

PATENT SPECIFICATION

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(54) METHOD OF RESTORING WORN OR DAMAGED MARINE PROPELLOR SHAFTS

(71) I, DONALD KENNETH HEALEY, a British subject, of 31 Harbour View Road, Poole, Dorset, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of restoring a worn or damaged marine propeller shaft.

According to this invention there is provided a method of restoring a worn or damaged marine propeller shaft by the deposition and fusion of a metal to the shaft, characterised by the steps:

(a) cleaning by exposing the base metal in the area of the shaft to be restored by chemical or mechanical means,

(b) rotating the shaft in a lathe or similar machine about its longitudinal axis at an accurately controlled rate,

(c) feeding the metal to be deposited as a single wire through an inert gas shielded arc welding gun mounted on the lathe and movable longitudinally thereof to the periphery of the rotating shaft with the wire itself forming a consumable electrode for the arc,

(d) the welding gun being mounted on the lathe in a longitudinally movable manner and traversed along the shaft during rotation thereof while feeding said single wire therethrough and depositing the material of the wire as it is consumed over the length of the damaged area in the form of a continuously fused metal deposit, all while controlling the feed of the wire and maintaining a steady, continuous rotation of the shaft and traverse of the welding gun,

(e) applying current through the wire to the shaft to subject the junction of the wire and shaft as feeding and winding progresses to heating to effect fusion welding of the material of the wire to the shaft and adjacent turns to form a homogeneous substantially uniform metal deposit which blends with the base metal of the shaft, and

(f) subsequently machining in the lathe the weld deposit to provide a finished surface. The deposited metal covers the area of the

repair to a sufficient depth so that it may be subsequently machined to the original diameter.

The applied wire is preferably of the same or similar metal composition to the shaft although widely different metals can be applied, subject to the ability to form an alloy with the shaft. The weld is effected by feeding the wire through an inert gas shielded welding gun positioned close to the shaft and moved longitudinally as the winding progresses. By this method a homogeneous build-up of metal integral with the original shaft metal is effected over the damaged area and by subsequent machining the surface may be reformed.

The method is particularly useful for re-metalling the worn bearing areas or corroded areas of a propeller shaft.

The rate of rotation of the shaft, wire diameter, type of wire, work speed, current, shielding gas or gas mixtures, gas flow, electrode traverse speed, wire feed speed, voltage-work power scale, induction, electrode-polarity, work-polarity, voltage regulation, and equipment are related to the shaft diameter and welding gun used. The rotational speed of the shaft and its composition and wire size and its composition, feed rate and the related voltage and current used including the shielding gas, are related and differ for each combination of work, wire and composition. These interrelationships are complex and require experiment for optimum results. The parameters for specific embodiments are given herein by way of examples.

The method may also be applied to the reconditioning of gunmetal or aluminium bronze or alloy bearing sleeves on marine propeller shafts. Hitherto such sleeves, when only slightly worn, were machined off and a new sleeve machined and shrunk onto the shaft followed by machining and subsequent truing of the shaft.

When the process is applied to propeller shaft which have been subject to salt water a chemical de-salination process will be applied as part of the preliminary cleaning operation.

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A continuous weld of metal identical, or compatible, with the shaft is fused around the worn or damaged area of the shaft by a circular motion instead of the more commonly used lateral welding methods which can cause distortion and other problems, or metal spraying which can be the subject of porosity difficulties and lack of body strength. The continuously fed wire is simultaneously welded to the shaft and to itself as a deposition of compatible weld metal, using an inert gas shrouded electric welding process. The voltage and current is selected to ensure correct and even penetration to suit the particular shaft and weld material concerned. The process is continued until the deposit is sufficient to permit machining of the areas to the required dimensions. The laying-on of the weld is controlled by varying the traverse and rotation rate of the lathe or other similar machine being used, such as a pipe rotating machine.

Stress relieving, or heat treatment, can be carried out on completion of the method if necessary, but one advantage of the method is that in the majority of cases it is self-normalising and if the welding process is back-tracked to a suitable finishing point to allow for heat dissipation, it is unlikely that any surface cracking will occur.

It is not always necessary to machine the surface or prepare it by methods such as shot blasting, as the process can be applied to any cleaned surface.

Dissimilar metals may be used, for example stainless steel can be applied to mild steel and aluminium bronze to stainless steel, mild steel and bronze materials. Nickel-aluminium bronze also can be applied in cases where a harder wearing surface is desired.

Surface hardness can be maintained by using an appropriate metal, or subsequent heat treatment.

The method of the invention proves to be faster than known processes such as metal spraying and flame plating and is less liable to produce distortion in the shaft or affect the composition of the parent metal at lower levels.

