Faculty of Engineering

IN PROCESS SURFACE ROUGHNESS RECOGNITION (IPSRR) SYSTEM USING ACOUSTIC EMISSION (AE) (I)

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Bachelor of Engineering with Honours
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BORANG PENYERAHAN TESIS

Judul: In-Process Surface Roughness Recognition (IPSRR) System Using Acoustic Emission (AE), Part I

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This project entitled "In-Process Surface Roughness Recognition (IPSRR) System Using Acoustic Emission (AE) (I)" was prepared and presented by Tay Tuan Ho as a partial fulfillment of the requirement for the degree of Bachelor of Engineering (Hons) in Mechanical Engineering and Manufacturing System is hereby read and approved by:

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IN-PROCESS SURFACE ROUGHNESS RECOGNITION (IPSRR) SYSTEM USING ACOUSTIC EMISSION (AE) (I)

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ABSTRACT

This report contain the effect of different cutting parameters such as spindle rotation speeds, cutting feed rates and depth of cut in turning process to the surface finish of the specimen, mild steel. The report will discuss three main points that are the surface roughness, tool wear and specimen defects. In the first part of the discussion, surface finish result and trend is shown and the effects to the result have been discussed. The cutting process is categorized into 8 groups with different feed rate 0.05 mm/rev, 0.10 mm/rev, 0.15 mm/rev and 0.20mm/rev. The depths of cut are 0.2 mm and 0.4 mm. Spindle speeds are 360 rpm, 430 rpm, 530 rpm, 700 rpm, 860 rpm, 1000 rpm, 1400 rpm and 2000 rpm. The surface roughness measure in arithmetic mean value, Ra is plotted in graph against the spindle speed shown a trend of decreasing. The second part will discuss the tool wear and defects. The causes of the tool wear and defects as well as the affect of these wear and defect to the surface roughness of the specimen is discussed. The main wears were crater wear and flank wear. As in the last part of discussion, the defects on the surface of the specimen were being discussed. The causes of the defect are stated in this section. The main defects were chatter and rough surface. Furthermore, the report includes some suggestions and recommendation to improve the Final Year Project, some improvement to this research and prospect of continuing this project.

ABSTRAK

Laporan ini mengandungi kesan daripada kaedah pemotongan iaitu kelajuan putaran bindu, suapan pemotongan dan kedalaman pemotongan pada proses larik kepada kesan permukaan, keluli lembut. Laporan ini juga mengandungi tiga bahagian penting termasuk kekasaran permukaan, kehausan mata alat dan kecacatan spesimen. Pada bahagian pertama, keputusan kekasaran permukaan dan keadaan pada graf dan akibatnya turut dibincangkan. Proses pemotongan dibahagikan kepada 8 kumpulan dengan suapan berbeza iaitu 0.05 mm/rev, 0.10 mm/rev, 0.15 mm/rev dan 0.20mm/rev. Kedalaman pemotongan adalah 0.2 mm dan 0.4 mm. Kelajuan bindu ialah 360 rpm, 430 rpm, 530 rpm, 700 rpm, 860 rpm, 1000 rpm, 1400 rpm dan 2000 rpm. Kekasaran permukaan diukur dalam unit "arithmetic mean value, Ra" diplotkan melawan kelajuan bindu dan keputusannya menunjukkan penurunan pada kekasaran. Pada bahagian kedua, kehausan mata alat dan kecacatan dibincangkan. Akibat kehausan dan kecacatan serta kesannya terhadap kehalusan permukaan turut dibincangkan. Pada bahagian akhir perbincangan, kecacatan pada permukaan telah dibincangkan. Faktor yang mengakibatkan kecacatan dibincang pada bahagian ini. Laporan ini turut mengandungi cadangan serta saranan untuk meningkatkan mutu Projek Tahun akhir, peningkatan terhadap projek ini dan cadangan untuk meneruskan projek ini.

CONTENT

CHAPTER 2 – LITERATURE REVIEW

LIST OF FIGURES

TOPIC **PAGE NUMBER**

CHAPTER 3 – METHODOLOGY

CHAPTER 4 – RESULT AND DISCUSSION

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.0 Background Of Industrial

Metal cutting is one of the most significant manufacturing processes (Chen & Smith, 1997) in the area of material removal. Black (1979) defines metal cutting as the removal of metal from a workpiece in the form of chips in order to obtain a finished product with desired attributes of size, shape, and surface roughness. Drilling, sawing, turning, and milling are some of the processes used to remove material to produce specific products of high quality.

