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(71) Applicant: **SANDVIK AKTIEBOLAG**

S-811 81 Sandviken 1(SE)

(72) Inventor: **Rystedt, Per Anders**
Dalagatan 1 A
S-811 31 Sandviken(SE)

(74) Representative: **Eriksson, Kjell et al**
Sandvik AB Patent Department
S-811 81 Sandviken(SE)

(54) **Method to increase the strength of an element for percussive drilling.**

(57) The present invention relates to a method to increase the strength of an element for percussive drilling, said element being made of hardened steel and transferring impact energy in its axial direction, said method involving deep rolling of the surface layer of the element, at least in certain sections. The invention also refers to an element worked in accordance with the method of the invention.

Fatigue cracks in elements of the above mentioned kind are initiated in areas having an intensive dislocation motion. Such areas are originated near notches and parts having sharp-edged corners.

The aim of the present invention is to remedy the influence that "poor surfaces" have upon the fatigue strength.

The main characterizing feature of the invention is that said deep rolling of elements for percussive drilling creates a surface finish ≦ Ra 1.0.

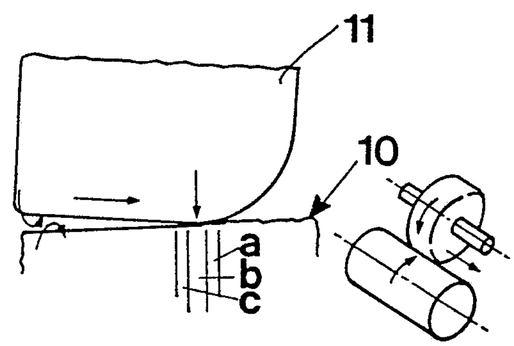

Fig.5

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Method to increase the strength of an element for percussive drilling

The present invention refers to a method to improve the strength of an element for percussive drilling, said element being made of hardened steel and transferring impact energy in its axial direction, said method involving deep rolling of the surface layer of the element, at least in certain sections. The invention also refers to an element worked in accordance with the method according to the invention.

By the term fatigue the structural change is meant that arises due to the influence from a pulsating load and that eventually gives rise to a successively growing crack resulting in a fracture. Fatigue is caused by strain hardening in connection with a complex dislocation motion and fatigue cracks are initiated in areas of very intensive dislocation motion. Such areas originate near notches and parts having sharp-edged corners etc. From this it is concluded that to a great extent fatigue cracks are initiated at the surface of the material.

The normal prior art method to counteract the creation of fatigue cracks is to produce compression stresses in the surface layer of the element. This is normally effected by shot peening. However, this method provides comparatively rough surfaces of the element that is treated. This is an obvious disadvantage since the surface finish also is of importance for the creation of fatigue cracks.

The aim of the present invention is to remedy the negative influence that "poor" surfaces have upon the fatigue resistance. Said aim of the present invention is realized by a method and an element that has been given the characteristics of the appending claims.

Below the invention will be described more in detail, reference being made to the accompanying drawings. Figs.1-5 disclose how deep rolling is carried out; Fig.6 discloses comparative surface sizing for different treatments; Fig.7 shows how fatigue test of test pieces has been carried out; and Fig.8 discloses a table of results from the fatigue test.

The characterizing feature of the invention is thus that the surface layer of elements for percussive drilling, at least in some "slim" sections, is subjected to deep rolling. As non-restrictive examples threads of drifter rods, external surfaces of hexagonal rods and radii of down-the-hole bits may be mentioned. By the deep rolling plastic deformation of the surface layer of the element without heat treatment is achieved. There are basically three reasons why the plastic working of the surface increases the fatigue strength.

* Compression stresses in the surface result in that the resulting stress in the surface is reduced, i.e. the amplitude of the tensile stress decreases while the amplitude of the compression stress increases.
* Cold working increases the hardness of the surface.
* Cold working makes the surface notches less sharp-edged and evens out stress peaks in the bottom of the notches.