In practice the shaft is rotated in a lathe, which is capable of rotation at an accurately controlled speed. The speed may be as low as 0.2 r.p.m. depending on diameter of the shaft and rate of metal deposition. Further the rate of traverse of the welding head across the area of the shaft being restored is variable and accurately controlled in relation to the rotational speed by means of an independent variable speed motor controlled from a variable potentiometer.

Existing machines may be easily modified to carry out the method of the invention with particular attention being given to protection

of the machine slideways from weld splatter and the method of current feed to the shaft. Because of the high direct currents employed, feeding through the machine bearings is unsatisfactory as the high current densities and attendant arcing destroys the bearing surfaces in the machine and leads to variations in weld current. This problem is overcome by fitting the machine with electric motor brushgear contacting the machine spindle or a sleeve thereon, or by using a brushgear band strapped to the workpiece to complete the circuit.

As example a two inch diameter stainless steel shaft was rotated at four r.p.m. and a 0.8 m.m. stainless steel wire was fused to the shaft using a low voltage shielded argon arc. The area of the shaft was then turned and ground to the final dimensions. This type of work can be carried out in accordance with predetermined data thereby providing minimal heat input and reducing any possible detrimental effects to the parent metal or deposited weld.

Conventional repairs using metal spraying often fail due to the porosity of the repair allowing salt water penetration and subsequent separation of the metal layers. This is avoided with the method of the invention.

The accompanying drawing shows one arrangement for carrying out the method of the invention using a conventional lathe. As shown the propeller shaft 1 to be restored is mounted for rotation by the machine headstock drive 2 in steady bearings 3 and 4. The lathe saddle 5 carries the arc welding equipment 6 with feeds for shielding gas and wire 7. An adjustment 8 provides for variation of the height of the welding equipment. The saddle 5 also carries a cutting tool and mounting 9.

The following examples taken in conjunction with the tables illustrate the various parameters for a number of combinations and dimension of shafts and wire.

In the examples the welding equipment used was by Norman Butter and Company Limited designated NBC 350 or NBC 500 being 350 Amp and 500 Amp respectively and the parameter "wire feed speed" is the dial reading on this equipment. In all examples the polarity was, welding electrode-positive, and workpiece-negative. Other sizes of different diameters can be calculated from the data presented in order to achieve satisfactory results. A wire brush is used on the opposite side to the weld gun on the workpiece to remove possible splatter which could cause pin points of porosity especially when subsequent layers are being applied. A constant voltage is to be maintained in all cases.

Example	Shaft	Wire	Weld Equipment
1	Stainless Steel EN18C	Aluminium Bronze BS2901 Part 3	NBC350
2	Aluminium Bronze DGS8452	"	NBC500
3	Aluminium Bronze	"	"
4	Monel K500	Monel 60	NBC350
5	"	"	NBC500
6	Stainless Steel EN18C	Stainless 29/9 R BS2901 Part 2	NBC350
7	Stainless Steel EN58J	Inconel 625 (Regd. Trade Mark)	NBC500
8	"	"	"
9	Gun Metal BS1400	Phosnic (Ni 1.38 : Mn 0.22 : Si 0.46 : P 0.021 : Sn 5.22 : Balance Cu)	NBC350
10	Gun Metal BS1400 1969	Phosnic	NBC500
11	Gun Metal, Admiralty Spec. DGS 203 or LG4	Phosnic N	"
12	Mild Steel EN3C	PZ.6000 BS 2901 Part 1, Al 6	NBC350
13	Mild Steel EN3B	"	"
14	Mild Steel EN3C	"	NBC500
15	EN5K C:0.25-0.35 Si:0.05-0.35 Mn:0.6-1.0 S:0.05 P:0.05	PZ.6000 C:0.25-0.3 Si 0.3-0.5 Mn:1.3-1.6 S:0.04 P:0.04	"
16	Mild Steel EN3L	PZ.6000 BS 2901 Part 1 Al 6	"
17	"	"	"
18	EN5K	PZ.6000	"

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TABLE Example No:		1	2	3	4	5	6	7	8
a	Shaft Diam. inches	2	1½	3 to 4	2	3 to 4	2	3	4
b	Wire Size, mm	0.8	1.6	0.8	0.08	1.00 to 1.20	0.8	0.08	1.0 - 1.2
c	Work Speed, rpm	6	6-8	2-9	6	4	6	3	3-6
d	Shield Gas	Argon	Argon	Argon	Argon (Pure)	Argon (Pure)	Cougar (See 1)	Cougar	Cougar
e	Gas Pressure p.s.i.	45	35-40	35-40	35-45	35-45	45	35-45	35-45
f	Electrode traverse inches/revolution	$\frac{3}{16}$	0.15	0.166	0.093	0.166	$\frac{3}{16}$	0.15	$\frac{3}{16}$
g	Wire feed (dial) (See 2)	5	6.5	6.2	10	60-70	10	84	57-65
h	Potential (Volts)	25	24	28	24	27	25	33	30
i	Current (Amps)	120-130	120-130	88	130-150	260-280	230	280-290	280-300

Note 1 - Cougar (Registered Trade Mark): 92.5% Argon: 5% CO₂ : 2.5% O₂

Note 2 - Wire feed as dial reading on specified equipment.

