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PROCESS OF PREPARING ALLOY STEEL FOR DIE BLOCKS AND OTHER PURPOSES.

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My invention has to do with the production of steel suitable for use in making die blocks and other articles for which steel having similar characteristics is necessary or peculiarly suitable, and it has for its object to provide an alloy steel which besides having the necessary strength, durability and toughness, will possess the requisite hardness, but will not be too hard to be machined, or to be trimmed down for resinking after it has been used to such an extent that resinking is necessary or desirable; also to provide such a material that will be peculiarly homogeneous and of especially refined grain, as well as comparatively free from surface and internal imperfections; and which will be well adapted to be used for the purposes stated without being subjected to the usual or any treatment for hardening.

Heretofore alloy steels used for the purposes mentioned have generally been cast in the form of ingots which, after being cast, have been allowed to cool under atmospheric conditions until they become cold. When required for use the ingots were then reheated to forging temperature and after having been forged the forgings were annealed, after which they were generally subjected to a further heat treatment for the purpose of hardening, usually consisting of reheating and bringing the steel up to a critical point, then withdrawing it from the furnace for quenching in such mediums as air, water or oil, and then again reheating it to relieve strains set up during the hardening process. In spite of this subsequent annealing, all stresses cannot always be removed and certain losses from rejections due to warping and cracking may occur.

In the process of hardening, as described, the surface of the steel becomes harder than the interior so that when after use the die block is trimmed down, as for resinking, a different grain structure is exposed and die blocks which have been hardened usually have to be annealed and rehardened after each trimming. Therefore, such hardening process has a tendency to produce a metal which is inferior for die block purposes. In the making of die blocks, a chrome-molybdenum-nickel steel has been used containing a relatively small proportion of nickel, generally not exceeding two per cent,—because according to the heretofore known methods of treating such steels any greater proportion of nickel would make the alloy difficult to machine, and give it a tendency to warp and crack as a result of such hardening treatment as was required to bring the material to a state suitable for die block use. I have however discovered that a superior material for that purpose may be produced by combining nickel in larger proportions with chromium and molybdenum to form a steel alloy, and then subjecting such alloy to a process of treatment which, without undergoing a hardening process, brings it to finished form for use in the manufacture of die blocks, and leaves it with a peculiarlly homogeneous, and especially refined grain, free from surface and internal imperfections, and of such degree of hardness that while it is long lived when used as a die block, it is not too hard to be machined, or trimmed down for resinking, and, therefore, may be successfully used after numerous resinking operations. The fact that the material is peculiarly homogeneous and of especially refined grain throughout, and is free from surface and internal imperfections and strains, is an important consideration; these qualities adapt the die block for resinking, as there is little danger that in that operation a different grain structure, or cracks or fissures will be encountered, which would, of course, prevent further use of the block.

In the production of the improved product above referred to I may make use of an alloy steel having substantially the following composition:

	Per cent.
Carbon	0.15 to 0.80
Manganese	0.20 to 1.00
Silicon	0.10 to 0.80
Chromium	0.25 to 2.25
Molybdenum	0.20 to 1.50

Nickel, above 1.00 per cent.

The percentage of the several elements above indicated give the permissible ranges of variation in the production of a material for various purposes, but I have found the following analysis to be that best suited for die block manufacture:

	Per cent.
Carbon	0.40 to 0.50
Manganese	0.60 to 0.80
Silicon	0.10 to 0.25
Chromium	0.75 to 0.95
Molybdenum	0.30 to 0.50
Nickel	2.75 to 3.25

The proportions given in the latter list are, therefore, preferred where the alloy is to be used for the making of die blocks.

An alloy steel showing by analysis the above mentioned elements, and having approximately the same percentage composition is not in itself new, but so far as I am aware such alloy steel has not been subjected to my improved treatment hereinafter described, but on the contrary has been differently treated in several of the stages leading to the production of the finished material, and, therefore, the resulting product has not had the novel characteristics which distinguish my improved product from that heretofore derived from such alloy steel.

According to my improved method a heat, having the chemical analysis above indicated, is made, preferably in an electric furnace, and the finished heat is poured into ingot molds. The steel is then allowed to stand until it becomes thoroughly solidified. The ingot is then stripped, and, preferably without being allowed to cool below a surface temperature of approximately 1000° F., it is charged into a heating furnace to be reheated to a proper forging temperature. If forging cannot take place immediately after casting the ingot, provision is made so that such further cooling as occurs shall be very slow and at the same time uniform, to avoid setting up strains.

By subsequent slow and uniform heating the ingot is brought up substantially above its critical temperature, preferably to 2000° F. to 2100° F. After reaching the proper forging temperature the ingot is put under a forge press for forging it into die blocks and during the forging process is not allowed to cool below the point where it loses the requisite plasticity. After the die blocks are finished to size in the forging operation, while still hot they are transferred to a preheated soaking pit or furnace having a temperature of approximately 1000° F. The blocks at that time have a temperature of about 1400° F. In this way all the die blocks are equalized in the soaking pit or furnace to a temperature of about 1000° F., and then additional heat is applied to the furnace and by slow and uniform heating the die blocks are brought up to a temperature of about 1700° F. and held at such temperature until they become equalized in temperature throughout, after which the heat is shut off and the blocks are allowed to cool slowly and uniformly down to a temperature where they will not be affected by atmospheric conditions. They are then removed from the furnace to allow them to come to atmospheric temperature. The annealing process to which the die blocks are subjected in the soaking pit or furnace as above described completes the treatment of the material so that after the usual machining and sinking operations the die blocks are ready for use. I thus eliminate the steps of hardening and tempering that have heretofore been necessary, which not only saves time and expense, but also avoids losses that are apt to occur incidentally to such heat treatment, such as those due to warping, shrinking or cracking.

