

METHOD FOR OBTAINING ENHANCED FATIGUE STRENGTH IN WELDED METAL JOINTS AND HAMMER HEAD FOR USE AT COLD WORKING

FIELD OF THE INVENTION AND PRIOR ART

5 The present invention relates to a method for obtaining enhanced fatigue strength in welded metal joints comprising a weld toe, where the weld toe is subjected to cold working such that a visible and/or measurable indentation at the weld toe is produced. The present invention also relates to a hammer head for
10 use at cold working of a weld toe for obtaining enhanced fatigue strength in welded metal joints and -components.

BACKGROUND OF THE INVENTION AND PRIOR ART

The fatigue life of welded constructions, for example offshore or
15 ship constructions, is often reduced as a consequence of untreated welds in critical areas. The large amount of heat required during welding, results in a substantial shortening of the fatigue life after welding. This is mainly due to residual stresses in the transverse direction of the weld toe. The
20 geometry of the weld toe makes the fatigue life even shorter.

Methods to enhance the fatigue life of welded constructions have partly consisted of improving the geometry, and partly consisted of eliminating residual stresses.

25 Geometrical improvements are today obtained by grinding or re-melting of the weld toe by means of TIG (Tungsten Inert Gas), whereafter cracks at the weld toe are removed and the weld toe is rounded off. Hereby, stress concentrations are reduced and the
30 fatigue life is increased. Common for these methods is that the fatigue life only increases to a limited extent, since the negative effect of the residual stresses remain unaffected.

Alternatively, the fatigue life of metal constructions can be
35 improved by cold forging (hammering) of the weld toe such that the residual stresses are locally eliminated and advantageous compressive stresses are established in the metal surface (hammer

peening). There are four known methods of hammering. These are hammer peening, needle peening, UIT hammering and shot peening. Common for these methods is that the geometry of the weld toe only improves to a limited extent. The result is that the fatigue
5 life only increases to a limited extent when the dynamic stress amplitudes are high.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method for
10 obtaining enhanced fatigue strength in welded metal joints and - components.

This object is achieved by the initially defined method, characterized in that the cold working is carried out by means of
15 a power driven hammer head, which has a slightly convex, elongated contact surface in the length direction for contact with the weld toe.

Preferably, the cold working is carried out in a pregrinded
20 steering groove or a pregrinded track rounding the weld toe profile to a geometry fitting the geometry of the hammer head.

Preferably, the weld toe is subjected to the cold working sufficiently to produce a smooth-forged hammered track without
25 individual indentations deviating more than 10 % of the average indentation obtained by the cold working.

An object of the present invention is also to provide a hammer
head for use at cold working.

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This object is achieved by the initially defined hammer head, characterized in that the hammer head has a slightly convex, elongated contact surface in the length direction for contact with the weld toe.

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Preferably, the elongated contact surface of the hammer head has a radius in the transverse direction that is smaller than the radius in the length direction.

Preferably, the elongated contact surface of the hammer head has a smoothly rounded form in each end.

Preferably, the contact surface of the hammer head is polished
5 with a surface smoothness better than Ra 1.2.

Preferably, the radius of the hammer head in its length direction is larger than two times the radius of the hammer head in its transverse direction and smaller than 20 times of the radius in
10 the transverse direction.

The present invention combines geometrical improvement of the weld toe profile with elimination of residual stresses and establishment of beneficial compressive stresses, in that the
15 hammer peening is carried out in a novel way by means of a hammer head, where the geometry of the hammer head is strongly changed in relation to prior art, with significantly improved geometry as a result.

20 A geometrical improvement, which so far only has been known from grinding or re-melting of the weld toe by TIG is according to the invention combined with the advantageous elimination of residual stresses.

25 The present invention is preferably used for hammer peening.

Further advantages as well as advantageous features of the present invention will appear from the following description and the dependent claims.

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BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, a specific description of preferred embodiments of the invention cited as examples follows below.

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In the drawings:

- Fig. 1 shows a hammer head according to an embodiment of the invention, mounted in a pneumatic hammer,
Fig. 2 shows a side view of the hammer head in Fig. 1;
Fig. 3 shows a frontal view of the hammer head in Fig. 2,
5 Fig. 4 shows a weld ready for grinding of a steering groove at the weld toe,
Fig. 5 shows a pregrinded steering groove,
Fig. 6 shows position of the hammer head in the steering groove,
10 Fig. 7 shows a finished cold worked weld toe,
Fig. 8 shows fatigue strength of a specific untreated weld,
Fig. 9 shows fatigue strength of the same type of weld as in Fig. 8 after it has been cold worked according to an embodiment of the invention, and
15 Fig. 10 shows a preloading load sequence applied to the welds tested, and for which the results are presented in Figs. 8 and 9.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

- 20 Figure 1 shows a part of a pneumatic hammer 1 with a hammer head 2 according to an embodiment of the invention.

