FASTENING ELEMENT MADE OF CARBON-CONTAINING STEEL AND METHOD FOR THE PRODUCTION THEREOF

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A fixing element which comprises carbon-bearing steel and has a hardened functional tip is overall heated to the austenitisation temperature, held at that temperature and then quenched and is then subjected to an annealing operation which is effected by inductive heating and limited to the region of the fixing element, which lies outside the functional tip. In that way the structure of the fixing element comprises in part martensite and in part annealed martensite, wherein the functional tip comprises throughout martensite and the remainder of the fixing element comprises a martensite which is annealed by short-term inductive heating.
FASTENING ELEMENT MADE OF CARBON-CONTAINING STEEL AND METHOD FOR THE PRODUCTION THEREOF

[0001] The invention concerns a process for the production of a fixing element which has a hardened functional tip and comprises a carbon-bearing steel which after heating to austenitisation temperature and subsequent quenching forms martensite, wherein the fixing element is heated overall to the austenitisation temperature, held at that temperature and then quenched and is then subjected to an annealing operation. It further concerns a fixing element, in particular a screw having a screwthread-forming and possibly hole-forming shaping zone, the structure thereof comprising in part martensite and in part annealed martensite.

[0002] Fixing elements which are to be driven into hard materials require a correspondingly hard functional tip. The functional tip can involve preferably in the present case— the shaping zone of a screw, which forms a counterpart thread and possibly pre-bores or flow-shapes the hole which is required beforehand. The functional tip however can also be the driving-in tip of a firing bolt fixed by a bolt-setting gun, or the cutting ring edge of a stamping rivet.

[0003] In the case of screws comprising low-alloyed carbon steel (heat-treatable steel or case-hardening steel), it is known for them to be hardened and annealed in continuous heating furnace installations or case-hardened and annealed, with recarburisation or carbotriding. In particular after subsequent galvanic coating, screws of that kind are susceptible to hydrogen-induced delayed brittle fracture formation or stress crack corrosion. It is also known from DE-AS No 22 11 608 to impart a very high degree of hardness to the screwthread-forming portion of a screw of that kind, such hardness extending only slightly into the screwthread core which in other respects is of a lower degree of hardness (but higher toughness). Induction hardening which is used in that respect admittedly permits the desired limited hardening effect to be achieved, but it requires individual treatment of the screws in an annular coil, which involves the corresponding expenditure of time and cost.

[0004] Finally, it is also known for thorough or penetration hardening of a screw consisting of heat-treatable steel (heating it and holding it for a prolonged period of time at the austenitisation temperature and then quenching in water or oil) with subsequent annealing, to be followed by inductive hardening which is limited to the shaping zone, by a procedure whereby the outer edge region of the shaping zone is briefly heated again to the austenitisation temperature and freshly quenched. As a result, in this case also, only that edge region is transformed to hard martensite while the core retains the lattice structure of the annealed martensite produced by the preceding annealing operation. It will be noted however that disconformities are formed between that edge zone and the core structure, because at that location there is an unintended annealing effect in respect of inductive heating. Those disconformities can penetrate so far in the radial direction that they partially displace the heat-treated structure which is initially present there and in that way produce a torsional rupture-endangered cross-section.

[0005] In place of the generally multi-stage and at any event complicated and expensive process for the production of a fixing element with a hard functional tip, the invention seeks to provide simplified production without limitation of the range of uses of the fixing elements and also to afford a simpler structure of such fixing elements.

[0006] The process aspect of the invention provides that the annealing operation is effected by inductive heating to a temperature above annealing brittleness and is limited to the region of the fixing element, which is outside the functional tip. That is based on the fundamental notion that the hardness of the martensite structure formed by the known austenitisation operation and subsequent quenching is sufficient for the purposes of use in relation to a hard counterpart material, in accordance with a development of the invention that hardness can be still further increased by recarburisation or carbonitriding in the region near the edge. Then the hardness of the martensite structure is not reduced again (in the interests of higher toughness) by heating/entire fixing element to the annealing temperature, and the functional tip—that is to say for example the screwthread-forming and possibly hole-forming shaping zone of a screw—is also not subjected to more extensive special treatment, but a heat-treated structure consisting of annealed martensite is produced in the remainder of the fixing element (for example the screw), which does not belong to the functional tip or the shaping zone, by virtue of partial short-term annealing by means of inductive heating; that heat-treated structure of annealed martensite, in the fixing condition, can withstand the stresses produced in that situation, without stress crack corrosion and brittle fracture formation. The annealing treatment in the furnace is eliminated and correspondingly reduces the manufacturing expenditure.

[0007] In this respect, the term martensite, besides non-annealed martensite, is also used to denote unstressed and low-annealed martensite. That can be afforded if the fixing element is subjected for example to a tempering treatment (about 1800-2200°C after galvanic coating or a baking/precipitation-hardening treatment (approximately 300°C) in the context of a dip coating operation. In comparison heating to a temperature above annealing brittleness (≥360°C) results in (highly) annealed martensite.

