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(54) **Abrasive blast contour machining to remove surface and near-surface crack initiation**

(57) A multi-axis machine (20) includes a controller (28) operable to control a nozzle (24) which ejects a par-

ticulate material relative to a part surface (S) to maintain a compound angle and predetermined stand off distance to remove surface and near-surface crack initiation sites.

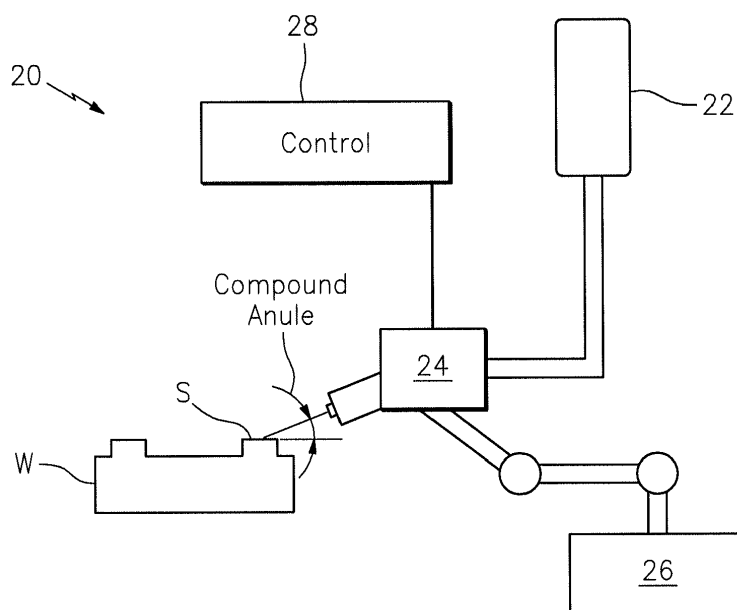


FIG. 1

Description

[0001] The present disclosure relates to a surfacing technique, and more particularly to an abrasive machining technique that eliminates crack initiation sites.

[0002] Conventional machining of alloy 718 material may introduce damage to surface and near surface carbide particles inherent to the 718 alloy. These surface carbide particles are cracked by interaction of the machining tools and the brittle carbides. Under fatigue loading conditions, these carbides may serve as preferential locations for crack initiation which may limit the useful life of the material.

[0003] A multi-axis machine according to an exemplary aspect of the present disclosure includes a controller operable to control a nozzle which ejects a particulate material, relative to a part surface to maintain a compound angle and predetermined stand off distance to remove surface and near-surface crack initiation sites.

[0004] A method of surface machining according to an exemplary aspect of the present disclosure includes removing surface and near-surface crack initiation sites with a particulate matter.

[0005] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiment. The drawings that accompany the detailed description can be briefly described as follows:

Figure 1 is a general schematic view of a multi-axis system for use with the present disclosure;

Figure 2 is a schematic view of a nozzle position with respect to a workpiece to illustrate a first component of the compound angle;

Figure 3 is a sectional view of the workpiece in Figure 2 taken along line 3-3 to illustrate a second component of the compound angle; and

Figure 4 is a perspective view of a nozzle position with respect to an example workpiece.

Figure 1 schematically illustrates a multi-axis system 20. The system 20 generally includes a particulate matter supply 22, a nozzle 24 to dispense the particulate matter, a positioning apparatus 26 and a control 28. The nozzle 24 is located relative a workpiece W by the positioning apparatus 26 under direction of the control 28. The particulate matter supply 22 in the disclosed non-limiting embodiment supplies a 500 grit aluminum oxide powder through the nozzle 24 which may be a 5/16" (7.9375 mm) diameter nozzle. The positioning apparatus 26 provides multi-axis motion with variable velocity control to consistently position the nozzle 24 relative to each surfaces S of the workpiece W under direction of the control 28. The control 28 is utilized to implement the operational functionality of the positioning apparatus 26 to direct the nozzle 24 relative to the workpiece W. In terms of hardware architecture, the computing device can include a processor, memory, and one or

more input and/or output (I/O) device interface(s) that are communicatively coupled via a local interface. It should be understood that the system 20 is schematically depicted herein with conventional systems, however, various other configurations may alternatively or additionally provided to effectuate the surface machining technique disclosed herein.