The term "elements for percussive drilling" refers to elements transferring impact energy in their axial direction.

For an extremely schematic illustration of deep rolling reference is being made to Figs.1-3. As is apparent from these figures an element 10 is worked by a rotating roller 11 under high pressure. This means that a rotation is imparted to the element 10 itself. This is indicated in Fig.1 and 2 by arrows of rotation 12 and 13. Normally a number of rolling laps of the element 10 are carried out. As pointed out above the idea of the invention includes both deep rolling of the entire element 10 as well as deep rolling of only certain portions of the element 10. In case of deep rolling of the surface layer of e.g. a hexagonal rod no rotation of the rod is carried out but the rod itself is fed axially past a deep rolling roller. In Fig.4 it is shown what the distribution of compression stresses looks like in a deep rolled radius. The depth of the compression stresses can reach up to 4 mm and depends on rolling pressure, material, etc.

In Fig.5 is shown more in detail how deep rolling is carried out. The rotating roller is designated by 11 and the detail by 10. The plastic working of the surface layer is provided by applying comparatively high forces - forces that exceed the yield point of the material - and thereby a plastic deformation occurs. Below the contact surface a wedge shaped zone is created. In said zone the condition of the material is changed. The surface layer is primarily compressed in subzone a and then it is plastified in subzone b and finally "flattened down" to a superfinish in subzone c as the contact is decreased and the stresses are reduced.

The main process is carried out in the area of the plastifying, whereby both the tops and the bottoms of the surface are plastified. For a complete glazing of the surface a rolling lap is required. After a number of rolling laps the tops have in principle filled the bottoms in the metal cutted surface. This is however carried out in micro level and therefore no breaking down of coarseness tops occurs.

It is extremely important that the originated contact area gets the above mentioned wedge shape having its terminating point directed in the feeding direction of the deep rolling roller. The elongated feeding zone prevents the material from building up bulge-like at the end of the roller involving the risk of a thread-like waviness occurring on the surface of the part.

In order to give an understanding of the finish of the surfaces after shot peening and deep rolling resp. reference is being made to Fig.6 that also shows a turned surface. Both in shot peening and deep rolling one starts with a turned surface. Comparative tests have been made upon test pieces that through bending fatigue by 4-point load, se Fig.7, have been subjected to load changes, either to a fracture or until the number of load changes exceed 10^6. The test pieces have after turning either been untreated, shot peened or deep rolled. As is appearent from the table in Fig.8 significantly higher fatigue resistances are achieved for the deep rolled test pieces as compared to untreated and shot peened test pieces.

The present invention thus refers to deep rolling of elements for percussive drilling. Said elements are made out of hardened, preferably case-hardened, steel. The deep rolling gives rise to compression stresses to a depth of preferably at least 0.5 mm from the surface that is worked. The residual stress (compression) of the element must preferably be > 0.5 σ_S. According to a preferred embodiment of the invention the residual stress (compression) must be in the magnitude of 0.7-0.8 σ_S. The surface finish that is achieved by the deep rolling must be ≦ Ra 1.0.

The expression roller burnishing is in principle equivalent with the above used deep rolling. However, there is usually the difference that in deep rolling higher forces are used within a more concentrated area of the element that is worked. No definite border line between the two methods exists but there is an overlapping zone. Throughout the present application the expression deep rolling has been used.

In this connection the well-known fact should be pointed out that corrosion reduces the fatigue resistance. A more finished surface makes it harder for the corrosion to attach itself to the surface. This is manifested in such a way that more finished surfaces give rise to a more general nature of corrosion while coarse surfaces more likely get pittings. Since the products within the field of percussive rock drilling often work in extremely corrosive environments it is of the utmost importance that the corrosion is counteracted as much as possible.

Within the scope of the invention it is possible to have a further treatment of the elements for percussive drilling after the deep rolling. This subsequent treatment has the aim of further improving the surface finish of the elements. Preferably this improvement of the surface finish is achieved by polishing or grinding. Said surface finish is preferably in the magnitude of Ra 0.1.