The die blocks produced by the method described are peculiarly homogeneous and of especially refined grain throughout, and are practically free from surface and internal imperfections, so that there is very little loss on that account. They are of such a degree of toughness and hardness that by actual tests they have been found to be greatly superior to other chrome-molybdenum-nickel alloy steel die blocks, which usually require hardening by heat treatment. The fact that because of their homogeneity and uniform hardness my improved die blocks may be trimmed for resinking, gives them an added feature of superiority.

While as I have stated, in practicing my improved process I prefer to conduct the several steps as hereinbefore specifically described, some latitude is permissible. This mode of treatment, that is to say, the keeping of the ingot and forgings hot, or otherwise avoiding the setting up of strains therein, as decribed, during the intermediate stages of the process antecedent to the annealing operation, may also be applied with advantage to chrome-molybdenum-nickel alloy steels the analysis of which varies considerably from the preferred percentages hereinbefore mentioned, since, by appropriately varying the relative percentages of the principal elements, a sufficiently hard material can be produced, without hardening by heat treatment, to be suitable for the making of die blocks and analogous articles.

The range of analysis of the various elements as hereinbefore given, which are included in my invention, is necessarily a wide one, since the interrelation of the several elements is such that the increase of one usually means the decrease of another; for instance with a higher chrome or nickel content a lower carbon content would follow. Also my invention includes the substitution in whole or in part for any of the elements mentioned, of any equivalent thereto, such as vanadium, tungsten, cobalt, and others. The claims hereinafter made are therefore intended to include the substitution of equivalents for the elements specifically mentioned therein.

It should be understood that while my improved process is peculiarly suitable for the manufacture of die blocks, it may also be used for making trimmer die steels, insert die steels, piston rods, and other articles which can be made to advantage from steel having similar characteristics.

What I claim as new and desire to secure by Letters Patent, is—

1. The method of treating alloy steel analyzing chromium .25–2.25 per cent, molybdenum .20–1.50 per cent, and nickel above 1.00 per cent, to form a finished material for the purposes specified requiring no hardening and subsequent tempering which consists in molding the steel into an ingot, heating the ingot to a temperature of from 1800° F. to 2300° F. while substantially free from internal strains, and forging the same, and then annealing the forging.

2. The method of treating alloy steel analyzing chromium .25–2.25 per cent, molybdenum .20–1.50 per cent, and nickel above 1.00 per cent, to form a finished material for the purposes specified requiring no hardening and subsequent tempering which consists in molding the steel into an ingot, heating the ingot to a temperature of from 1800° F. to 2300° F. without permitting it to cool materially after solidification, and forging the same, and then annealing the forging by slow and uniform heating up to a temperature of from 1400° F. to 1700° F., followed by slow and uniform cooling.

3. The method of treating alloy steel analyzing chromium .25–2.25 per cent, molybdenum .20–1.50 per cent, and nickel above 1.00 per cent, to form a finished material for the purposes specified requiring no hardening and subsequent tempering which consists in molding the steel into an ingot, allowing the ingot to solidify, heating it to a temperature of from 1800° F. to 2300° F. without allowing it to cool below a surface temperature of approximately 1000° F., forging the ingot into die blocks, and then annealing the forgings by heating them to a temperature of from 1400° F. to 1700° F., and subsequently allowing them to cool slowly and uniformly.

4. The method of treating alloy steel analyzing chromium .75–.95 per cent, molybdenum .30–.50 per cent, and nickel 2.75–3.25 per cent, to form a finished material for the purposes specified requiring no hardening and subsequent tempering which consists in molding the steel into an ingot, heating the ingot to a temperature of from 1800° F. to 2300° F. while substantially free from internal strains, and forging the same, and then annealing the forging.

5. The method of treating alloy steel analyzing chromium .75–.95 per cent, molybdenum .30–.50 per cent, and nickel 2.75–3.25 per cent, to form a finished material for the purposes specified requiring no hardening and subsequent tempering which consists in molding the steel into an ingot, heating the ingot to a temperature of from 1800° F. to 2300° F. without permitting it to cool materially after solidification, and forging the same, and then annealing the forging by slow and uniform heating up to a temperature of from 1400° F. to 1700° F., followed by slow and uniform cooling.

6. The method of treating alloy steel analyzing chromium .75–.95 per cent, molybdenum .30–.50 per cent, and nickel 2.75–3.25 per cent, to form a finished material for the purposes specified requiring no hardening and subsequent tempering which consists in molding the steel into an ingot, allowing the ingot to solidify, heating it to a temperature of from 1800° F. to 2300° F. without allowing it to cool below a surface temperature of approximately 1000° F., forging the ingot into die blocks, and then annealing the forgings by heating them to a temperature of from 1400° F. to 1700° F., and subsequently allowing them to cool slowly and uniformly.

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