[0008] The hardness of the functional tip can be further increased if at least the tip is recarburised or carbonitrided during heating to and holding at the austenitisation temperature. The edge hardness of the functional tip/screwthread-forming zone can thereby be increased to 750-950 HV0.3, with a core hardness of 350-650 HV0.3. If the region of the fixing element, which is outside the functional tip, is also recarburised or carbonitrided, that affords overall four regions of different hardness levels, more specifically two in the axial direction (tip/shank) and two in the radial direction (edge/core).

[0009] Preferred inductive heating of the fixing elements in a continuous-heating procedure through a line inductor permits a high treatment speed and a correspondingly high output which further reduces the additional costs of such fixing elements, in comparison with conventional fixing elements of the same quality. During inductive heating of the remaining length of the fixing element, that is to say all portions thereof which are outside its functional tip, the functional tip is advantageously cooled—for example in a water bath—in order not to adversely affect its hardness, by virtue of heating to the annealing temperature.

[0010] If the fixing element is a screw the functional tip is formed by an at least screwthread-forming shaping zone.
The shaping zone however can also be continued to the screw tip in a hole-forming portion, that is to say a boring portion or a flow hole-forming portion. In a comparable manner however the fixing element can also be a firing bolt fixed by a bolt-setting gun or a rivet, in particular a stamping rivet.

Example

1. A process for the production of a fixing element which has a hardened functional tip and comprises a carbon-bearing steel which after heating to austenitisation temperature and subsequent quenching forms martensite, wherein the fixing element is heated overall to the austenitisation temperature, held at that temperature and then quenched and is then subjected to an annealing operation, characterised in that the annealing operation is effected by inductive heating to a temperature above annealing brittleness and is restricted to the region of the fixing element, which lies outside the functional tip.

2. A process according to claim 1 characterised in that a low-alloyed carbon steel is used as the carbon-bearing steel.

3. A process according to claim 1 characterised in that a high-alloyed carbon steel is used as the carbon-bearing steel.

4. A process according to claim 2 characterised in that at least the functional tip is recarburised or carbonitrided during the operation of heating to the austenitisation temperature.

5. A process according to one of claims 1 to 4 characterised in that the inductive heating operation is effected in a continuous mode through a line inductor.

6. A process according to one of claims 1 to 5 characterised in that the functional tip is cooled during inductive heating of the rest of the fixing element.

7. A process according to one of claims 1 to 6 characterised in that the fixing element is a screw and the functional tip is a screwthread-forming and possibly hole-forming shaping zone.

8. A process according to one of claims 1 to 6 characterised in that the fixing element is a firing nail or setting bolt.

9. A process according to one of claims 1 to 6 characterised in that the fixing element is a rivet, in particular a stamping rivet.

10. A fixing element which comprises a carbon-bearing steel and has a hardened functional tip and whose structure comprises in part martensite and in part annealed martensite, characterised in that the functional tip comprises martensite throughout and the remainder of the fixing element comprises a martensite annealed by short-term inductive heating. The functional tip consisting of martensite has the high level of hardness required for driving the fixing element into a hard counterpart material, while the annealed martensite of the remainder of the fixing element (as a consequence of the short-term inductive heating thereof to the annealing temperature) has a notched bar toughness which allows it, even under stress, to withstand being endangered by hydrogen-induced brittle fracture formation or stress crack corrosion. In this respect in this case also the term martensite, besides non-annealed martensite, is further used to denote unstressed and low-annealed martensite.

Example

A wire portion (bar) of low-alloyed carbon steel such as SAE 1018/18B3/16MnCr5 (which can be case-hardened with recarburisation or carbonitriding) or SAE 1022/22MnB4Cr/35B2/34CrMo4 (which can be heat-treated) or a high-alloyed carbon-bearing steel such as for example X20Cr13 or X38CrMoV15 (that is to say stainless steel) is upset at one end to form a screw head. A boreforming part or flow hole-forming part of the functional tip is formed on the other end by squeezing. Then, a screwthread is rolled on to the shank which is therebetween. The initial threads serve for forming the thread and belong to the shaping zone which forms the functional tip.

The rough screw is then heated to austenitisation temperature in the furnace and, depending on the respective material: dimensioning/furnace type, maintained at that temperature for 10 to 60 minutes; in that case, case-hardenable steel can be recarburised or carbonitrided. The screw is then quenched in water or oil.

Thereupon, the portions of the screw which lie outside the functional tip (head, possibly the screwthread-free shank portion, and the holding pitches of the screwthread) are inductively heated to an annealing temperature in a linear inductor for 3 to 60 seconds, while at the same time the functional tip is cooled, for example in a water bath.

Finally the screw can be coated for the purposes of corrosion protection.