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(71) Applicant *(for all designated States except US)*: **OUTOKUMPU OYJ** [FI/FI]; Riihitontuntie 7, FI-02200 Espoo (FI).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **TORVINEN, Terho** [FI/FI]; Matalamaantie 8, FI-67100 Kokkola (FI). **SALMINEN, Antti** [FI/FI]; Multamäenkatu 3 A, FI-53850 Lappeenranta (FI).

(74) Agent: **OUTOKUMPU OYJ, LEGAL AFFAIRS AND IPR**; P.O. Box 140, FI-00221 Espoo (FI).

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(54) Title: METHOD FOR REMOVING AN OXIDATION FROM THE SURFACE OF A METAL OBJECT

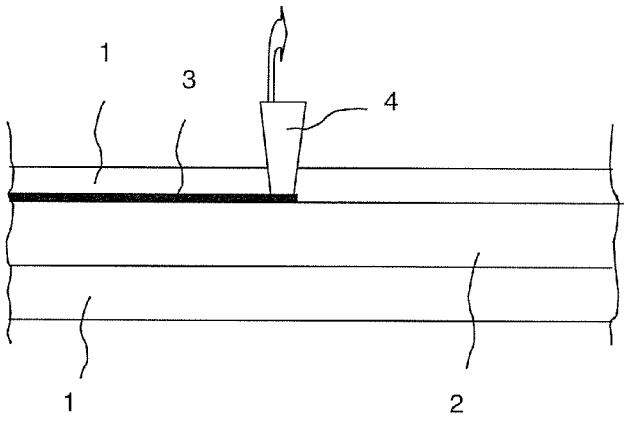

FIG. 1

(57) Abstract: The invention relates to a method for the removal of an oxidation from a surface of metal object. It is directed to an oxidation (3,12) on the surface of a metal object (2,11) at least one laser beam (4,13), which is essentially absorbed on the surface of the oxidation (3,12) existing on the surface of the metal object, in which case the oxidation (3,12) is heated and the oxidation (3,12) is made to remove without any mechanical treatment.

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METHOD FOR REMOVING AN OXIDATION FROM THE SURFACE OF A METAL OBJECT

This invention relates to a method for removing an oxidation from the surface of a metal object, onto which surface at least one laser beam is conducted. The method is suitable advantageously for a continuously-operated removal of an oxidation from a movable metal surface.

An oxidation on the surface of a metal object causes corrosion to the surface in question. Therefore, the oxidation is typically removed either chemically by pickling, i.e. by an acid treatment, or mechanically by grinding for instance with a mechanical grinding wheel. The advantage of pickling is that the surface becomes even and scratchless. In wire brushing it is needed acids, but from the metal it is loosened fine particles, which are dangerous especially for craftsmen. Further, brushing scratches the metal surface. The brushing done as hand work is also remarkably difficult working phase. The mechanical removal of an oxidation leaves the surface without a protective oxide layer and is vulnerable for corrosion. The mechanical removal of an oxidation is carried out for instance in the JP patent application 1-170592 by dry honing or by shot peening before laser welding. According to the JP patent application 2-088161 the surfaces of a metal strip to be welded is cleaned from an oxide film by means of sand rollers before seam welding.

Nowadays pickling is typically carried out in a large basin with a great amount of acid. The object to be treated is dipped into the basin totally, although the treatment is often needed to a part of the object. During the treatment the acid is diluted, when the material to be pickled is dissolved therein. Because usually it is treated the whole object and not only the part required for the treatment, the acid is diluted mostly groundless. After a defined use period the acid shall be renewed and the neutralization of a great amount of acid is problematic. The effect of the acid treatment can be added by increasing the process temperature, but the consequence therefrom is usually the problem, that

substantial amounts of acid is evaporated into air in which case the cleaning of air is made more effective. With the large objects it can pickle the arrant welding seam, but then the danger is an uneven process, because the acid is spread on the point to be treated manually and the acid is allowed to effect a correct time. The implementation of both the spreading and the correct effecting time so that it is in every point similar, is in practice remarkably difficult. The problem in so called paste pickling is safety at work and environment protection; drilling water cannot lead into a sewer. The removal of an oxidation is described for instance in the JP patent application 56-105467, wherein an oxide film on the welding zone and on its surroundings is removed by pickling and by wet cleaning after pickling. A chemical removal of an oxidation is carried out also in accordance with US patent 6656603. In the continuously-operated method of the CN patent application 101249606 pickling is used for the removal of an oxidation being on the surface of metal plates.