The quality of machined components is evaluated by how closely they adhere to set product specifications of length, width, diameter, surface finish, and reflective properties. High speed turning operations, dimensional accuracy, tool wear, and quality of surface finish are three factors that manufacturers must be able to control (Lahidji, 1997). Among various process conditions, surface finish is central to determining the quality of a workpiece (Coker and Shin, 1996).

Surface roughness is harder to attain and track than physical dimensions are, because relatively many factors affect surface roughness. Some of these factors can be controlled and some cannot. Controllable process parameters include feed, cutting speed, tool geometry, and tool setup. Other factors, such as tool, workpiece and machine vibration, tool wear and degradation, and workpiece and tool material variability cannot be controlled as easily (Coker & Shin, 1996).

The surface parameter used to evaluate surface roughness in this study is the Roughness Average, Ra. This parameter is also known as the arithmetic mean roughness value, arithmetic average (AA), or centerline average (CLA). Ra is recognized universally as the commonest international parameter of roughness, as defined by the following equation:

$$Ra = 1/L \int_0^L |Y(x)| \, dx \text{ ---------------------(1.1)}$$

where L is the sampling length, and y is the ordinate of the curve of the profile, the arithmetic mean of the departure of the roughness profile from the mean line (Lou, 1997). [3]

1.1 Analysis of Surface Roughness

Surface texture is the repetitive or random deviation from the nominal surface that forms the three-dimensional topography of the surface. Surface texture includes roughness, waviness, lay, and flaws.

Nano- and microroughness is formed by fluctuations in the surface of short wavelengths, characterized by hills (asperities) (local maxima) and valleys (local minima) of varying amplitudes and spacings, and these are large compared to molecular dimensions. Asperities are referred to as peaks in a profile (two dimensions) and summits in a surface map (three dimension). Nano- and microroughness include those features intrinsic to the production process. These are considered to include traverse feed marks and other irregularities within the limit of the roughness sampling length. Waviness is the surface irregularity of longer wavelengths and is referred to as macroroughness. Waviness may result from such factors as machine or workpiece deflections, vibration, chatter, heat treatment, or warping strains. Waviness includes all irregularities whose spacing is greater than the roughness sampling length and less than the waviness sampling length. Lay is the principal direction of the predominant surface pattern, ordinarily determined by the production method. Flaws are unintentional, unexpected, and unwanted interruptions in the texture. In addition, the surface may contain gross deviation from nominal shape of very long wavelength, which is known as error of form. They are not normally considered part of the surface texture.

Surface textures that are deterministic may be studied by relatively simple analytical and empirical methods; their detailed characterization is straightforward. However, the textures of most engineering surfaces are random, either isotropic or anisotropic, and either Gaussian or non-Gaussian. Whether the surface height distribution is isotropic or anisotropic and Gaussian or non-Gaussian depends upon the nature of the processing method. Surfaces that are formed by so called cumulative processes (such as peening, electropolishing and lapping) in which the final shape of each region is the cumulative result of a large number of random discrete local events and irrespective of the distribution governing each individual event, will produce a cumulative effect that is governing by the Gaussian form; it is a direct consequence of the central limit theorem of statistical theory. Single point processes (such as turning and shaping) and extreme-value processes (such as grinding and milling) generally lead to anisotropic and non-Gaussian surfaces. The Gaussian (normal) distribution has become one of the mainstays of surface classification. [18]

