



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**EFFECT OF SURFACE FINISH ON FATIGUE LIFE OF
COMPONENT.**

This report submitted in accordance with the requirements of the Universiti Teknikal
Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering
(Manufacturing Process) with Honours

by

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I hereby, declared this report entitled "effect of surface finish on fatigue life of component" is the results of my own research except as cited references

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ABSTRACT

Generally, Surface roughness is one of the factors that affect fatigue-life of a component that cause microscopic stress concentrations that lower the fatigue strength. Surface finish is often of great concern factor because of their impact on product performance. The main purpose of this study is to investigate the effect of surface finish on fatigue life of components. In practice, a mechanical part is exposed to a complex, often random, sequence of loads, large and small. Fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. This study focuses on the effect of surface finish on fatigue life of components. Work materials have been studied is AISI 1020 of 68 HRC. Cutting test were conducted on Computer Numerical Control (CNC) lathe machine model SL-20. The cutting tools used is tungsten carbide coated by titanium nitride (TiN) and all work material were machined at the different cutting parameter in order to produce different surface finish. Feed rate used are 0.066, 0.166, and 0.266 with constant cutting speed, $V_c = 63$ m/min and dept of cut = 0.2mm. Roughness value (Ra) is taken through by portable surface roughness tester. Evaluation of the test results indicated that the smooth surface have more long life span. It also becomes apparent from this studies that feed rate have influence on the surface finish.

ABSTRAK

Umumnya, produk yang dihasilkan melalui proses pemesinan mempunyai beberapa kualiti permukaan yang dihasilkan. Kualiti permukaan merupakan salah satu daripada faktor yang menjejaskan tempoh hayat bagi suatu komponen yang berpunca dari penumpuan tekanan mikroskopik yang akan mengurangkan kekuatan komponen tersebut. Kualiti permukaan juga merupakan faktor yang sering menjadi kebimbangan besar di dalam sektor pembuatan disebabkan oleh kesan kualiti permukaan yang dihasilkan kepada prestasi komponen. Tujuan utama kajian ini adalah untuk mengkaji kesan kualiti permukaan terhadap tempoh hayat sesuatu komponen. Praktikalnya, satu bahagian mekanikal adalah terdedah kepada beban yang berturutan, kompleks, rawak, besar dan kecil. Keletihan lesu dan kerosakan struktur merupakan kegagalan progresif yang berlaku di dalam tempoh hayat suatu komponen tertakluk kepada nilai beban berkisar yang dikenakan. Ekperimen ini menggunakan bahan dari jenis keluli sederhana (mild steel) AISI 1020 kekerasan 68 (HRC) yang dimesin menggunakan mesin berteknologi tinggi (CNC) dari model SL-20. Mata pemotong bersadur jenis titanium nitride (TiN) telah di gunakan di dalam proses pemesinan ini. Parameter yang digunakan untuk proses pemesinan adalah berlainan mengikut specimen yang telah ditetapkan. parameter kadar hantaran untuk specimen 1,2 dan 3 adalah 0.066, 0.166, dan 0.266. kelajuan pemotongan = 30m/min dan kedalaman pemotongan = 0.2mm adalah tetap. Selepas proses pemesinan, kekasaran permukaan spesimen diambil menggunakan penguji permukaan. Spesimen yang telah siap melalui proses methodology akan di uji menggunakan mesin jangka hayat untuk mendapatkan kesan yang dikehendaki. Penilaian keputusan ujian itu menunjukkan bahawa permukaan licin dan berkualiti mempunyai jangka hayat yang lebih panjang. Ia juga membuktikan bahawa kadar hantaran pemotongan mempengaruhi kualiti permukaan yang dihasilkan.

DEDICATION

Specially dedicated for my family especially to my father and mother, Mohd Timyati Bin Sajiran an Azizah Bte Abd Majid who are very concerns, understanding patient and supporting. Thank you for everything to my supervisor, Dr Ahmad Kamely Bin Mohamad which give idea and knowledge to guide my last year project and all my friends. The work and success will never be achieved without all of you.