In the US patent 4245768 it is described a method for the removal of an oxidation wherein gas, such as xenon or argon, is by an ion beam generator ionized and accelerated towards the metal surfaces to be cleaned in a vacuum. This kind of solution is suitable for special purposes and for small objects, because the required device arrangements are very expensive.

From the JP patent application 3-052775 it is known a method, wherein it is prevented by TIG method to create oxide scale formed by an oxide layer of the inner surface of a tube made of stainless steel and to be welded when feeding hydrogen gas in the interior of the tube to be welded. By means of hydrogen gas the creation of the oxide layer can be decreased, but from the safety at work point of view the use of hydrogen gas in this purpose is risky.

The object of the present invention is to eliminate some drawbacks of the prior art and to achieve an improved method for the removal of an oxidation for a metal surface advantageously essentially continuously-operated by means of at

least one laser beam directed on a surface of a metal object. The essential features of the invention are enlisted in the appended claims.

According to the invention it is directed to an oxidation in the metal object or on the surface of a metal object at least one laser beam so that the laser beam is used for heating the oxidation on the surface of the metal object, in which case the removal of the oxidation from the surface of the metal object is accelerated without a separate mechanical treatment. According to the invention the metal can even be vaporized by using the laser beam with a great intensity. The treatment according to the method is further concentrated essentially to the point required for the treatment on the metal surface. The method of the invention can be used for the removal of an oxidation either in connection with a pickling treatment or without a pickling treatment.

The at least laser beam to be used in accordance with the invention is selected from the wave length of view such that the laser beam is absorbed essentially only to a metal surface or to the surface of an oxidation on the metal surface. With the advantageous selection of the wave length of the laser beam it is further prevented the essential absorption of the laser beam into a pickling liquid possibly surrounding the metal surface. When reaching the metal surface the laser beam heats the oxidation on the metal surface to a higher reaction temperature in order to accelerate the removal of the oxidation from the metal surface. The temperature change created by the laser beam is so small that the surface surrounding the oxidation is not essentially heated and the surface surrounding the oxidation is not fallen vulnerable for the impact of the laser beam.

When using the method according to the invention in connection with a pickling treatment of a metal surface thanks to the laser beam directed to an oxidation it can be used in the pickling treatment a more dilute solution, because the pickling is carried out only in the desired point of the metal surface. The pickling liquid can be changed and cooled outside the point to be pickled. Thus it is

prevented the vaporization of the pickling liquid caused by a possible over-heating. The cooling of the pickling liquid is carried out advantageously by circulating the heated part of the pickling liquid. In connection with the circulation of the pickling liquid it can advantageously be cleaned and cooled in an essentially continuously-operated process.

The heat-up of a pickling liquid in an oxidation on a metal surface in connection with the method of the invention causes itself a liquid flow, because the heated part of the acid tries to move away from the heating point. So the over-heating of the pickling acid is prevented and simultaneously the circulation of the pickling acid is made to start. The flow and the cooling can be made more effective by external devices. Thus the consumption of the pickling acid through vaporization remains essentially small. The possible vaporization is further local and the vaporization can be controlled easier by point removals than the vaporized acid from the large pickling basins.

The method according to the invention can be used also without a pickling liquid surrounding the metal objects to be treated. It is directed to an oxidation on a metal surface at least one laser beam, which heats and even vaporizes the oxidation and the generated vapor pressure breaks the oxidation. Thanks to the vapor pressure the parts of the oxidation further come loose from the metal surface and the metal surface is made to clean of the oxidation.

In the method according to the invention the laser beam is used advantageously as pulse-type, in which case the individual laser pulses are directed to the surface of a metal object advantageously partly bonded towards the metal object to be treated longitudinally and/or transversely. The bonded relation depends on the application and on the treatment speed required for the oxidation. By means of the bond it is also possible to broaden the treating area of the oxidation, if needed, when the bon is done advantageously in two directions towards the metal object both longitudinally and transversely.

The removal of an oxidation from a metal surface according to the invention can be done advantageously by a laser device for generating a laser beam, whereto it is connected a so-called scanner optics. In the scanner optics the beam is lead through two mirrors to the surface to be treated. Using the mirrors it can be generated a realization of two movements being perpendicular to each other. The optics has also a focus of the beam, with which the size of the beam is diminished to the intensity required in the processes. By means of this scanner optics it is generated the movement of the laser beam for cleaning a metal surface. When using optical fiber in the conduction of the laser beam to the scanner optics, it is received a laser device easily to be moved. This device is moved along the metal surface to be cleaned advantageously by a robot, a manipulator or alternatively manually. When required the treatment of the metal surface can be repeated at least once in which case the metal surface can be cleaned more deeply.