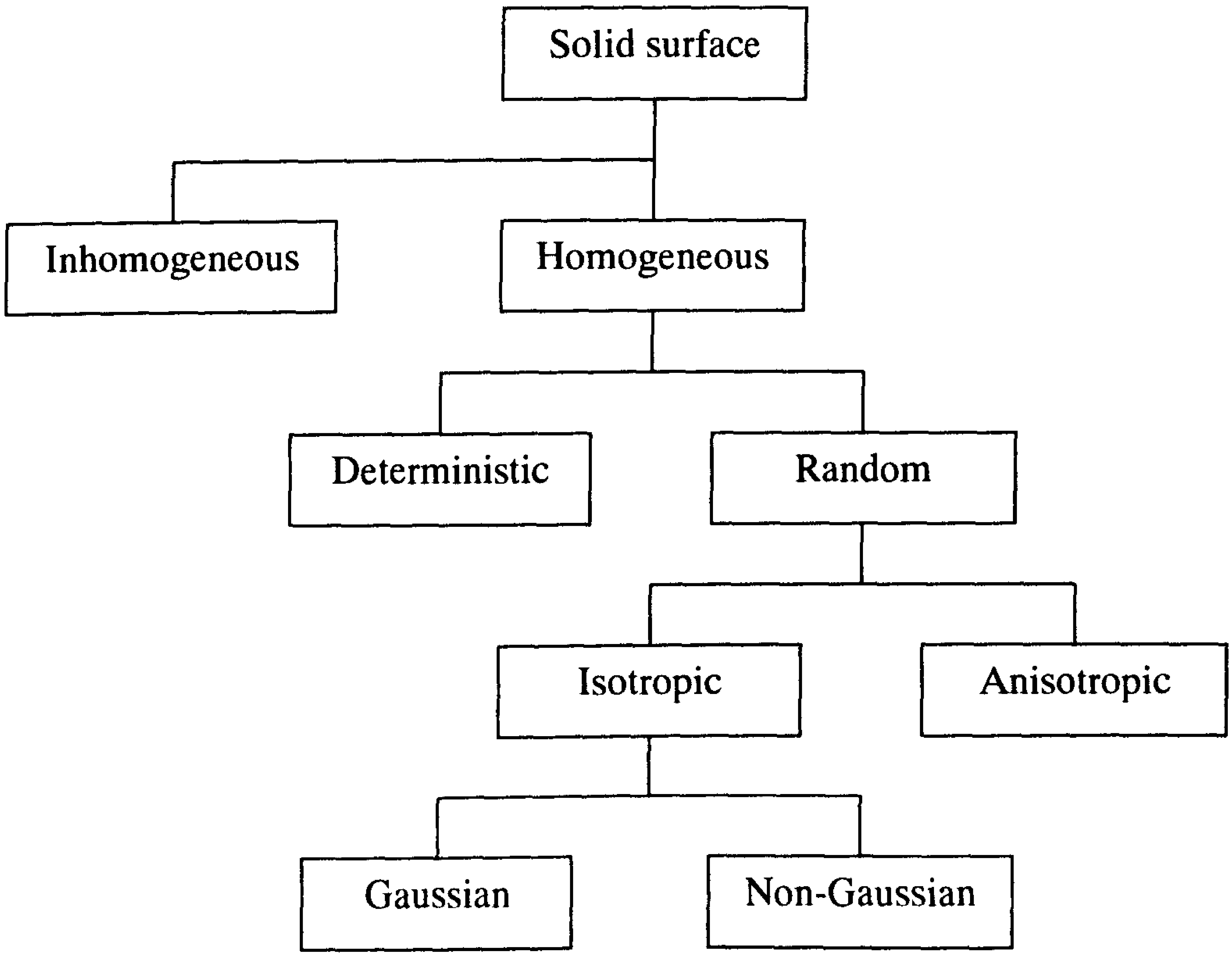

Figure 1.0: General typology of surface (courtesy of Bhushan, 1999)

1.2 Surface Defects

Several defects caused by and produced during component manufacturing can be responsible for inadequate surface integrity. These defects are usually caused by a combination of factors, such as (a) defects in the original material, caused by a casting or metal working process, (b) the method by which the surface is produced, and (c) lack of proper control of process parameters, which can result in excessive stresses, excessive temperatures, or surface deformation.

The following are general definitions of the major surface defects found in practice:

1. **Cracks** are external or internal separations with sharp outlines; cracks that require a magnification of 10X or higher to be seen by the naked eye are called **microcracks.**
2. **Craters** are shallow depressions.
3. **Folds** are the same as seams.
4. **Heat-affected zone** is the portion of a metal which is subjected to thermal cycling without melting.
5. **Inclusions** are small, nonmetallic elements or compounds in the metal.
6. **Intergranular attack** is the weakening of grain boundaries through liquid-metal embrittlement and corrosion.
7. **Laps** are the same as seams.
8. **Metallurgical transformation** involves microstructural changes caused by temperature cycling. These changes may consist of phase transformation, recrystallization, alloy depletion, decarburization, and molten and recast, resolidified, or redeposited material, as in electrical-discharge machining.

