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METHOD OF HEAT TREATING METAL OBJECTS

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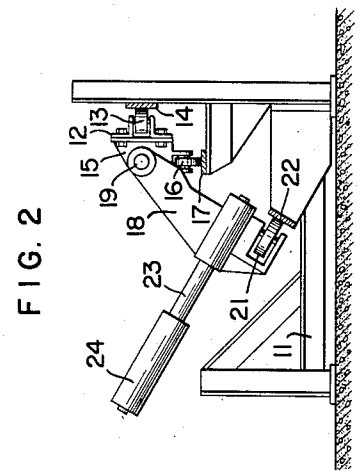


FIG. 2

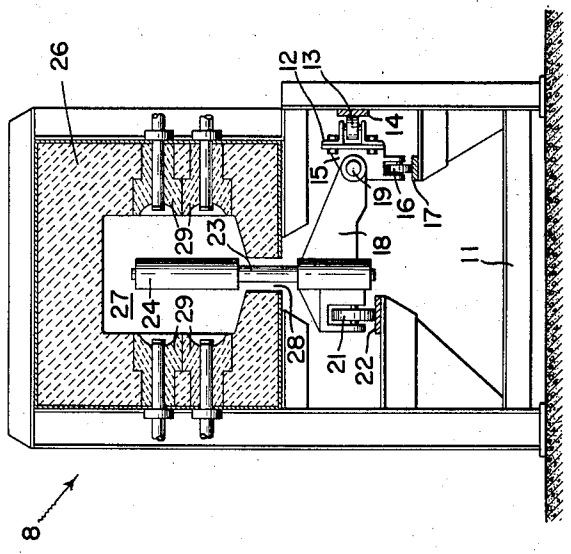


FIG. 3

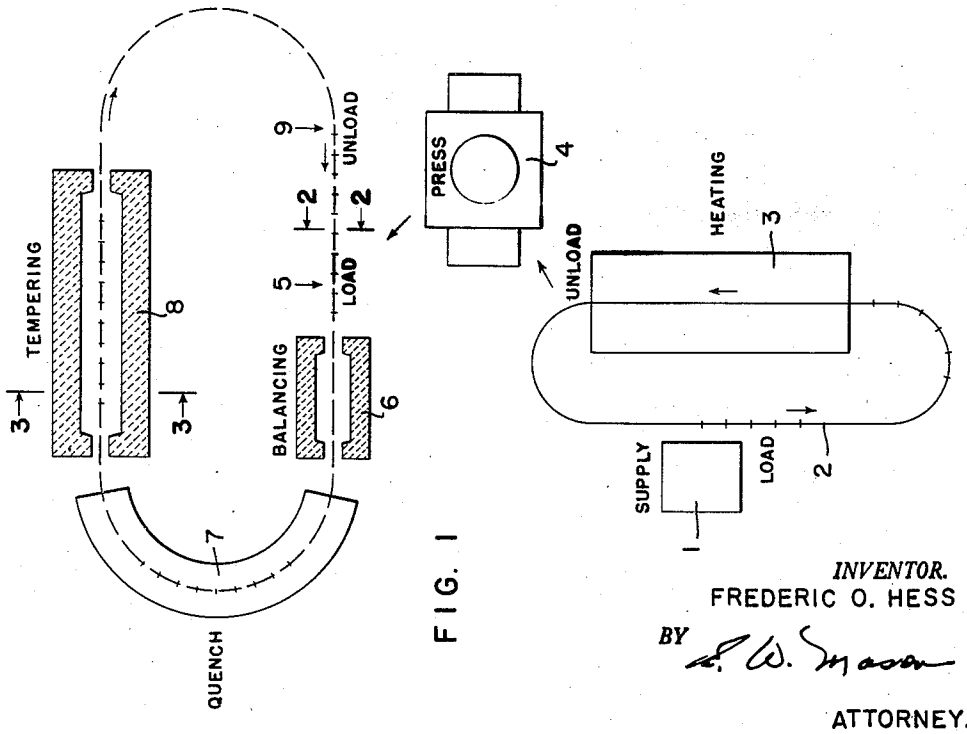


FIG. 1

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METHOD OF HEAT TREATING METAL OBJECTS

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7 Claims. (Cl. 148—12.4)

The present invention relates to the heat treatment and shaping of metals, and more particularly to a method of handling and heating metals that are to be hot formed for various purposes. The method of the invention is particularly applicable to the heat treating of all carbon and alloy steels in the water and oil hardening grades.

At the present time, it is the normal and accepted procedure to heat metal, such as various steels, over a relatively long period of time to bring them to a forging temperature of about 2250° F. The metal must then go through a descaling process prior to the time it is sent to the forging press. Thereafter, the work is cooled and reheated for quenching before it is tempered for further hot or cold working. These various steps require quite a long time and much labor, not to mention the fuel that is required for the various heating operations.