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LIST OF ABBREVIATIONS

AISI	AMERICAN STANDARD INSTITUTE
Ra	SURFACE ROUGHNESS.
CNC	COMPUTER NUMERICAL CONTROL
UTE	UNIVERSITY TECHNICAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

1.1 Overview

In many applications, materials are subjected to vibrating, impact or oscillating forces. The behavior of materials under such load conditions differs from the behavior under a static load. Because the material is subjected to repeated load cycles (fatigue) in actual use, designers are faced with predicting fatigue life, which is defined as the total number of cycles to failure under specified loading conditions.

This paper presents the effect of surface finish on fatigue life of a component. Fatigue is defined as 'failure under a repeated or otherwise varying load, which never reaches a level sufficient to cause failure in a single application. Fatigue cracks always develop as a result of cyclic plastic deformation in a localized area. This plastic deformation often arises, not due to theoretical stresses in a perfect part, but rather due to the presence of a small crack or pre-existing defect on the surface of a component, which is practically undetectable and clearly unfeasible to model using traditional Finite Element techniques.

In practice a real component from a machine or structure will generally have various surface finishes and different fatigue strengths. The usual stand by which various surface conditions are judged is the polished laboratory specimen. Irregular and rough surfaces generally exhibit inferior fatigue properties. (Mohamed R. Bayoumi and A. K. Abdellatif, 1994)

According to independent studies by (Battelle, 1982), between 80-90% of all structural failures occur through a fatigue mechanism, with an estimated annual cost in the US of about \$1.5B. Furthermore Battelle concluded this could be reduced by 29% by application of current fatigue technology. In this section we overview the physical behavior responsible for fatigue from initiation to final component failure.

With the advent of modern magnification techniques, fatigue cracks have been investigated in more detail. That knows that a fatigue crack initiates and grows in a two-stage process. In the early stages a crack is seen to grow at approximately 45° to the direction of applied load. After traversing two to three grain boundaries its direction changes and then propagates at approximately 90° to the direction of the applied load. These are known as Stage I and Stage II cracks.

The development of a Stage I crack at high magnification we see the alternating stress leads to persistent slip bands forming along the planes of maximum shear. These bands slip back and forth, much like a deck of cards, and give rise to surface extrusions and intrusions. The surface intrusions essentially form an 'embryonic' crack. The Stage I crack propagates in this mode until it encounters a grain boundary, at which point it briefly stops until sufficient energy has been applied to the adjacent grain and the process continues. After traversing two or three grain boundaries the direction of crack propagation now changes into a Stage II mode. In this stage the physical nature of the crack growth is seen to change. The crack itself now forms a macroscopic obstruction to the flow of stress that gives rise to a high plastic stress concentration at the crack tip. It should be noted that not all Stage I cracks evolve to Stage II. (Fernand Ellyin, 1997)

1.2 Background of the problem.

Due to market pressure for improvements in productivity, quality, reliability, ductility, wear resistant and profitability of mechanical system, In order to enhance the surface properties of today materials, producer of components are turning to different surface finish and treatment. There are several techniques available for mechanical improving a component surface and the various method produce a different type of surface quality for each component

In this section that show investigate and explain conceptually the effect of the following parameters on fatigue life of a component. Fatigue is a complex phenomenon that is affected by a number of factors, such as the surface finish of the component, environmental effects, heat treatments, presence of stress concentration factors, etc. It is therefore important to carefully analyze components subjected to fluctuating loads so that the desired reliability can be built into these components and over-designed or under-designed components can be avoided. In this project only a Factor affecting the rate of fatigue cracks growth that be analysis. The factor is the quality of surface finish of the component.