To sum up it can be concluded that elements for percussive drilling are subjected to a pulsating stress that gives rise to fatigue cracks. The deep rolling of an element for percussive drilling simultaneously provides compression stresses in the surface layer and a comparatively high surface finish.

The invention can be varied freely within the scope of the appending claims.

Claims

1. Method to increase the strength of an element for percussive drilling, said element being made of hardened steel and transferring impact energy in its axial direction, said method involving deep rolling of the surface layer of the element, at least in certain sections,
characterized in that said deep rolling creates a surface finish ≦ Ra 1.0.

2. Method according to claim 1,
characterized in that the residual stress is bigger than half the yield point.

3. Method according to claim 1 or 2,
characterized in that the deep rolling gives rise to compression stresses to a depth of at least 0.5 mm from the surface that is worked.

4. Method according to any one of the previous claims,
characterized in that after the deep rolling the element is subjected to polishing.

5. Element for percussive drilling, said element being made of hardened steel and transferring impact energy in its axial direction, the surface layer of the element, at least in certain sections, being deep rolled,
characterized in that said deep rolled sections having a surface finish ≦ Ra 1.0.

6. Element according to claim 5,
characterized in that the residual stress is bigger than half the yield point.

7. Element according to claim 5 or 6,
characterized in that the compression stresses caused by the deep rolling are present to a depth of at least 0.5 mm from the surface that is worked.

