THESIS

INVESTIGATION OF VIBRATION CHARACTERISTICS ON THE END-MILLING PROCESS OF THIN-WALLED Ti6Al4V

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APPROVAL PAGE

INVESTIGATION OF VIBRATION CHARACTERISTIC ON THE END-MILLING PROCESS OF THIN-WALLED Ti6Al4V

Thesis

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DECLARATION

I declare that my thesis is the result of my own work accompanied by supervisor and not the result of plagiarism. If encounter plagiarism in this thesis, then I am willing to accept academic sanctions from Sriwijaya University. Thus, I made this statement in a conscious and uncontrolled situation by any party.

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ABSTRACT

In achieve better results from thin-walled Ti6Al4V machining, the manufacturer must have the knowledge to avoid noise or sources of errors that affect machining results. The modelling or simulation using FEM software as a solution to get empirical value on experimental result in determining the thin-walled characteristics. DEFORM-3D software that is able to describe the milling process can also determine the value of deformation along thin-wall using point tracking. This value will be validated with experimental cutting force result. As a result, Undesirable result has been indicated in FEM-simulation where it is due to software limitation to provide the number of thin-wall elements needed. Furthermore, in the investigation of vibration using SolidWorks and MATLAB software, where the results show the natural frequency of thin-walled is in the range 4685 – 1212.6e+02 Hz and 55.8 - 7942.6 Hz respectively.

Keywords: Ti6Al4V, thin-walled, DEFORM-3D, vibration

ABSTRAK

Dalam mencapai hasil yang lebih baik dari pemesinan Ti6Al4V berdinding tipis, seorang manufaktur harus memiliki pengetahuan untuk menghindari gangguan atau sumber kesalahan yang memengaruhi hasil pemesinan. Pemodelan atau simulasi menggunakan perangkat lunak FEM sebagai solusi untuk mendapatkan nilai empiris pada hasil eksperimen dalam menentukan karakteristik berdinding tipis. Perangkat lunak DEFORM-3D yang mampu menggambarkan proses pengfraisan, hal ini juga dapat menentukan nilai deformasi sepanjang dinding tipis menggunakan pelacakan titik. Nilai ini akan divalidasi dengan hasil gaya potong eksperimental. Sebagaimana hasil yang diperoleh, hasil yang tidak diinginkan telah ditunjukkan pada simulasi FEM, dimana hal ini disebabkan oleh keterbatasan perangkat lunak untuk menyediakan jumlah elemen dinding tipis yang dibutuhkan. Selanjutnya, pada analisis getaran menggunakan perangkat lunak SolidWorks dan MATLAB, dimana hasilnya menunjukkan frekuensi alami berdinding tipis masing-masing berada di kisaran 4685 - 1212.6e + 02 Hz dan 55,8 - 7942,6 Hz.

Kata Kunci: Ti6Al4V, dinding tipis, DEFORM-3D, getaran

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Dear my Ummi,

You're my soul and direction, now I am losing you.

Now, I am like a zombie, moving without soul and direction.

I hope Allah bring me to you in Jannatul Firdaus early.

اللّٰهُمَّ اغْفِرْلَهَا وَارْحَمْهَا وَعَافِهَا وَاعْفُ عَنْهَا

CHAPTER 1
INTRODUCTION

1.1 Background

Titanium alloy are known as based of the material which used in several part of the aviation and biomedical industries component. Ti6Al4V is metastable alloy of titanium α-β alloy, where the ability to withstand extreme temperature, excellent toughness and high strength to weight ratio makes this alloy reliable in various fields of application (Mohruni et al., 2017). The technology development in machining process is able an manufacturer in made the monolithic component, where this component is proposed to achieve the homogeneity component which is able replaced several component in assembly process that increased weight caused the addition component as the fastener, and the monolithic component is able to reduce in time and cost of machining process.(Izamshah et al., 2012).

Precision and accuracy of the product are considered crucial for the manufacturer, especially in structure or shape of the aeroplane component. The complex structure of workpiece is difficult to achieve in component with tight tolerance. Even if the component on the tolerance's range, but several factors must be considered such as surface roughness and tool wear. These problems are to be a challenge for the manufacturer in machining process, thin-walled is one of the components which have a complex structure that difficult to be machined.

The definition of thin-walled is the relation between height and depth with approx. ratio 15:1, where the thickness of the walls generally ranges from 3-5 mm. And also, this condition can be called a thin-walled component if the elastic deformation reaches or equals to allowance machining tolerance (T) which is written as $\delta \geq T$.

Although the allowance tolerance is obtained, another obstacle comes from the behaviour of material, where the low thermal conductivity of titanium alloy Ti6Al4V causes chip not release easily and stick to the tool. (Mohruni et

al., 2017; Safari et al., 2014). The actually problem is found in thin-walled chatter which is due to the tool being further from the cutting zone, and increasing surface roughness. (Altintas et al., 2008; Ding et al., 2010b)

Some investigations on mitigation surface roughness in the machining, which uses several parameters such as regulating feeding and addition coolant to reduce machining temperature (Muthukrishnan et al., 2011; Shokrani et al., 2016), but this treatment not equal to in the thin-wall machining.

The helix shape and many flutes on end-mill tool made the dynamic cutting force and deflection along thin-walled. Generally, these magnitudes were obtained by trial and error process that increased in cost of machining. Deficiency in experimental method make several investigations try to change into simulation method, where FEM simulation is a flexible observation that is able to determine in optimum value of the parameter repeatedly.

1.2 Research Problems

Several investigations about machining on the thin-walled titanium alloy that aims to achieve good machinability with analysis in surface roughness, cutting force and tool wear. The analysis aims to reduce vibration, where the experimental is conducted to determine vibration magnitude using sound measurement and laser sensor. In this investigation tried to analysis vibration using cutting force and deformation that was achieved by FEM simulation. The result will be validated with the experimental result, then this analysis continues to define stiffness of thin-wall using mathematical modelling software. The simulation is conducted as a solution of the experimental that spend much money by trial and error.

1.3 Scope of The Study

The scope of the study is concern in analysis cutting force, dynamic deformation, and vibration on the helical end-milling TI6Al4V. The calculation of cutting force and dynamic deformation is conducted using FEM simulation DEFORM-3D, then continues for calculation vibration using mathematical modelling software.

1.4 Objective of The Study

In this study, the objective is aims to define as listed in below:

1. To investigate the characteristic of thin-walled Ti6Al4V machining that is depicted from magnitude of cutting force, deformation and vibration using simulation.
2. To validate the FEM simulation with experimental result as a solution in define optimum parameter value

1.5 Contribution of The Study

The study is expected to be able giving a contribution and evaluation as mentioned in below:

1. A solution in determining the machining characteristics of thin-walled Ti6Al4V using modelling, then it is an approach to reduce experimentation.
2. Contributions to knowledge, especially in the characteristics of thin-walled Ti6Al4V vibration milling using FEM-simulation.

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