Since fatigue cracks usually initiate from a pre-existing defect at the surface of a component, the quality of the surface will greatly influence the chance of a crack initiating. While most material test specimens have a mirror finish and therefore achieve the best fatigue lives, in practice most components are seldom as good and so we need to modify the fatigue properties. Surface finish has a more significant effect on the fatigue of components subjected to low amplitude stress cycles.

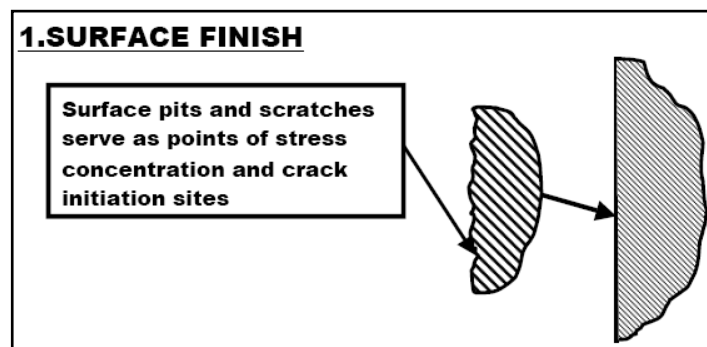


Figure 1.1: Surface finish

1.3 Problem statement

Fatigue is a complex phenomenon that is affected by a number of factors, such as the surface finish of the component, environmental effects, heat treatments, presence of stress concentration factors, etc. It is therefore important to carefully analyze components subjected to fluctuating loads so that the desired reliability can be built into these components and over-designed or under-designed components can be avoided. It is well known that fatigue cracks generally initiate from the surface and the performance of the component/part is therefore dependent on the surface finish produced by machining or other manufacturing processes.

The surface quality is an important parameter to evaluate the productivity of machine tools as well as machined components. Hence, achieving the desired surface quality is of great importance for the functional behavior of the mechanical parts (Benardos and Vosniakos, 2003). Surface roughness is used as the critical quality indicator for the machined surfaces and has influence on several properties such as wear resistance, fatigue strength, coefficient of friction, lubrication, wear rate and corrosion resistance of the machined parts (Feng and Wang, 2002). In today's manufacturing industry, special attention is given to dimensional accuracy and surface finish. Thus, measuring and characterizing the surface finish can be considered as the predictor of the machining performance (Reddy and Rao, 2005).

1.4 Objective

The objectives of this study are as follow::

1. To study the effect of surface finish on fatigue life of component.
2. To study morphology of surface produce by CNC machining.

1.5 Scope

The Material that use for this project is Mild Steel round (AISI 1020). Computer numerical control (CNC) machine type Haas SL20 is use in the project. The parameter that use for this project is spindle speed, feed rate and dept of cut with have different parameter setup to produce different type of surface finish. Fatigue life machine test types TERCO MT3012 are used in the experiment.

1.6 Significant of study

Fatigue failures are failures caused in components under the action of fluctuating loads. With fatigue, components fail under stress values much below the ultimate strength of the material and often even below the yield strength. What makes fatigue failures even more dangerous is the fact that they occur suddenly, without warning. The failure begins with a minute crack that is so small that it may not be detected by non-destructive methods such as X-ray inspection. The crack may get initiated by internal cracks in the component or irregularities in manufacturing. Once a crack has formed, it propagates rapidly under the effect of stress concentration until the stressed area decreases so much that it leads to a sudden failure.

CHAPTER 2

LITERATURE REVIEW

2.1 Machining overview

2.1.1 MT 3012-E Fatigue Testing Machine

With the varying load to which most machines are exposed it is not the static break point but the fatigue limit which decides when a fracture occurs. Fatigue strength is thus of very great significance in machine design. MT 3012-E shows in figure 2.1 and 2.2 provides a simple way of learning the effect of radius of fillet, surface smoothness, etc. on a material subjected to fluctuating flexural stresses. The machine is can delivered with interface to PC and Software. MT 3012-E is driven by a 1-phase asynchronous motor. The number of load changes and revolution cycle is read directly on the LCD display. Tapered test pieces are attached to a very stable shaft in two spherical ball bearings. The force is applied to the test piece with a spring and can be varied between 0 and 300 N. Test can be carried out with