8. Element according to any one of claims 5 to 7,
characterized in that the deep rolled sections are polished.

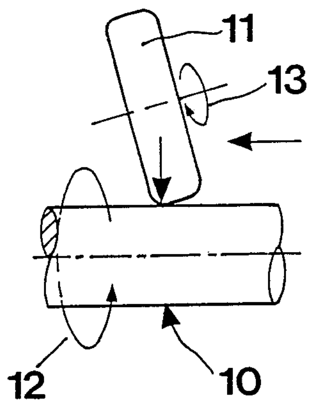

Fig.1

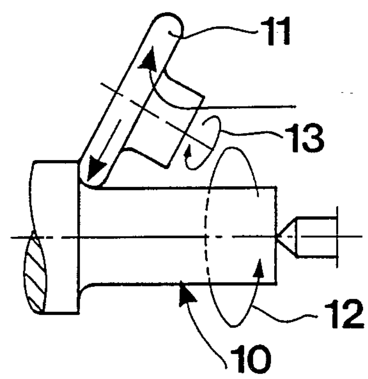

Fig.2

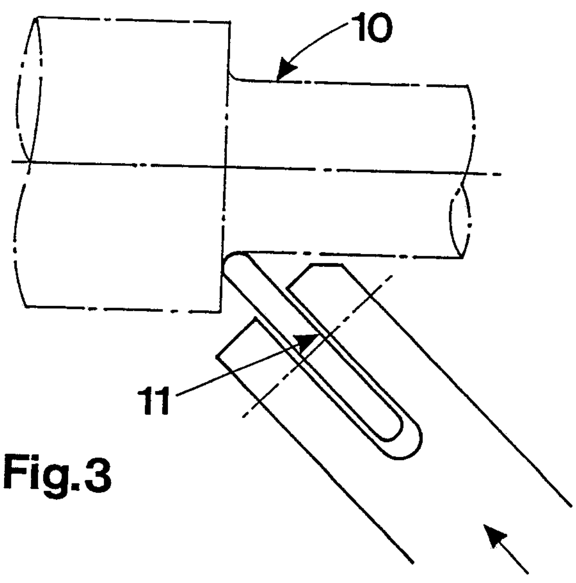

Fig.3

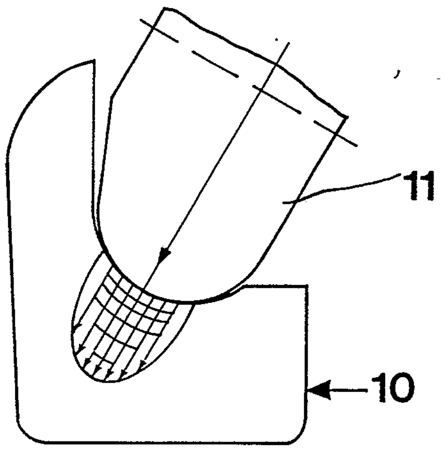

Fig.4

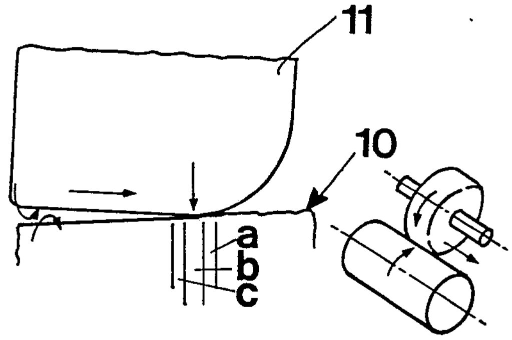

Fig.5

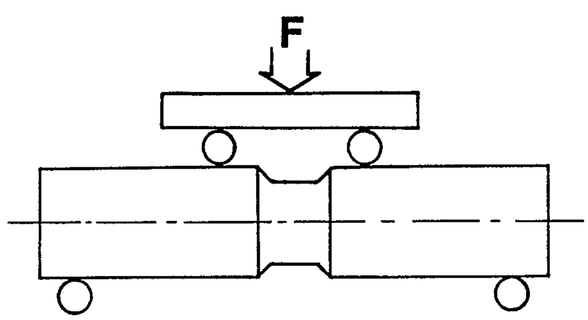

Fig.7

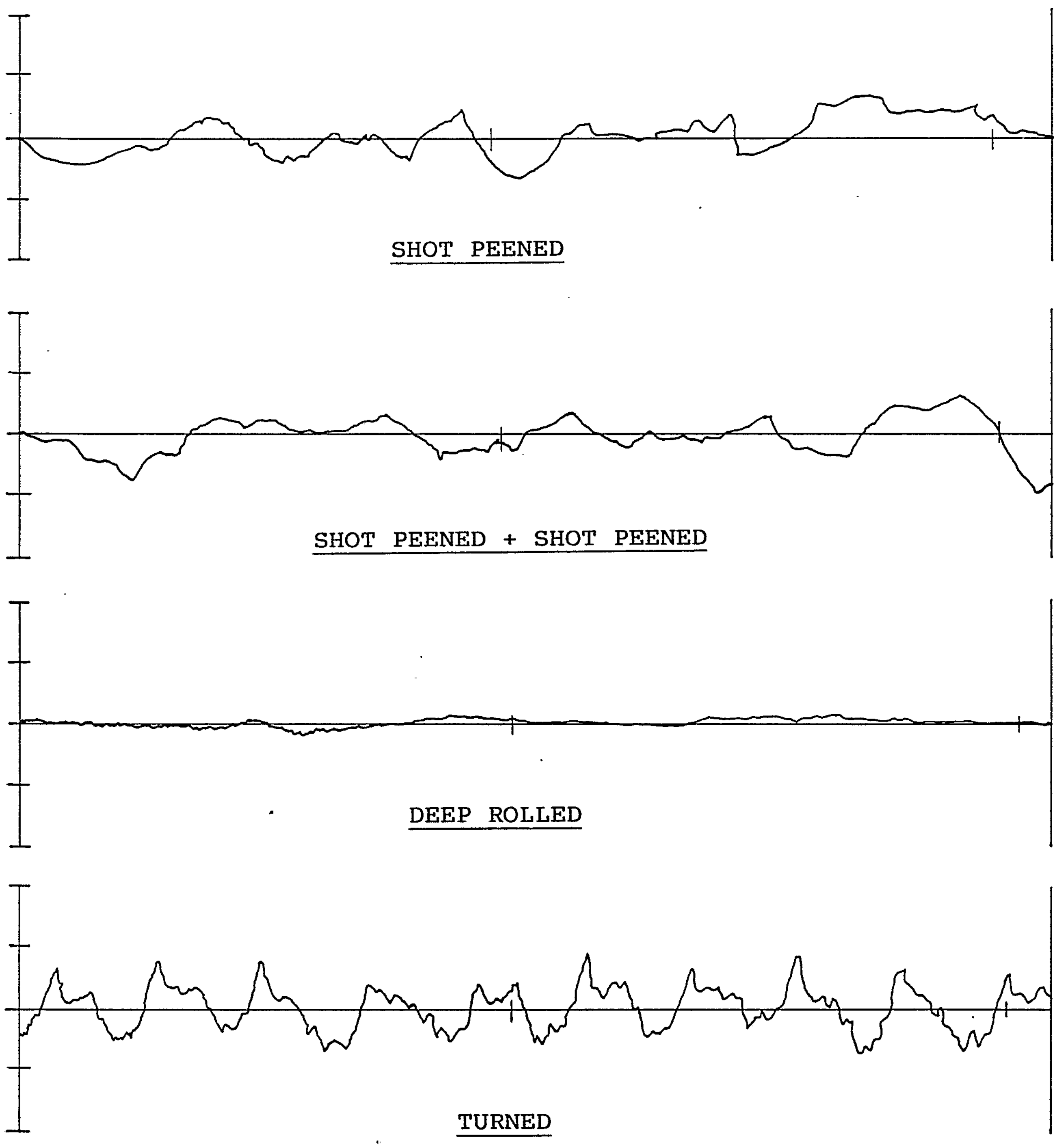

Fig.6

TABLE 1 NUMBER OF LOAD CHANGES UP TO FRACTURE

Material \ Condition	Load, ton						
	2-4	2-4.5	2-4.75	2-5	2-5.5	2-6	2-6.5
Case-hardened steel							
Untreated	-	63800	-	19600	-	-	-
Shot peened	320400	53750	-	16900	-	-	-
Shot peened x 2	-	105650	88800	56400	-	-	-
Deep rolled	> 10^6	> 10^6	> 10^6	> 10^6	64900	-	-
Tough-hardened steel							
Untreated	-	48000	-	-	-	-	-
Shot peened	246000	131000	133700	109250	-	-	-
Deep rolled	-	-	> 10^6	> 10^6	> 10^6	> 10^6	77600

Fig.8

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EUROPEAN SEARCH REPORT

Application Number

EP 90 85 0025