It is an object of the present invention to provide a method of handling metal pieces that are to be heat treated and hot worked which omits several operations that are performed in the prior methods of handling metal pieces for this purpose.

It is a further object of the invention to heat metal pieces fast and forge or otherwise hot work them at a lower temperature than is usual.

It is a further object of the invention to provide a process for handling metal pieces while they are being heat treated and worked which is economical in time and fuel, and which requires a minimum of labor. An additional object is to produce a superior heat treated metal product.

It is a further object of the invention to produce a product of a given weight with a smaller piece of metal than it has heretofore been customary to start with.

In the following the present invention, metal such as a steel billet, for example, is heated at an extremely rapid rate until it reaches a temperature where it is sufficiently plastic to be hot worked. This heating is so rapid that substantially no surface scaling takes place; therefore, the piece can be moved directly to the press. Immediately after hot working has taken place, the piece is quenched and tempered. These operations are performed in sequence on a plurality of work pieces that are supplied one after another, and the operations are performed with a minimum of labor in handling the pieces.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

In the drawings:

Figure 1 is a diagrammatic view of the apparatus to be used in following the applicant's invention;

Figure 2 is a section taken on line 2—2 of Figure 1; and

Figure 3 is a section taken on line 3—3 of Figure 1.

The invention will be described for use in connection with the heating of steel billets for forging, and the subsequent treatment thereof. It will be apparent, however, that the invention can be used with other types of hot working such as extrusion, for example.

The method of the invention can be carried out by different types of apparatus as long as they are capable of acting on the work pieces that are being treated in the manner that is required.

For purposes of disclosing one form of apparatus by means of which the invention can be carried out, reference is made to Figure 1 of the drawing. Referring to that figure, it will be seen that the supply of billets to be heated is indicated at 1. These billets with suitable means to support them are placed one after the other on a conveyor 2 and moved in the direction of the arrow through a furnace 3 which is capable of heating the billets at the rate of 2 inches to 5 inches a minute from room temperature to a temperature within the range of 1600° F. to 1900° F. A furnace of this type is disclosed in the applicant's co-pending application, Serial No. 249,831, filed October 5, 1951, now patent 2,754,104, dated July 10, 1956. In that application, there is shown a furnace having a slot in the roof through which extend rods welded to and supporting the billets. The billets are moved through the furnace and are rapidly heated to the desired temperature by the time they leave the furnace chamber. This heating is accomplished with such rapidity and in such an atmosphere that the billet is covered with no more than a surface coating of oxide, rather than scale in the usually accepted meaning of the word. The billets can, therefore, be moved directly from the discharge end of the furnace 3 to the press 4, which will be referred to herein by way of example as a forging press, without appreciable cooling and without any of the generally accepted delay required for scale removal.

Immediately after the billets have been forged, they are moved to the loading point 5 of a conveyor. From this point on, the conveyor automatically carries the billets one after the other in a continuous stream past a series of treating apparatuses to perform the subsequent heat treatment without manual handling thereof. From the loading point 5, the billets are moved first through a balancing furnace 6 which serves to even out the temperature in the various sections of the billets at their as forged temperature of from 1675° F. to 1725° F., rather than to heat them to any particular temperature. Immediately upon leaving the balancing furnace, the billets are carried through a quench apparatus indicated at 7. Thereafter, the billets are moved through a tempering furnace 8 where they are drawn at the proper temperature for the composition of the material being treated. This temperature is generally within the range of 700° F. to 1300° F. After that, the billets move through a path where they are permitted to air cool until they reach the unloading point 9. At this point, the billets are removed from the conveyor for future treatment if such is necessary or desired.

One mechanism for moving the forged pieces through the balancing furnace 6, the quench 7 and the tempering furnace 8 is shown in Figures 2 and 3 of the drawing. Referring to those figures, it will be seen that there is provided a structural steel frame 11 along which a conveyor chain 12 travels at a constant speed. Each link of the chain is provided with a roller 13 that bears against a track 14 in order to guide it in a fixed path of travel. Work moving castings 15 are bolted to selected links of the chain at spaced apart points along the length thereof. Each casting is provided with a roller 16 riding

along a track 17 that extends through the length of the path of travel of the conveyor. Roller 16 in connection with the roller 13 definitely locates the castings 15 with respect to the operating portions of the apparatus that is to operate on the forged billets. A work supporting casting 18 is pivoted at 19 to each casting 15. These castings can move around pivot 19 from the position shown in Figure 2, for example, to that shown in Figure 3 because of the co-action between a roller 21 on the work support and a track 22 upon which it rides. When the position of this track is changed relative to the pivot 19 as shown in Figures 2 and 3, it will act as a cam to move the work supporting casting into various positions around the pivot. As shown herein, each casting 18 is provided with a spindle 23 upon which the work 24 is placed after it has been forged. The spindles can be rotated if desired while being moved by conveyor 12.