TABLE Cont. Example No: 9		10	11	12	13	14	15	16	17	18
a	9½	9½	9½	1¾	2	3	4	5	5	10
b	1.6	1.6	1.6	0.08	0.08	0.08	1.0	1.0 and 1.2	1.0 and 1.2	1.0-1.2
c	1	1	1	5-6	5-6	3	3	4	4	0.3
d	Argon	Argon	Argon	Argon	Argon	Cougar	Cougar	Argon	Argon	Cougar
e	34-45	35-45	35-45	35-40	35-40	35-40	45	35-40	35-40	45
f	0.1-0.2	0.187	0.187	0.093	0.166	0.15	$\frac{3}{16}$	0.166	0.166	$\frac{3}{16}$
g	4.8	6.5	6.5	$\frac{10}{(MAX)}$	$\frac{10}{(MAX)}$	84	57-65	57-70	57-70	57-65
h	29	30	32	24	24	33	30	30	30	27
i	290	300	320	130-150	130-150	280-290	280-300	280-300	280-300	270-290

TABLE 2.

EXAMPLE NO.	SETTING ON SPECIFIED EQUIPMENT			
	Coarse Voltage	Power Scale	Fine Voltage	Inductance Control
1	D	LOW	4	100
2	B	LOW	5	100
3	D	LOW	2	100
4	D	LOW	4	100
5	C	LOW	4-6	100
6	D	LOW	4	100
7	C	LOW	5-6	6.5
8	D	LOW	3-5	70
9	D	LOW	4-5	0
10	D	LOW	5	0
11	A	HIGH	3	0
12	D	LOW	4	100
13	D	LOW	4	100
14	C	LOW	5-6	6.5
15	D	LOW	3	70
16	D	LOW	3	70
17	D	LOW	3	70
18	A	HIGH	1	70

WHAT I CLAIM IS:—

1. A method of restoring a worn or damaged marine propeller shaft by the deposition and fusion of a metal to the shaft, characterised by the steps:

(a) cleaning by exposing the base metal in the area of the shaft to be restored by chemical or mechanical means,

(b) rotating the shaft in a lathe or similar machine about its longitudinal axis at an accurately controlled rate,

(c) feeding the metal to be deposited as a single wire through an inert gas shielded arc welding gun mounted on the lathe and movable longitudinally thereof to the periphery of the rotating shaft with the wire itself forming a consumable electrode for the arc,

(d) the welding gun being mounted on the lathe in a longitudinally movable manner and traversed along the shaft during rotation thereof while feeding said single wire there-

through and depositing the material of the wire as it is consumed over the length of the damaged area in the form of a continuously fused metal deposit, all while controlling the feed of the wire and maintaining a steady, continuous rotation of the shaft and traverse of the welding gun,

(e) applying current through the wire to the shaft to subject the junction of the wire and shaft as feeding and winding progresses to heating to effect fusion welding of the material of the wire to the shaft and adjacent turns to form a homogeneous substantially uniform metal deposit which blends with the base metal of the shaft, and

(f) subsequently machining in the lathe the weld deposit to provide a finished surface.

2. A method in accordance with Claim 1, wherein the wire is of the same material as the shaft.

3. A method in accordance with Claim 1



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	Coarse Voltage	Power Scale	Fine Voltage	Inductance Control
1	D	LOW	4	100
2	B	LOW	5	100
3	D	LOW	2	100
4	D	LOW	4	100
5	C	LOW	4-6	100
6	D	LOW	4	100
7	C	LOW	5-6	6.5
8	D	LOW	3-5	70
9	D	LOW	4-5	0
10	D	LOW	5	0
11	A	HIGH	3	0
12	D	LOW	4	100
13	D	LOW	4	100
14	C	LOW	5-6	6.5
15	D	LOW	3	70
16	D	LOW	3	70
17	D	LOW	3	70
18	A	HIGH	1	70

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3. A method in accordance with Claim 1

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or 2, wherein an electrical circuit for the weld gun is completed through brushgear associated with shaft.

5 4. A method according to any preceding Claim, wherein the cleaning includes a desalination process.

5. A method as claimed in Claim 1, sub-

stantially as herein described with reference to any one of the examples herein.

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