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	MACHINES AND TOOLING, vol. 40, no. 1, 1969, pages 35-39; Y.G. SHNEIDER: "Classification of metal-burnishing methods and tools" * Page 36, items no. 3-8 * ---	1,2,5,6	C 21 D 7/08
A	METAL SCIENCE AND HEAT TREATMENT, vol. 19, no. 7/8, 8th July 1977, pages 624-626; D.D. PAPSHEV et al.: "Formation of the hardened layer during burnishing of steel 55SM5FA" * Figure 1; page 625, lines 13-18 * ---	1,2,3,5,6,7	
A	TOOLING AND PRODUCTION, vol. 36, no. 10, January 1971, pages 37-38; "Burnishing that's really not" * Page 37, left-hand column, lines 27-30 * ---	1,5	
A	METAL PROGRESS, vol. 118, no. 2, July 1980, page 51, Cleveland, US; "Surface roughness averages for common production methods" * Line 17 * ---	1,5	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C 21 D
A	STAHL UND EISEN, vol. 104, no. 14, July 1984, pages 657-660, Düsseldorf, DE; E. VON FINCKENSTEIN et al.: "Eigenspannungen beim Oberflächen-Feinwalzen" ---		
A	US-A-3 770 595 (CROS et al.) -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10-05-1990	WITTBLAD U.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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