Figure 2 shows the position of the work support that will be assumed in the loading station 5 and the unloading station 9. As the conveyor moves, the supports 18 will pivot around 19 to shift from the position shown in Figure 2 to the position shown in Figure 3, which position is assumed as the work is being moved through the furnaces 6 and 8. The position that the work assumes as it is moving through quench 7 will, of course, depend on the type of quench that is being used.

The furnace 8 is shown in Figure 3 as comprising an elongated structure through which the work is moved. The furnace itself is mounted upon the support 11 and comprises refractory material 26 built in accordance with ordinary furnace practice to form an elongated furnace chamber 27 having a slot 28 in its floor through which work supporting spindles 23 can extend. The furnace can be heated by any suitable type of burners. Preferably, and as shown herein, the burners 29 are of the radiant cup type disclosed in my Patent 2,215,079 issued September 15, 1940. Furnace 6 may be identical to furnace 8 except that it is considerably shorter, since it does not actually have to raise the temperature of the work any appreciable amount.

In practicing the invention, billets which may be of any carbon or alloy steel in the water or oil hardening grades are placed on the conveyor 2 and moved through the furnace 3 to be heated in a manner similar to that described in the above mentioned application. The billets that are to be heat treated and worked may be of any size that is necessary for the forging that is to be produced. The furnace is heated to a temperature of substantially 2600° F. and the billets are heated at the rate of from two to five inches per minute. At this heating rate, three inch billets are brought up to a forging temperature of from 1700° F. to 1900° F., and preferably 1850° F. in fifteen minutes. For some reason tht is not exactly known, it has been determined that billets heated at this high rate of speed may be forged or extruded at temperatures considerably lower than the generally accepted forging temperature of 2250° F. In addition, billets heated at this speed are not in the furnace long enough or at high temperature long enough to acquire a coating of scale in the generally accepted meaning of that word. The billets will only have a thin coating of oxide on their surfaces, the thickness of which will vary with the heating time and temperature. In no case will a descaling operation be required. The billets, therefore, can be moved directly and without delay from the furnace to the forging press 4 or other hot working apparatus.

The two biggest factors in die wear in a press are heat and scale. The transfer of heat to the die from the work over a period of time changes the physical characteristics of the metal of which it is made and increases its susceptibility to wear. The lower temperature to which billets are heated by the present process decreases appreciably heat transfer to the die. Scale on the surface of a billet not only causes imperfections in a finished forging, but its abrasive characteristics cause rapid wear of a die, particularly one that is too hot. Billets heated according to the present process do not have scale on them, so this cause of die wear is eliminated.

By the time the billet has been forged, it has cooled to a temperature within the range of 1675° F. to 1725° F. At this temperature, the grain structure of the metal is quite satisfactory for quenching. Quenching at this temperature also serves to retain in the billets the physical properties obtained by the hot working. The forged billet can, therefore, be moved directly from the press to the quench. This contrasts with the usual procedure where the billet is so hot after forging that it must be cooled several hundred degrees before it is at quenching temperature. The grain growth during this cooling period is such that the metal must be cooled below the critical temperature and reheated for quenching. By the present process, this cooling and reheating is completely eliminated. The billet is then placed on conveyor 12 at loading point 5 to be moved through the subsequent stations.

In some cases, the forging may be such that it has thick and thin sections. When this happens, the sections will cool at different rates so that the entire piece will normally not be at a uniform temperature when it reaches the quench. Therefore, it may be desirable to move the piece through a balancing furnace such as that indicated diagrammatically at 6 in Figure 1. This furnace serves the purpose only of balancing the temperature of the forging to bring all of its sections to the same value. The only time it would be used to raise the temperature of the forging would be when, for some reason, there has been such a delay in handling the piece that its temperature has fallen below a minimum quenching temperature of about 1650° F.

Immediately after the forging operation or after the piece has passed through the balancing furnace 6 which requires about two minutes, if this is necessary, it is moved to quench station 7 and quenched in about one minute by a suitable quenching medium with suitable quenching apparatus, the details of which form no part of the present invention, to reduce the temperature of the forging to a temperature not above 300° F.

When the forgings leave the quenching zone 7, they are carried by the conveyor 12 continuously through tempering furnace 8 where their temperature is raised in about five minutes to a range of from 700° F. to 1300° F. depending upon how much they are to be drawn and the composition of the piece. After the forgings leave furnace 8, they are moved through a path by the conveyor to the unload point 9. During their trip through this path, they will be slowly air cooled and will drop in temperature from 200° F. to 500° F. depending upon what temperature they reached in furnace 8.

