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A Review on Surface Roughness Measurement using Image Processing

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ABSTRACT

In industries like aerospace, automotive, and other manufacturing industries, machining has become one of the major tasks, which involves turning, drilling, milling, etc. Drilling is one of the most difficult machining processes in the aerospace industry because millions of holes have to be drilled to assemble the parts. In another way, it is also a difficult machining process because the quality of drilling should be good, otherwise it may cause crack propagation and lead to the failure of the entire aircraft. The quality of the machining is predicted based on surface roughness. The contact method which involves the physical contact between the surface of the material and the measuring instrument, is used to measure the surface roughness, which has the major drawback of damaging the surface of a workpiece. To avoid this drawback, a non-contact method of measuring the surface roughness has been developed. This research paper thoroughly reviews the recent development and research by many researchers on image processing, which is one of the non-contact methods used to find the roughness value.

Key Words – surface roughness, image processing, MATLAB.

I. INTRODUCTION

Drilling is the most crucial machining process in the aerospace industries because an aircraft structure must be assembled with millions of holes, particularly in riveted and bolted joints. Maintaining the quality of the machining is the main challenge here; an important quality metric parameter is hole surface finish, also known as hole surface roughness. The surface irregularities of a workpiece due to any machining operations can be evaluated by measuring surface roughness. Surface roughness is generally measured as the average roughness (Ra). One of the key elements of hole quality is surface roughness. High surface roughness in holes leads to excessive wear and fatigue in the material, which directly affects the manufacturing process. [4]. Contact profilometry is the approach used the most frequently to measure surface roughness. Due to their easy tractability, tactile profile measurement techniques are frequently used in industry to measure surface roughness. This measurement technique involves drawing a stylus over the surface with a needle that has been specially shaped. This generally gives a brief description of the surface roughness. The needle's deflection is measured in relation to the drawn distance. The arithmetic average roughness Ra represents a typical target value. Even though this technique is still frequently used, it has a number of shortcomings, including slow measurement speeds, sensitivity to vibrations, and the need for exact positioning of the measured sample [1-7]. Optic systems are used as replacements for these devices to prevent the unwanted processes that damage the surface, where statistical roughness parameters of image textures, such as spatial frequency and arithmetic average of grey level, are assessed after images are captured using a vision system. These parameters were then used as input values during the training of neural networks. Comparisons were made between the surface roughness values from the training network and the stylus roughness values. [12].

II. Working principle.

Different machining operations are done on the material. The material has to be selected according to the applications. In the optical system, nothing but image processing techniques are used to measure the roughness parameters. To proceed with the image processing, there is a need to grab the images of the surface of the workpiece.

A. Material selection.

Due to factors such as their improved fatigue performance, lighter weight, and corrosion resistance, composites have somewhat reduced the use of aluminum in airframe designs in the aerospace industry. However, low impact resistance, complex mechanical behavior brought on by environmental factors like moisture absorption, and repair and recycling continue to be major obstacles for composite materials. As a result of their advanced manufacturing techniques, corrosion resistance, light weight, and reasonable price compared to other metals and composites, aluminum alloys are still used as structural materials in the aerospace industry [4]. While pure aluminum and some aluminum alloys are notorious for having extremely low strength and hardness, others, like the AA7075 alloy, have strength levels that are higher than structural steel. Additionally, the majority of Al alloys maintain their ductility and strength at low temperatures; in fact, these qualities are typically even better at low temperatures [8]. As technology and industry advance quickly, so does the demand for structural materials that are stronger, lighter, and have excellent wear resistance. Aluminum and its alloys are widely used in the aviation, computer, and medical industries due to their high corrosion resistance and thermal conductivity [5].

B. Machining Operations.

Production-related processes like turning, milling, drilling, grinding, tapping, etc. are the main components of metal cutting. However, the majority of these processes are drilling (30%), turning (20%), and milling (16%) [10]. After selection of the material, machining is to be conducted. Different machining operations are conducted like turning, drilling, milling, even the parameters involved in the machining affects the surface finish of the material [21]. Milling is the process of machining flat, curved, or irregular surfaces by feeding the workpiece against a rotating cutter with several cutting edges. Because of the intermittent cutting involved in the milling process, the cross-section of the chips is not uniform. Due to the high impact loads at entry and the erratic cutting force, milling is prone to vibration and chatter [17]. For construction and assembly, a typical wide body aircraft needs at least 55,000 holes to be drilled. For an aircraft to be safe and reliable, the quality and integrity of the holes must meet both the high standards set by the aviation industry and the strict requirements of aircraft manufacturers. Therefore, it is crucial to ensure that the drilling technique, tools, and parameters chosen will meet the tight tolerance and requirements of aircraft assembly. Additionally, the preceding processes are designed to require the fewest possible operational steps and the fewest possible reworks, which significantly reduces production costs [2]. Any material's surface roughness during machining is influenced by the cutting speed, feed rate, depth of cut, and approach angle. Low feed rate and high cutting produce the best surface finish. Nevertheless, the impact of approach is not as great [11].

