented by a piston 11, which is slidable in a cylinder 10 and to which hydraulic pressure is applied. The piston rod 13 of the piston 11 is pivoted by a strap 14 to the adjusting housing 9 (FIG. 4). By the pressure acting on the piston 11, the adjusting housing 9 is forced against a stop, which may be adjustable. If the swaging pressure or the reaction thereto exceeds a predetermined limit, the adjusting housing 9 is rotated against the hydraulic pressure acting on the piston 11 so that the upper die is lifted from the workpiece.

The swaging units are so controlled that, as far as possible, work of deformation is performed only by the pair of dies of one swaging unit at a time whereas the pairs of dies of the remaining units do not then contact the workpiece. FIG. 8 illustrates the timing of blows in an apparatus having two pairs of swaging units, i.e., four swaging units A–D, and four pairs of dies. The dies of each pair are in contact with the workpiece while the associated eccentric shafts rotate through approximately 60°. The illustrated circle symbolizes one revolution of the eccentric shaft of the first swaging unit A. The contact between the dies of the first swaging unit A and the workpiece begins at a point A and is maintained throughout the arc of 60° which is represented by a thick solid line. After that rotation, the dies are lifted from the workpiece. If the eccentric shafts of the first unit rotate through 90°, the dies of the fourth unit contact the workpiece at point D. The eccentric shafts of the third and fourth swaging units C, D rotate, e.g., at twice the speed of the eccentric shafts of units A, B. The contact between the pair of dies of the unit D with the workpiece begins at point B and is maintained while the eccentric shafts of the first unit rotate through an arc of 30°. The same remark is applicable to the third unit C, in which the pair of dies begin to contact the workpiece at point C. This is succeeded by the pair of dies of the second unit B, in which the eccentric shafts have the same speed as those of the first swaging unit A so that the contact between the pair of dies of the unit B with the workpiece is maintained through 60° from point B. Because the eccentric shafts of units C, D rotate at twice the speed of the eccentric shafts of units A, B, the pairs of dies of units C, D must blow twice during a revolution of the eccentric shafts of the units A, B. This is indicated in FIG. 5 by two additional arcs, which begin at points D and C, respectively. Hence, the eccentric shafts of units C and D perform two revolutions through 360° and each of the associated pairs of dies blow twice during the time when the eccentric shafts of units A, B perform one revolution and each of the pairs of dies in these units perform one blow. Owing to the different eccentricities of the eccentric shafts in units C and D, the feeding velocity of their pairs of dies is approximately the same as that of the pairs of dies of units A and B. If six swaging units are arranged one behind the other, as is shown in FIGS. 6 and 7, it will be necessary to select a different sequence or pattern of blows and it may be necessary to change from one unit to another or from one pair of units to another not only the speed and eccentricity of the eccentric shafts but also the leverages at the dies 1. This leverage depends on the relation of the guides 3 to the eccentric shafts 2.

What we claim:

1. Apparatus for the continuous swaging of continuous workpieces, which apparatus comprises:
   two swaging units each of which defines a path of travel for a workpiece and comprises:
   two pivoted guides disposed on opposite sides of and directed to said path,
   two dies slidably mounted in respective ones of said guides, and
   two eccentric shafts, each of which is operatively connected to one of said dies,
   said two eccentric shafts being rotatable to impart to the respective dies an oscillating motion, whereby said dies are simultaneously extended and retracted toward and from said path and perform a pivotal movement which has a component in a workpiece-feeding direction along said path when said dies are extended, said shafts and guides in each unit being related to provide a leverage for the transmission of motion from said eccentric shafts to said dies,
   said units being arranged so that said paths of travel defined thereby are longitudinally aligned,
   said apparatus also comprising drive means operatively connected to said eccentric shafts and operable to rotate the eccentric shafts of the succeeding one of said units in said workpiece-feeding direction at a higher speed than those of the preceding one of said units so that the dies of said succeeding unit have a higher frequency of oscillation than those of said preceding unit,
   the arrangement being such that only one of said pairs of dies are fully extended at any given time, at least one of the factors consisting of the eccentricity of said eccentric shafts and said leverage being different in said two units so that the velocity of said component of movement in said workpiece-feeding direction is substantially the same throughout both said pairs of dies.

2. Apparatus as set forth in claim 1, in which
said two swaging units belong to respective pairs of swaging
units,
said preceding unit is preceded by the other unit of its pair,
said succeeding unit is succeeded by the other unit of its
pair,
all said units are so arranged that said paths of travel defined
thereby are longitudinally aligned,
said drive means are operatively connected to said eccentric
shafts of all said units and operable to rotate the eccentric
shafts of said pair of units comprising said succeeding unit
at a higher speed than those of the pair comprising said
preceding unit,
at least one of the factors consisting of the eccentricity of
said eccentric shafts and said leverage is different in said
two pairs of units so that the velocity of said component
of movement in said workpiece-feeding direction is sub-
stantially the same for all said pairs of dies.
3. Apparatus as set forth in claim 2, in which the arrange-
ment is such that only one of said pairs of dies of said two pairs
of swaging units is fully extended at any given time.
4. Apparatus as set forth in claim 2, in which said drive
means comprise
two trains of transmission units, which are connected in se-
ries in each train and operatively connected each to one
of the eccentric shafts of the two swaging units of one of
said pairs of swaging units to drive the same, and
two motors, each of which is connected to one of said trains
of transmission units.
5. Apparatus as set forth in claim 2, in which
said swaging units of each pair are flanged together,
said pair of dies of one swaging unit of said pairs are spaced
by an angle of 90° from said pair of dies of the other swag-
ing unit of the same pair, and
said drive means comprise two pairs of common transmis-
sion units and succeeding transmitting units operatively
connecting each of said transmission units to one of the
eccentric shafts of each of the two swaging units of one of
said pairs of swaging units, and
each of said succeeding transmitting units comprises a
straight transmission unit connected between said com-
mon transmission unit and one of said eccentric shafts
and an angle gear unit connected between said common
transmission unit and another of said eccentric shafts.
6. Apparatus as set forth in claim 1, in which said drive
means comprise two synchronized motors, each of which is
operatively connected to one of said eccentric shafts of one of
said units.
7. Apparatus as set forth in claim 1, in which said drive
means comprise
two trains of transmission units, which are connected in se-
ries in each train and operatively connected to respective
ones of said eccentric shafts to drive the same, and
two motors, each of which is connected to one of said trains
of transmission units.
8. Apparatus as set forth in claim 7, in which
said motors are disposed adjacent to said succeeding swag-
ing unit and
in each train the transmission unit operatively connected to
an eccentric shaft of said succeeding unit is coupled
between one of said motors and the transmission unit
operatively connected to an eccentric shaft of said
preceding unit.