[0006] The surface machining technique disclosed herein utilizes the multi-axis motion with variable velocity control through the positioning apparatus 26 to assure a uniform erosion rate is achieved upon the desired surfaces S of the workpiece W. The control 28 locates the nozzle 24 relative to the surface S of the workpiece W at a constant compound angle and predetermined stand off distance which is consistently maintained as the nozzle 24 traverses the various surfaces S1-Sn (Figures 2 and 3) of the workpiece W. The compound angle generally includes an alpha (α) and beta (β) component which may or not may not remain same relative to each surface S1-Sn of the workpiece W (Figure 3) depending on desired amount of erosion at each surface of the workpiece.

[0007] As the particulate matter strikes the workpiece W, the particulate matter erodes the material to produce a surface free of the damaged layer caused by previous conventional machining operations. That is, the previous conventional machining operations result in a damaged layer with surface and near-surface crack initiation sites. The surface machining technique disclosed herein eliminates this damaged layer to improve the fatigue life up to ten times compared to the life of conventionally machined alloy 718.

[0008] The surface machining technique uniformly removes high amounts of material as compared to conventional abrasive blasting processes. In other words, rather than a surface treatment/cleaning process typical of conventional abrasive blast processing, the disclosed surface machining technique uses specific media, machining angles and gun distances to achieve tightly controlled and relatively significant material removal rates more typical of a machining processes. Material removal typical of the surface machining technique in one non-limiting embodiment disclosed herein is 0.002-0.003" (0.05-0.07 mm) of material removal compared to a conventional abrasive surface treatment/cleaning process that removes only approximately 0.0005" (0.001 mm) of surface contaminants with little regard to final product size.

[0009] The material removal rate disclosed herein is for alloy 718 and may be varied dependant on the surface damage experienced by other alloys. That is, use of different grit sizes and materials may be utilized to remove surface damage of any type. The surface machining technique disclosed herein has been found to remove both hard surface material conditions and slightly distorted surface structure with equal efficiency on several high strength aerospace alloys, with no compromise in size control.

[0010] Since the surface machining technique enhanc-

es Low Cycle Fatigue (LCF) life, the surface machining technique disclosed herein provides for a competitive advantage over those that use a typically-processed alloy 718 part. Possible components that could necessitate enhanced LCF life are: different flight envelopes which increase stresses or temperatures, requirements for larger surface damage, i.e., handling damage, allowances in the field, or reverse engineering a material in a gas turbine engine program with lower life margins.

[0011] It should be understood that like reference numerals identify corresponding or similar elements throughout the several drawings. It should also be understood that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit herefrom.

[0012] Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present disclosure.

[0013] The foregoing description is exemplary rather than defined by the limitations within. Various non-limiting embodiments are disclosed herein, however, one of ordinary skill in the art would recognize that various modifications and variations in light of the above teachings will fall within the scope of the appended claims. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced other than as specifically described. For that reason the appended claims should be studied to determine true scope and content.

Claims

1. A multi-axis machine comprising:

a nozzle (24) operable to eject a particulate matter; and
a controller (28) operable to control said nozzle (24) relative to a part surface (S) to maintain a compound angle and predetermined stand off distance to remove surface and near-surface crack initiation sites.

2. The multi-axis machine as recited in claim 1, wherein said nozzle (24) directs an aluminum oxide powder at a constant pressure.

3. The multi-axis machine as recited in claim 1 or 2, wherein said compound angle is never perpendicular to a workpiece surface.

4. The multi-axis machine as recited in claim 1, 2 or 3, further comprising maintaining a uniform erosion rate across all features of a workpiece surface (S).

5. The multi-axis machine as recited in claim 4, wherein

said uniform erosion rate removes at least 0.002 inches (5.1 μ m) of material.

6. A method of surface machining comprising:

removing surface and near-surface crack initiation sites with a particulate matter.

7. The method as recited in claim 6, wherein said removing comprises:

maintaining a compound angle and predetermined stand off distance between a nozzle (24) which ejects the particulate matter and a workpiece surface (S).

8. The method as recited in claim 6 or 7, wherein said removing comprises:

maintaining a uniform erosion rate across all features of a workpiece surface (S).