When using in the method according the invention an device based on a laser and a scanner optics the treatment speed of the device connected to the removal of the oxidation is made to accelerate by adding instead of one scanner optics device two or more scanner optics devices. The laser device for generating the laser proper can be positioned then essentially long away from the surface to be treated, if the laser is conducted to the scanner by means of a optical fiber. When using two or more scanner optics devices for conducting the laser beam to the metal surface to be treated it can be optimized the removal of the oxidation, and the first stages of the oxidation removal can be, if required, done with different laser parameters or with different laser types. In the oxidation removal according to the invention it can then be performed for instance first the breaking of the surface to be treated at least once, thereafter it is performed the surface cleaning at least once. In the terminating stage of the oxidation removal, advantageously in the cleaning stage wherein the metal surface is at least partly pure, the oxidation removal is performed, if desired, in a protecting gas and so it is prevented the rapid oxidation of the surface when using reactive materials.

When using the method according to the invention in connection with a movable metal surface, when the metal surface itself performs a longitudinal movement, it can be used advantageously at least one scanner optics device, which moves a laser beam advantageously only transversely considering the moving metal surface. Advantageously there are scanner optics devices then several sequential, advantageously 2-5 pieces, from which devices everyone treats one certain layer thickness. The speed of the scanner optics device can be adjusted further by changing the power to be led to the device.

The method according to the invention can be used advantageously also for metal objects wherein it is possible to separate both an outer surface and an inner surface. These kind of metal objects are for instance tubular metal objects manufactured by welding, in which objects it can be directed to the external or to the internal or alternatively both to the external and to the internal welding seam a laser beam by means of a scanner optics for the removal of an oxidation when manufacturing a tubular object. Depending on the welding speed the operation speed of the scanner optics device can be adjusted by adding the power to be fed in the device or by using several scanner optics devices.

The invention is described in more details in the following referring to the attached drawings, wherein

Fig. 1 shows one preferred embodiment of the invention schematically from the side view in connection with a pickling treatment,

Fig. 2 shows another preferred embodiment of the invention schematically from the side view,

Fig. 3 shows the embodiment of Fig. 2 schematically from the top view.

According to Fig. 1 the pickling liquid 1 is surrounding a metal object 2 to be pickled, on which surface is an oxidation 3, which has been generated in the weld of the metal object 2. It is directed to the oxidation 3 from the outside of

the pickling liquid 1 a laser beam 4, which wave length transmits the pickling liquid 1 essentially without any absorption. When facing the metal object 2 the laser beam 4 heats the oxidation 3, in which case the increase of the temperature intensifies the pickling of the metal object 2 generated by the pickling liquid 1 and thus accelerates the pickling process itself. The heating of the oxidation 3 causes in the pickling liquid 1 liquid flow, in which case the heated part of the pickling liquid 1 tries away from the heating point. The pickling liquid 2 surrounding the oxidation 3, however, cools the heated part of the pickling liquid 1 in which case the consumption of the pickling liquid 2 caused by the laser beam 4 remains small.

In Fig. 2 it is directed to an oxidation layer 12 on the surface of a metal object 11 moving to the direction 17 a laser beam 13, which heats and vaporizes the oxidation layer 12. The pressure of generated vapor breaks the oxidation layer 12 and the recoil generated by vaporization removes the broken oxidation layer 12 from the surface of the metal object. The laser beam 13, which is connected with a laser optics device and further to the power source through a connection 16, is conducted to the oxidation layer 12 as pulse-type so that the individual laser beam pulses are directed to the surface of the metal object 11 partly bonded.

In Fig. 3 the oxidation layer 12 on the surface of the metal object 11 is essentially broad and the laser beam pulses 13 directed to the oxidation layer 12 are made to move partly bonded both in the longitudinal direction of a metal object 11, as shown in Fig. 3 in bonded circles 14, and in the lateral direction, as shown in Fig. 3 in arrows 15.

EXAMPLE

In the table 1 it is described results, when the method according to the invention has been used for the removal of an oxidation from the surface of a stainless steel. As a laser source it was used a VMc5 laser, a diode pumped

ytterbium vanadate laser, which produces a wave length of 1064 nanometer. Further, it was used optics of 163 millimeter, that means the focal length of 163 millimeter for the scanner optics. The laser source was used with a pulse power of 50 kW and the sequence of the loading of the laser source was 0,05 millimeter, i.e. it was fed into the laser source the power, when the transition on the metal surface was 0,05 millimeter.