C. Image Capturing.

The image must be captured using specific setups in order to calculate the surface roughness. The images of the workpiece for the online method are taken using a high-resolution camera with the appropriate focal length lens. In order to get clear images of the machined part, backlight is used to properly expose the view of the workpiece [19]. The machine vision approach, a non-contact method, employs a CCD (charge coupled device) camera to capture light reflected from the machined surface. A computer running the necessary software is then used to store and analyze the images. Machine vision, which has a wider measuring range than other optical methods, is emerging as a key technology in response to rising quality expectations [10]. Of course, choosing suitable lighting, illumination, and optics, as well as precise image pre-processing algorithms, sufficient computing speed, and storage capacity, are necessary and crucial [14]. The images are captured for image processing using the tripod and the angle adjuster and the proper illumination is supplied for capturing the images [13].

Fig 1. Drilling of composite material [10]

D. Surface Roughness Using Image Processing.

Images obtained either by digital camera or by CCD camera is then processed to find the roughness value. The images are preprocessed and then using some algorithm the various roughness characteristics are measured [20]. Extracting the roughness parameters of surfaces using images is the most crucial requirement in roughness assessment using machine vision. In order to measure the roughness of the machined surface with optical methods, the characteristics are taken from the surface image that is captured and processed to estimate the roughness value. The shadows must be removed to get a more accurate result. [16]. The surface-generated images were examined utilizing the MATLAB image processing toolbox. The neural network toolbox was also used to train the networks. The test program was created in MATLAB to assess surface images in binary format at different resolutions. Any type of image can be utilized by MATLAB by converting it to matrix format. These resolutions were evaluated to identify the largest matrix size that the program can handle during the training networks. [12].

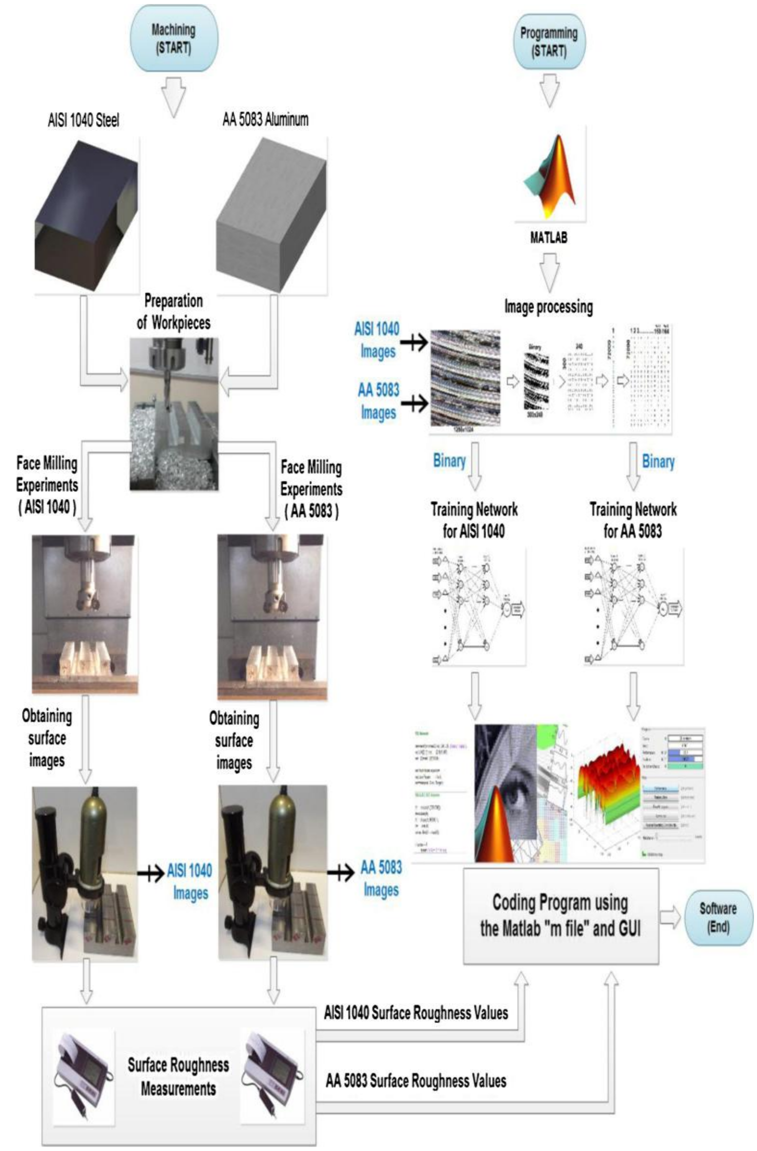

Fig 2. Methods of image processing [12].

The surface parameter that was obtained through image processing is then contrasted with the traditional method to see how similar they are. Using a stylus device, the roughness is measured using the conventional method, and the result is then compared to the image processing value [6].

III. CONCLUSION

In this work, the significance of the quality machining is discussed, and methods for quality control are provided. Surface roughness is one of the crucial parameters for quality checks and can be measured using the convectional method that is using a stylus instrument. The numerous drawbacks of using this method prompted the creation of non-contact methods, of which image processing is an example. Different techniques, including CCD, microscopes, and digital cameras, are used to capture images.The MATLAB image processing toolbox is then used to train the images. The surface roughness is then calculated using a tool in the image processing toolbox. then it is put up against the results of the convectional method. It can be seen from these reviews that the convectional method and image processing values are identical to one another. Using an image processing technique, we can measure roughness online while cutting down on measurement time.

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