9. **Pits** are shallow surface depressions, usually the result of chemical or physical attack.
10. **Plastic deformation** is a severe surface deformation caused by high stresses due to friction, tool and die geometry, worn tools, and processing method.
11. **Residual stresses** (tension or compression) on the surface are caused by nonuniform deformation and nonuniform temperature distribution.
12. **Seams** are surface defects which result from overlapping of the material during processing.
13. **Splatter** is when small resolidified molten metal particles are deposited on a surface, such as during welding. [15]

1.3 Surface Texture

Regardless of the method of production, all surfaces have their own characteristics, which are collectively referred to as surface texture. The description of surface texture as a geometrical property is complex. However, certain guidelines have been established for identifying surface texture in terms of well-defined and measurable quantities. For example,

1. **Flaws**, or defects, are random irregularities, such as scratches, cracks, holes, depressions, seams, tears, or inclusions.
2. **Lay**, or directionality, is the direction of the predominant surface pattern and is usually visible to the naked eye.
3. **Roughness** is defined as closely spaced, irregular deviations on a scale smaller than that of waviness. Roughness may be superimposed on waviness. Roughness is

expressed in terms of its height, its width, and its distance on the surface along which it is measured.

4. **Waviness** is a recurrent deviation from a flat surface, much like waves on the surface of water. It is measured and described in terms of the space between adjacent crests of the waves (waviness width) and height between the crest and valleys of the waves (waviness height). Waviness can be caused by (a) deflections of tools, dies, or the workpiece, (b) forces or temperature sufficient to cause warping, (c) uneven lubrication, (d) vibration, or (e) any periodic mechanical or thermal variations in the system during manufacturing operations. [15]