The removal of the oxidation took place in two stages; first the oxidation was ground at least once, after which it was performed a cleaning, i.e. the removal of the oxidation. In the grinding the scanner speed was at the frequency 60 kHz 500 millimeter per second, except in the test 11, where the speed was 100 millimeter per second. The number of the repeats mentioned in the table 1 means treatment times, i.e. the laser beam was scanned on the surface to be cleaned several times with the same parameters, if the number of the repeats is more than 1. For instance in the test four the grinding was repeated for the whole area with one parameter combination four times and thereafter the cleaning with the parameters once. The cleaning circulation removes residues of the grinding and makes the imprint uniform. In the cleaning the scanning speed was greater, i.e. at the frequency 60 kHz 5000 millimeter per second in all tests. The grinding done before the cleaning accelerates machining, but the cleaning makes the imprint uniform. If it was driven only with grinding times, the imprint would be more nonuniform and dirty. The repeat of only the cleaning circulation instead would lengthen the machining essentially.

Laser	VMc5 Trumpf	
optics	mm	163
Loading		net
Sequence of loading	mm	0,05
Focal length	µm	40
Power	W	50kW
Pulse time	ms	

	Grinding						Cleaning						The whole process						
	Power	frequency	speed	repeat	portion	time	Power	frequency	speed	repeat	portion	time	time	area	speed		10 mm wide band		
	%	Hz	mm/s	times		s	%	Hz	mm/s	times		s	s	mm²	mm²/min	cm²/min	m²/h	mm/min	m/min
1	100	60 000	500	1	0,909	8,364	100	60 000	5 000	1	0,091	0,836	9,20	100	652	6,52	3,91	65,22	3,91
2	100	60 000	500	2	0,952	16,476	100	60 000	5 000	1	0,048	0,824	17,30	100	347	3,47	2,08	34,68	2,08
3	100	60 000	500	3	0,968	24,687	100	60 000	5 000	1	0,032	0,823	25,51	100	235	2,35	1,41	23,52	1,41
4	100	60 000	500	4	0,976	32,829	100	60 000	5 000	1	0,024	0,821	33,65	100	178	1,78	1,07	17,83	1,07
5	100	60 000	500	5	0,980	40,902	100	60 000	5 000	1	0,020	0,818	41,72	100	144	1,44	0,86	14,38	0,86
6	100	60 000	500	6	0,984	49,062	100	60 000	5 000	1	0,016	0,818	49,88	100	120	1,20	0,72	12,03	0,72
7	100	60 000	500	7	0,986	57,183	100	60 000	5 000	1	0,014	0,817	58,00	100	103	1,03	0,62	10,34	0,62
8	100	60 000	500	8	0,988	65,432	100	60 000	5 000	1	0,012	0,818	66,25	100	91	0,91	0,54	9,06	0,54
9	100	60 000	500	9	0,989	73,612	100	60 000	5 000	1	0,011	0,818	74,43	100	81	0,81	0,48	8,06	0,48
10	100	60 000	500	10	0,990	81,713	100	60 000	5 000	1	0,010	0,817	82,53	100	73	0,73	0,44	7,27	0,44
11	100	60 000	100	1	0,980	40,304	100	60 000	5 000	1	0,020	0,806	41,11	100	146	1,46	0,88	14,59	0,88

Table 1

CLAIMS

1. Method for the removal of an oxidation from a surface of metal object, **characterized** in that it is directed to an oxidation (3,12) on the surface of a metal object (2,11) at least one laser beam (4,13), which is essentially absorbed on the surface of the oxidation (3,12) existing on the surface of the metal object, in which case the oxidation (3,12) is heated and the oxidation (3,12) is made to remove without any mechanical treatment.

2. Method according to the claim 1, **characterized** in that the laser beam (4,13) is directed to the oxidation (3,12) by means of at least one scanner optics device.

3. Method according to the claim 1 or 2, **characterized** in that the individual laser pulses of the laser beam (4,13) are directed towards to the metal object (2,11) partly bonded.

4. Method according to the claim 3, **characterized** in that the individual laser pulses of the laser beam (4,13) are directed towards to the metal object (2,11) partly bonded longitudinally.