The hammer head 2 is shown in more detail in Figs. 2 and 3. The hammer head 2 is characterized in that it has a slightly convex, elongated contact area or surface 3, here with a radius 4 in the
25 transverse direction that is smaller than a radius 5 in the length direction. The contact surface of the hammer head to be used against the weld toe (9 in Fig. 4) has a smoothly rounded form in each end 6,7. As seen in Figs. 2 and 3 the radius 5 of
30 the hammer head in the length direction is larger than two times the radius 4 of the hammer head in the transverse direction, and smaller than 20 times the radius 4 in the transverse direction. The figures as here given define preferred ranges. The contact surface of the hammer head to be used against the weld toe is,
35 although not shown, advantageous polished with a surface smoothness better than Ra 1.2.

Figure 4 shows a cross section through a weld 8 where one of the weld toes 9 is to be grinded with a suitable tool 10. In Fig. 5 the pregrinded steering groove is shown. Fig. 6 shows a position of the hammer head 2 against the steering groove 11. In Fig. 7 a finished cold worked weld toe 9 is shown. As here shown the groove bottom 11 is smooth, and folded material 12 and 13 along the groove edges is also shown. The other weld toe is cold worked in a corresponding way, although not shown. It should be realized that the steering groove as shown in Figs. 5, 6 and 7 is grossly exaggerated for the purpose to more clearly illustrate the exemplified embodiment.

The pregrinding of the groove 11 is carried out by smooth movements with an even and firm, but not an intensive, pressure on the tool 10. The tool 10 is preferably held about 30 to 50 degrees relative the normal of the work piece and is evenly moved along the weld toe. The tool is to be moved all the time. For very critical connections, the steering groove should be investigated for cracks with NDT (non destructive testing), visual inspections will however normally be sufficient.

The cold working is carried out by an even pressure against the continuously moving hammer tool. Usually three movements or passes by the hammer in the steering groove are recommended.

As mentioned above, the bottom of the groove should be smooth and without substantial singular indentations due to "jumps" of the hammer head 2. The surface roughness in the bottom of the groove 11 is measured to be below Ra 0.5. The groove edges can be slightly folded, this is however of no importance for the fatigue resistance.

The present invention results in a more significant improvement of fatigue life than up to now known methods, also for high stresses. The fundamental principle and idea behind the invention have been fully confirmed by laboratory tests. These tests were performed in such a way so as to obtain a direct relationship between fatigue life of steel connections and such connections

where the weld toe has been smoothly hammered, more exactly hammered by means of a pneumatic hammer with attached hammer head.

- 5 Figure 8 shows the fatigue strength according to performed tests for untreated welds 14. Figure 9 shows the fatigue strength according to performed tests for cold worked welds for the same type. As shown in Fig. 9 considerable improvements are obtained by the invention. Figure 10 shows a preloading sequence that was
10 applied to the welds tested, prior to the fatigue testing, where the probes were exposed to an even amplitude 17 of tensile stresses, after each testing probe has been loaded with five load cycles 16 to yield in form of compressive stresses such as 0.85 YS. The improvement as shown in Fig. 9 appears therefore
15 regardless if the conventional effect of the hammering is reduced after the hammered specimen is exposed to yield stresses.

- The invention is of course not in any way restricted to the preferred embodiments described above. On the contrary, many
20 possibilities to modifications thereof will be apparent to a person with ordinary skill in the art without departing from the basic idea of the invention such as defined in the appended claims.

CLAIMS

1. A method for obtaining enhanced fatigue strength in welded metal joints and -components comprising a weld toe (9), where the weld toe (9) is subjected to cold working such that a visible and/or measurable indentation at the weld toe
5 (9) is produced, **characterized in** that the cold working is carried out by means of a power driven hammer head, which has a slightly convex, elongated contact surface (3) in the length direction for contact with the weld toe (9).
- 10 2. The method according to claim 1, **characterized in** that the cold working is carried out in a pregrinded steering groove (11) or a pregrinded track rounding the weld toe (9) profile to a geometry fitting the geometry of the hammer head.
- 15 3. The method according to claim 1 or 2, **characterized in** that the weld toe (9) is subjected to the cold working sufficiently to produce a smooth-forged hammered track (11) without individual indentations deviating more than 10 % of the average indentation obtained by the cold working.
- 20 4. A hammer head for use at cold working of a weld toe (9) for obtaining enhanced fatigue strength in welded metal joints and -components, **characterized in** that the hammer head (2) has a slightly convex, elongated contact surface (3) in the
25 length direction for contact with the weld toe (9).
5. The hammer head according to claim 4, **characterized in** that the elongated contact surface (3) of the hammer head (2) has a radius (4) in the transverse direction that is smaller
30 than the radius in the length direction.
6. The hammer head according to claim 4 or 5, **characterized in** that the elongated contact surface (3) of the hammer head (2) has a smoothly rounded form in each end (6,7).

7. The hammer head according to any of claims 4 to 6,
characterized in that the contact surface of the hammer head
(2) is polished with a surface smoothness better than Ra
1.2.

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8. The hammer head according to any of claims 4 to 7,
characterized in that the radius (5) of the hammer head (2)
in its length direction is larger than two times the radius
(4) of the hammer head (2) in its transverse direction and
smaller than 20 times of the radius (4) in its transverse
direction.

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9. Use of the method according to any of claims 1-3 and/or the
hammer head according to any of claims 4-8 for hammer
peening.

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