9. The method as recited in claim 8, wherein the uniform erosion rate removes at least 0.002 (5.1 μ m) inches of material.

10. The method as recited in claim 8 or 9, wherein maintaining the uniform erosion rate comprises:

moving the nozzle (24) through a multi-axis motion machine with variable velocity control.

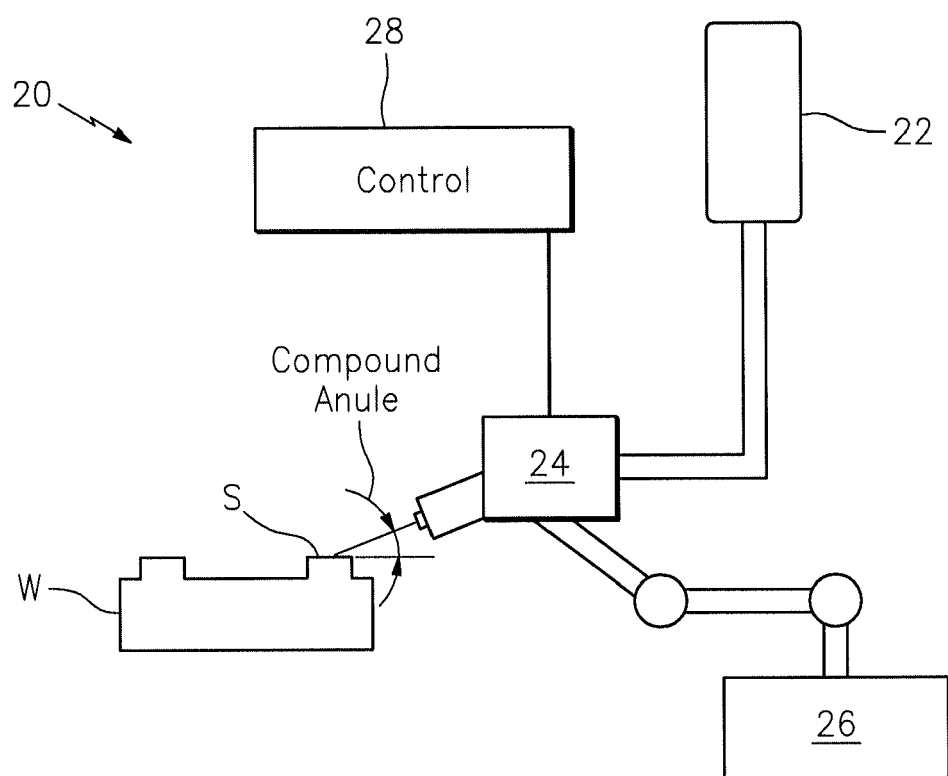


FIG. 1

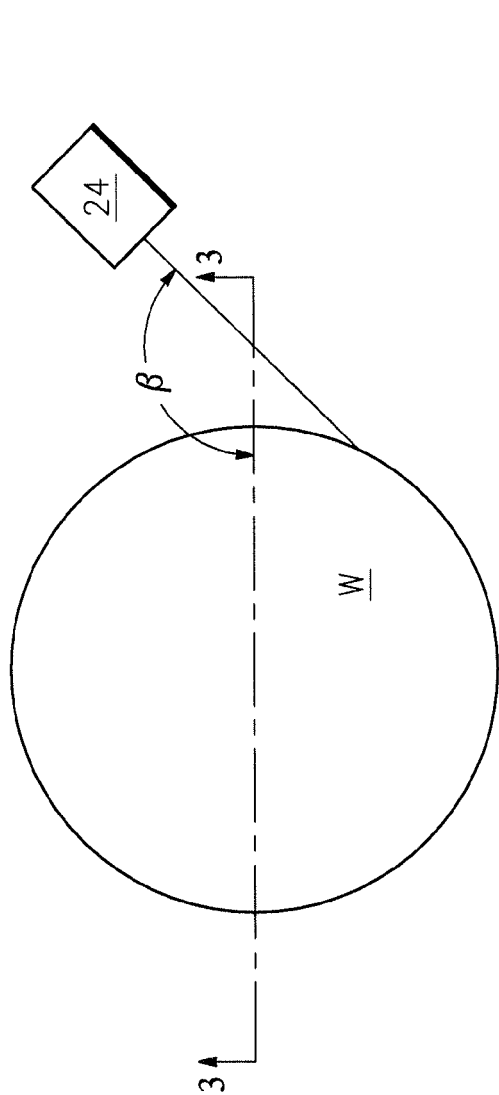


FIG. 2

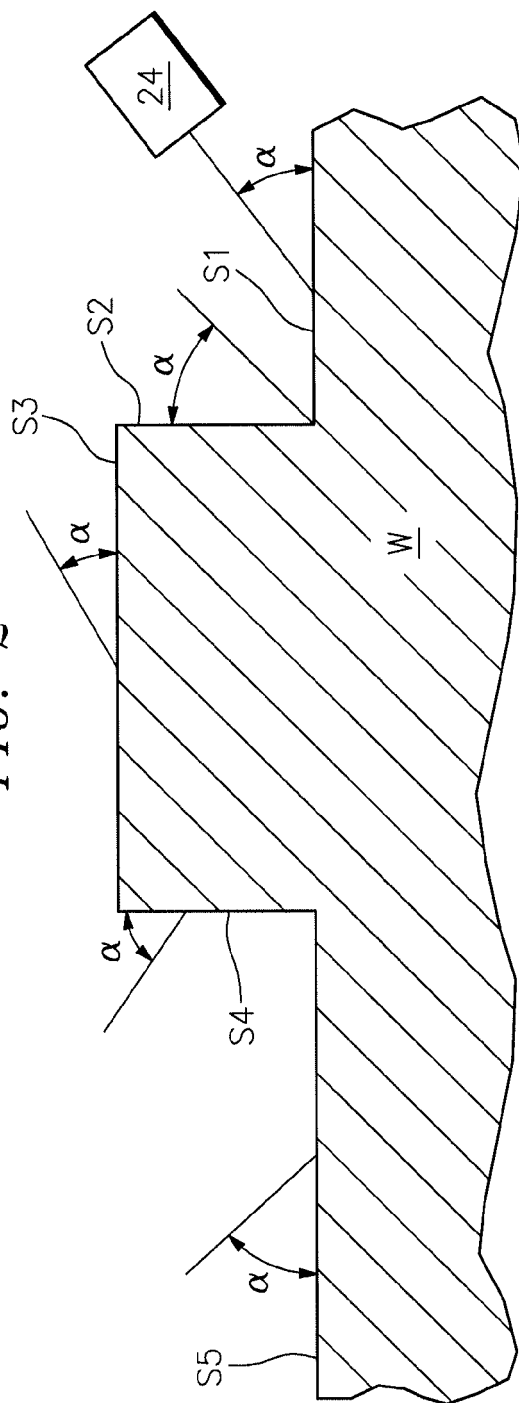


FIG. 3

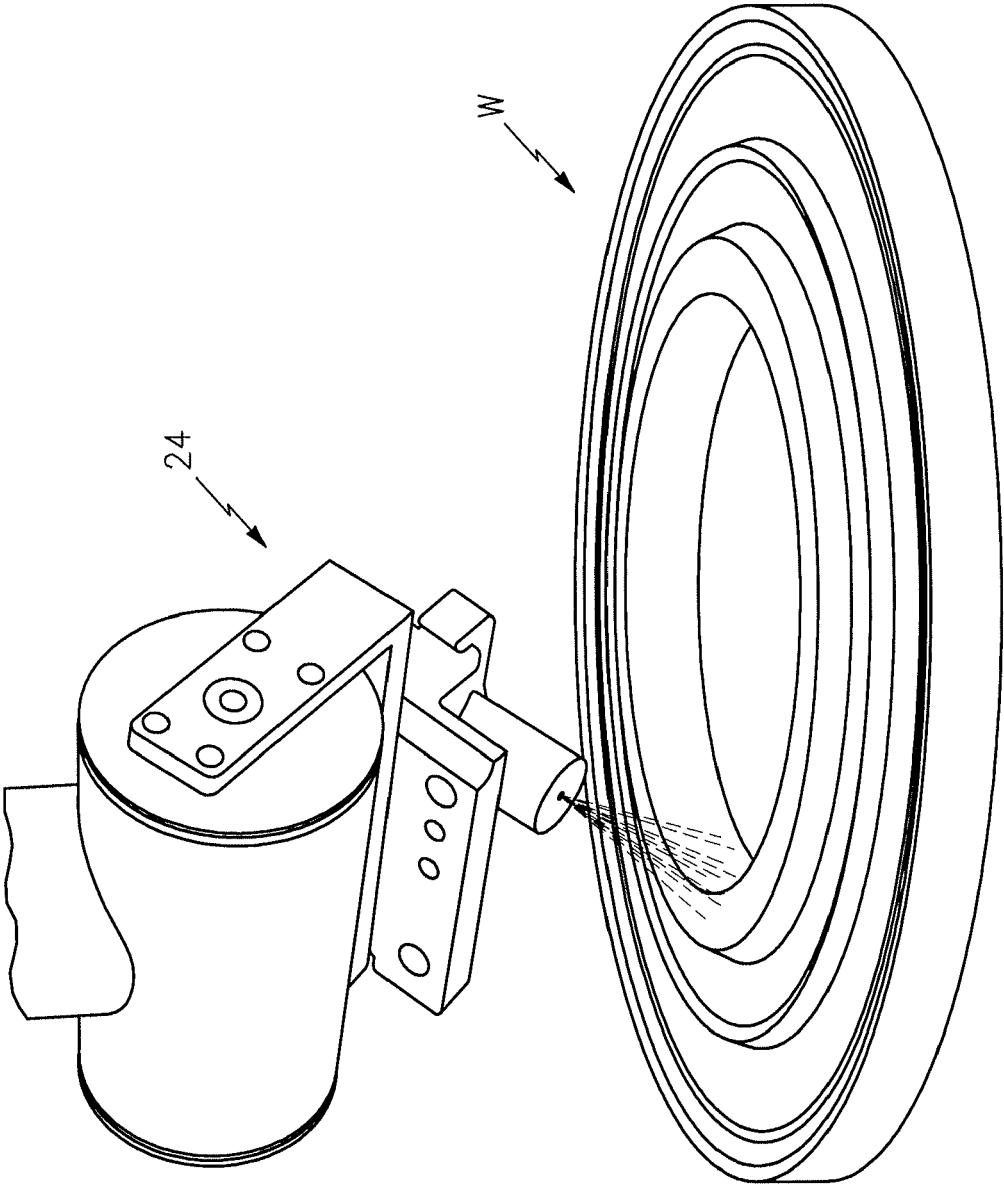


FIG. 4



EUROPEAN SEARCH REPORT

Application Number
EP 11 16 7875

