SURFACE INTEGRITY OF INCONEL 718 DURING DRILLING OPERATION

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ABSTRAK

Aloi-aloi super seperti Inconel 718 memiliki kekuatan yang tinggi pada suhu tinggi. Dan ini menjadikan mereka menarik digunakan untuk aplikasi industri angkasa. Walau bagaimanapun, bahan-bahan ini merupakan bahan yang sukar untuk dimesin. Keadaan permukaan yang digerudi pastilah dipengaruhi oleh parameter pemotongan, seperti halaju pemotougan, kadar uluran, jenis dan geometri mata gerudi. Ujian penggerudian pada berbagai halaju, jenis dan sudut mata gerudi dilakukan untuk menilai kesan parameter diatas pada kualiti lubang-lubang termesin dan integriti permukaan Inconel 718. Kualiti lubang-lubang yang dimesin dinilai dari segi ketepatan geometri dan pembentukan gerigis. Integriti permukaan yang dinilai melibatkan aspek-aspek kekasaran permukaan, perubahan metalurgi, dan kekerasan mikro substrat permukaan lubang. Dari kajian yang dilakukan, lubang-lubang yang dihasilkan memiliki kualiti yang tinggi meskipun digerudi menggunakan mata alat yang telah haus, jika dinilai dari sudut ukuran, kekasaran permukaan, dan tinggi gerigis. Walau bagaimanapun, nilai kekerasan mikro dan analisis struktur mikro menunjukkan perubahan-perubahan struktur mikro yang jelas yang berkait dengan kemerosotan sifat-sifat mekanikal. Secara umumnya, parameter pemotongan didapati memberikan kesan-kesan yang signifikan pada kualiti dan integriti permukaan pada penggerudian Inconel 718 menggunakan mata gerudi karbida tak bersalut.

ABSTRACT

Superalloys such as Inconel 718 have high strength at elevated temperatures, which make them attractive towards various applications in aerospace industry. However, these materials are considered difficult to machine materials. The state of a workpiece surface after machining is definitely affected by cutting parameters, such as cutting speed, feed rates, drill types and drill geometries. Drilling tests, at different spindle-speed, feed rates, drills and point angles of drill, were conducted in order to investigate the effect of the above parameters on the quality of machined holes and surface integrity of Inconel 718. The quality of machined holes was evaluated in terms of the geometrical accuracy and burr formation. Surface integrity involved the aspect of surface roughness, metallurgical alterations and microhardness of the substrate of the hole surface. High hole quality was observed even at holes produced using worn tools, in relation to dimensions, surface roughness and burr height. However, microhardness measurements and microstructural analysis of work-piece showed significant microstructural changes related with a loss of mechanical properties. In general the cutting parameters have significant effects on the surface quality and surface integrity when drilling Inconel 718 using uncoated carbide drill.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nickel-based alloys account for 80% of the superalloy usage within the aerospace industry, with the remainder being iron and cobalt based. Approximately 45–50% of the total material requirements for a gas turbine engine are met using nickel alloys [1]. Other areas of application are within space exploration (main space shuttle engine, nickel–hydrogen batteries (international space station)), power generation (industrial gas turbines), chemical industry (cryogenic tanks), etc. [1–3]. The properties that make nickel-based superalloys attractive to industry are: high yield strength (retained to approximately 750° C), high ultimate tensile strength, high fatigue strength, retention of corrosion and oxidation resistance up to elevated temperatures and good creep resistance [1,4,5].

Numerous publications have shown that nickel based superalloys are difficult to machine regardless of the process being used [6-11]. The properties that make Inconel 718 an important engineering material are also responsible for its generally poor machinability.

Low thermal conductivity (11.4 W/mK) leads to high cutting temperature being developed in the cutting zone. In turning, temperatures of around 900°C have been reported at the relatively low cutting speed of 30 m/min with over 1300°C found at 300 m/min [12]. In addition, temperature gradients in the tool are much steeper than for steels with the maximum temperature being generated in the tool nose region [13]. The materials ability to retain its mechanical properties at elevated temperature results in high cutting forces being generated, around double that found when cutting medium carbon alloy steels. This in combination with the relatively short chip tool contact length means that stress is concentrated on the area of maximum tool temperature leading to chipping and/or plastic deformation of the cutting edge [10, 13]. Nickel based superalloys have a high chemical affinity for many tool materials and as such form an adhering layer leading to diffusion and attrition wear[14]. They are also highly sensitive to strain rate and rapidly work harden causing abrasive wear, particularly at the depth of cut and leading edge positions. The presence of hard phases in the microstructure, such as carbides, nitrides, oxides, etc, further exacerbates tool abrasion.

In contrast to other machining processes drilling has received relatively little attention and most literature available for nickel base superalloys are related only to tool wear and productivity [15]. Drilling is one of the most important processes in aerospace manufacture and being the last operation performed, particular emphasis on the reliability of the process due to the costs already entailed. In addition a hole amplifies the stress around it by a factor of two, placing considerable restraints on dimensional tolerance and hole quality.

1.2 Problem statement

- The metallurgical and mechanical characteristics that give nickel alloys highly valued properties also make them one of the most difficult-to-machine aerospace materials.
- The tendency of nickel alloys to accrue surface damage during machining.
- Burr formation during drilling can increase the cost of manufacturing due to extra time give in removing the burrs.

1.3 Project objective

The objectives of the project are as follows:

- To evaluate the machined hole quality and surface integrity of a Inconel 718 when drilling using carbide drill with respect to surface roughness, microhardness, microstructure defects.
- To study the influence of the cutting conditions on the surface roughness, microstructure defects and burr formation when drilling of Inconel 718.

1.4 Project scope

This study will be focused on drilling of Inconel 718 using uncoated carbide tools. This process is conducted under various independent variables which include cutting speed, feed rate and tool geometries. The surface roughness, microhardness and microstructural changes of subsurface will be evaluated.

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