After this, the forging is ready for rough turning and cold working, if desired. The physical properties are such that annealing is not necessary.

The tempering operation can be performed in such a manner that it will compensate for changes in physical properties of the piece due to subsequent working thereof. As an example, for one purpose, a forging is produced which is cylindrical in shape and which has a cylindrical opening extending from one end almost to the other end. In a subsequent operation, this forging is to be cold worked to reduce the diameter of the end from which the opening extends. The cold working operation produces cold working hardening of the open end of the forging that is equivalent to 7 to 10 points Rockwell hardness. This hardness gradient from closed to open end of the forging must be erased by subsequent heat treatment so that the finished piece has uniform physical properties over its length.

With this invention, the burners in the tempering furnace 8 may be so positioned and fired that the open end of the forging is heated to a higher temperature than the

closed end. Thus, there is produced by the uneven or differential heating, a greater drawback of the forging in the area to be cold worked than there will be in the balance thereof. In this manner, the forging will have, after cold working, substantially uniform properties over its length. This arrangement will preclude the necessity for open end stress relieving following the cold working.

In summary, the process of the invention consists in heating a steel billet at the rate of two to five inches per minute to a hot working temperature of from 1600° F. to 1900° F. and with the formation of no more than a thin oxide coating on its surface. The billet is then moved immediately to a hot working apparatus. By the time the hot working is completed, the billet temperature is about 1700° F. and ready for immediate quenching to below 300° F. If necessary, the billet may have the temperature of its various sections balanced before quenching. After the billet is quenched, it is moved directly and automatically to a tempering furnace that brings its temperature within a range of 700° F. to 1300° F. Subsequently, the billet is air cooled.

If required, because of work to be done later on the billet, it can be so heated during the tempering that different portions thereof are heated to different temperatures.

In one installation using prior and conventional heating practices, an 18 pound billet of medium carbon steel to be hot worked into a deep, heavy walled cup required for the heat treating processes and handling alone a minimum of 36 hours. This included initially heating the billet for from 1½ hours to 2 hours to a temperature of 2200° F. to 2250° F. The transfer time between the furnace and the press, including descaling, was about one minute. The subsequent cooling, heating, quenching, annealing and handling to produce a forged piece of a given size and quality required the remaining time.

The same forged piece with equal or better physical qualities was produced by the new process described herein in approximately one half hour. The process only requires a 16 pound billet because of the complete lack of metal loss due to scaling. The lack of scale on the billet also means that it can be moved from furnace 3 to the press 4 in from 8 to 10 seconds. The saving in time and metal, as well as in fuel, by the present invention over what is required by previous practice is due to the rapid heating and handling, and the elimination of several steps. Furthermore, the present process does not require the time delays for cooling and reheating that were previously necessary. An additional saving accomplished by following the present process is that the die life of the forging press has been doubled.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. The method of processing a steel object that may be hardened which comprises heating the object from ambient temperature to a temperature in the range of from 1750° F. to 1900° F. at a rate of from 2 to 5 minutes per inch, moving the object directly from the place of heating to a hot working apparatus and performing work upon it, immediately quenching the object after it has been hot worked from the temperature at which it is removed from the hot working apparatus to a value not more than 300° F., transferring the object to a tempering zone in which its temperature is raised to a value within the range of from 700° F. to 1300° F., and thereafter air cooling the object.

2. The method of processing a steel object that may be hardened which comprises heating the object from ambient temperature to a temperature in the range of from 1600° F. to 1900° F. at a minimum rate of five minutes per inch and without noticeable scale on the surface thereof, transferring the object directly to a point where it can be forged and forging it, quenching the forged object from the as forged temperature to a temperature not more than 300° F., and immediately thereafter heating the forged object for tempering to a temperature within the range of from 700° F. to 1300° F.

3. The method of claim 2 in which the object is treated to balance its temperature throughout its area without increasing its as forged temperature between the time it is forged and quenched.

4. The method of claim 3 in which the object is moved automatically through a predetermined path while the temperature balancing, quenching and tempering operations are performed on it in sequence at various spaced points along said path.

5. The method of treating steel objects that may be hardened which comprises heating the objects substantially without surface scaling at a minimum rate of 5 minutes per inch to a temperature of from 1750° F. to 1900° F., moving the so heated objects directly to a hot working apparatus and performing work thereon, immediately quenching the objects from the residual hot working temperature to a temperature below the critical temperature for the composition thereof and thereafter heating the objects for tempering to a temperature below said critical temperature.

6. The method of claim 5 in which the temperature of the various sections of the object is balanced without increasing the residual hot working temperature between the time work is performed on the billet and it is quenched.

7. The method of claim 5 in which different portions of the object are heated to different temperature during the tempering operation to thereby vary the physical properties of different portions of the object.

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