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 01/15866 A1 (SIEMENS AG [DE]; DOEPPER GEBHARD [DE]) 8 March 2001 (2001-03-08) * page 1, lines 6-12,31-34 * * page 4, line 15 - page 9, line 3 * * page 12, paragraph 2 * * page 15, lines 23-37 * * page 18, lines 11-37 * * figures 1-8 * * abstract *	1-10	INV. B24C1/08
X	US 2001/047675 A1 (AROLA DWAYNE D [US] ET AL) 6 December 2001 (2001-12-06) * paragraphs [0005], [0032], [0035], [0036] * * claim 5 *	1-10	
A	WO 2005/018878 A2 (ORMOND LLC [US]; ALBERTS DANIEL G [US]; COOKSEY NICHOLAS [US]; BUTLER) 3 March 2005 (2005-03-03) * paragraph [0009]; figures 3a,3c,3d *	2,4,5, 8-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			B24C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 September 2011	Examiner Eder, Raimund
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 16 7875

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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23-09-2011

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0115866	A1	08-03-2001	CA 2383082 A1	08-03-2001
			CN 1372502 A	02-10-2002
			DE 50008357 D1	25-11-2004
			EP 1218145 A1	03-07-2002
			JP 2003508238 A	04-03-2003
			US 2002098776 A1	25-07-2002

US 2001047675	A1	06-12-2001	NONE	

WO 2005018878	A2	03-03-2005	AT 510658 T	15-06-2011
			EP 1670615 A2	21-06-2006
			US 2009124169 A1	14-05-2009
			US 2005048873 A1	03-03-2005