- a) Fixed applied force
- b) Fixed deviation



Figure 2.1: Fatigue machine

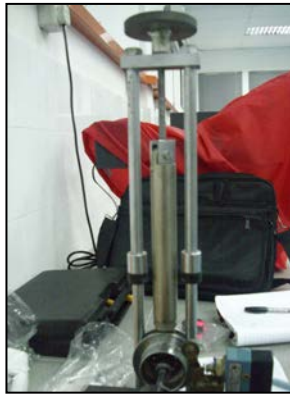


Figure 2.2: Load area

By use of the front panel you can program the test to stop at certain preset values.

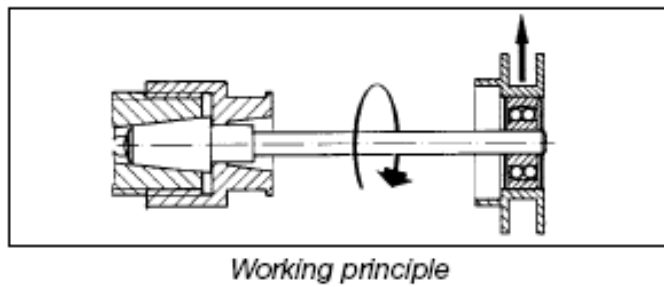


Figure 2.3: working principle

conceptually the effect of the following parameters on fatigue crack growth rate:

1. Stress or Strain Range
2. Mean Stress
3. Surface Finish and Quality
4. Surface Treatments
5. Sequence effects
6. Overload effects

2.1.2 CNC Machine



Figure 2.4: CNC machine

Haas Automation's complete line of CNC lathes is designed to meet the needs of modern machine shops, now and long into the future. The SL Series offers a wide range of capacities, and our space-saving Big Bore option increases capacity further while retaining the original footprint. The SL-20, with a max turning capacity of 10.3" x 20" (262 x 508 mm) and an 8.3" (210 mm) chuck, has a bar capacity of up to 2.0"(51mm). Haas high-performance turning machine also feature massive headstock castings with symmetric ribs for rigidity and thermal stability; on-the-fly wyes-delta switching for peak performance throughout the rpm range; and embedded chip trays and high-volume coolant systems for efficient chip removal. The Haas control features advanced tool management, single-button features, 15" color LCD monitor and a USB port. Haas has raised CNC turning to new levels of reliability, ease and productivity.

There are basically five elements to create part with a CNC machine:

Design - thinking and planning what you want to build

CAD - translating it into the computer

CAM - converting it into machine language

Controlling - directing your machine's motion

Machining - building the part to specifications

2.1.2.1 Reasons for CNC machining.

In the domain of manufacturing, computer numerically controllers (CNC) technology is a major contributor to the production capacity of the enterprises.

Reasons for CNC machining are:

- (a) The material is too hard to be machined economically. (The material may have been hardened in order to produce a low-wear finish.
- (b) Tolerances required preclude machining.
- (c) Precision and accurate of CNC machining and quality surface produce.

There are 3 main reasons why manufacturing technique used to prepare specimens surface may affect fatigue strength. First notch like surface irregularities may have created for example machining mark. Secondly the condition of material at the surface may have been changed. Finally residual stress has to be introducing into the surface layers.

2.1.2.2 Machining removes excessive material

In manufacturing processes, surface and their properties are as important as the bulk properties of the materials. A surface not only has a particular shape, roughness, and appearance, but it also is a layer having properties that can be differing significantly from those of the bulk material.

As the metal removal rate $w = df \times V_c$ mm³/s, any increase in cutting speed, depth of cut of feed will give a directly proportional increase in the metal removal rate. The power available at the machine spindle is one factor limiting the metal removal rate.

2.1.2.3 Feed rate