5. Method according to the claim 3, **characterized** in that the individual laser pulses of the laser beam (4,13) are directed towards to the metal object (2,11) partly bonded laterally.

6. Method according to any of the preceding claims, **characterized** in that in the method it is used sequential scanner optics devices (16), of which devices every treats a certain layer thickness from the oxidation (3,12) to be removed.

7. Method according to any of the preceding claims, **characterized** in that the method includes a grinding to be treated at least once and a cleaning to be treated at least once.

8. Method according to any of the preceding claims, **characterized** in that the speed of the scanner optics device (16) is adjusted by changing the power fed into the device.

9. Method according to any of the preceding claims, **characterized** in that it is used in connection with pickling (1) of a metal object (2,11).

10. Method according to any of the preceding claims 1 - 8, **characterized** in that it is used for the removal of an oxidation on a welding seam positioning on the internal surface of a tubular object to be welded.

11. Method according to any of the preceding claims 1 - 8, **characterized** in that it is used for the removal of an oxidation on a welding seam positioning on the external surface of a tubular object to be welded.

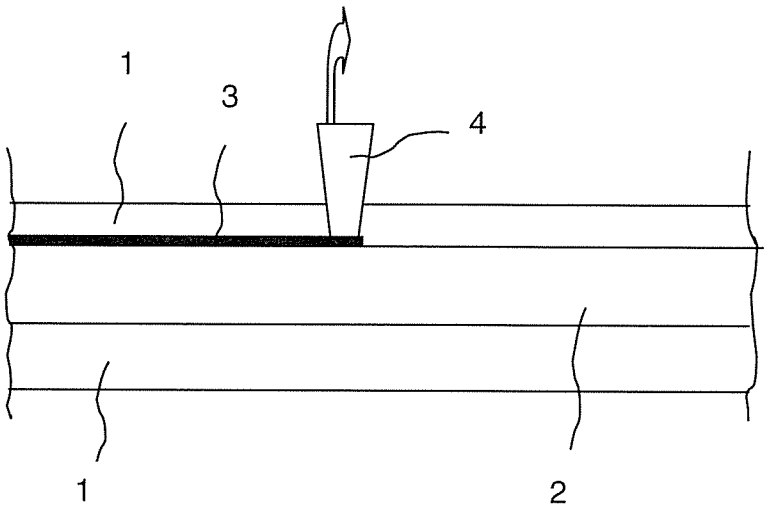

FIG. 1

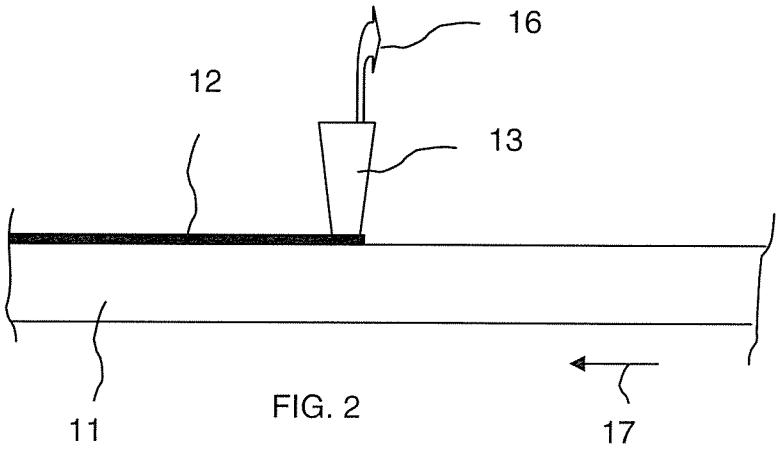

FIG. 2

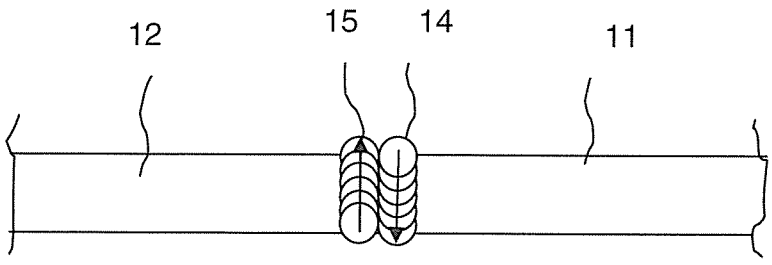

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B23K, B08B, C23G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, COMPDX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y		7, 10, 11
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Pirjo Kauraala
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT
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CLASSIFICATION OF SUBJECT MATTER

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