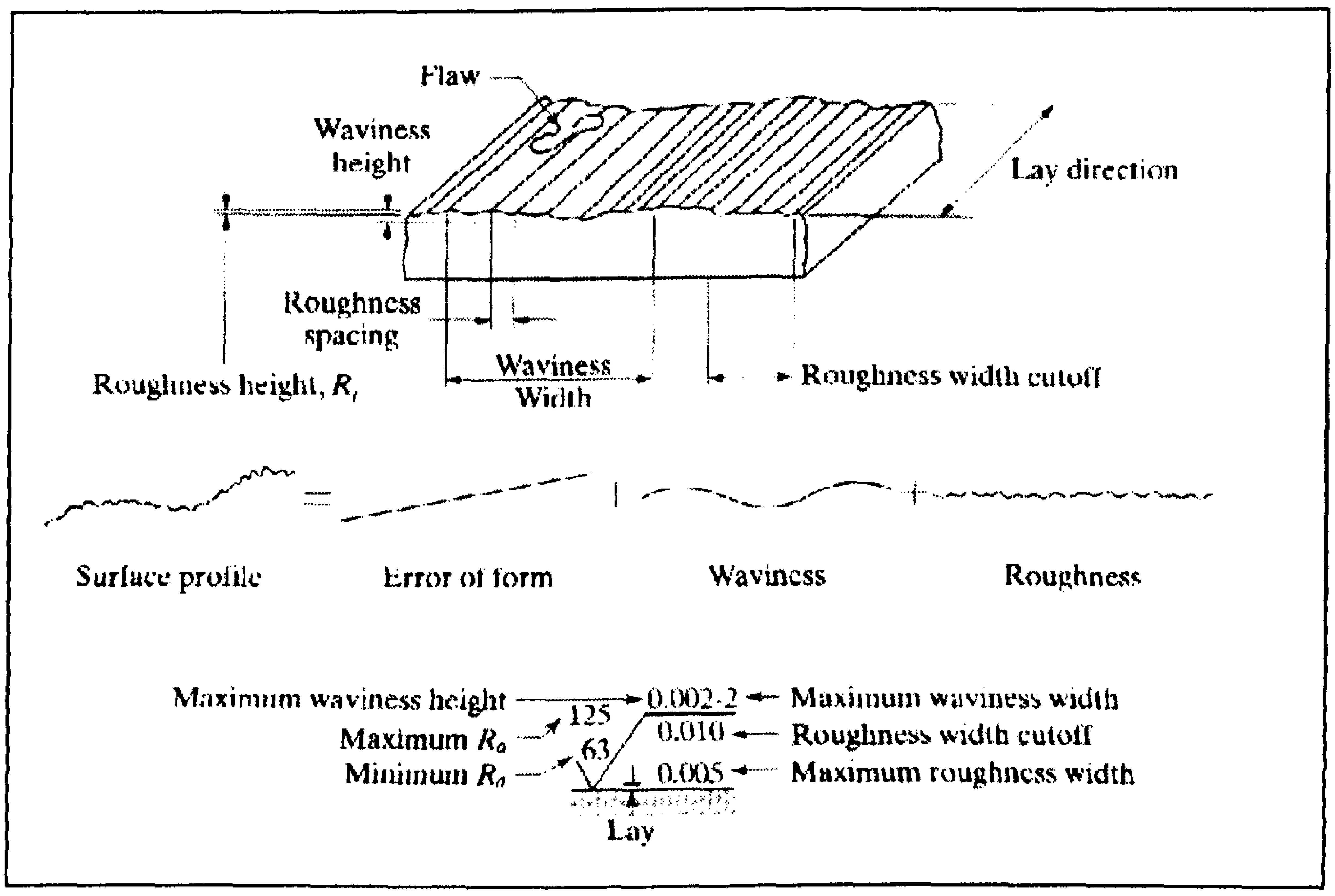

Figure 1.1: Standard terminology and symbols to describe surface finish. The quantities are given in μin (courtesy of Kalpakjian S. and Schmid S. R., 2001)

1.4 Surface Roughness

Surface roughness is generally described using two methods: arithmetic mean value and root-mean-square average.

The **arithmetic mean value** (R_a, formerly identified as AA for arithmetic average or CLA for center-line-average) is based on the schematic illustration of a rough surface. The arithmetic mean value, R_a, is defined as

$$R_a = a + b + c + d + \dots / n \text{ ------------------------------}(1.2)$$

where all ordinates, a, b, c, …, are absolute values, and n is the number of readings.

The **root-mean-square average** (R_q, formerly identified as RMS) is defined as

$$R_q = \sqrt{}\, a^2 + b^2 + c^2 + d^2 + \dots / n \text{ ----------------------}(1.3)$$

The datum line AB in Figure 1.2 is located so that the sum of the areas above the line is equal to the sum of the areas below the line. The units generally used for surface roughness are µm (micrometer, or micron) or µin. (microinch).

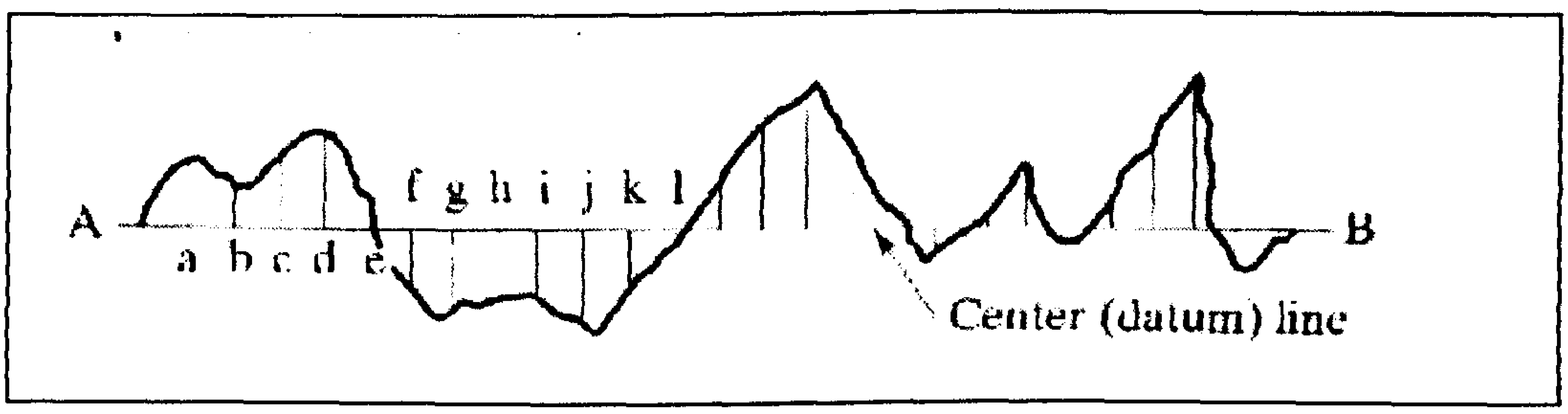

Figure 1.2: Coordinates used for surface-roughness measurement (courtesy of Kalpakjian S. and Schmid S. R., 2001)