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Benchmark Burnishing with Almen Strip for Surface Integrity

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Abstract

Burnishing is a surface treatment process widely used in aerospace, navy and other industries to improve fatigue and corrosion resistance by introducing a compressive residual stress layer. The measurement of residual stress by XRD is expensive, time consuming, and tedious. This work presented a quick method to determine the residual stress by using Almen strips. Inspired by the application of Almen strips in shot peening, deflections of burnished Almen strips under different burnishing conditions were measured. It was found that the deflection of Almen strip reflects the magnitude and penetration depth into subsurface of induced stress. Higher burnishing force, smaller feed, and smaller ball diameter tend to produce more deflection, which indicates more compressive residual stress.

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Keywords: Burnishing; Almen strip; Residual stress; Surface integrity

1. Introduction

Burnishing is a surface treatment process widely used in aerospace, navy and other industries. The process introduces a compressive residual stress layer on the burnished surface [1]. The depth of the compressive layer can exceed 1 mm, which is much deeper than shot peening. Thus burnishing can significantly improve high cycle fatigue and corrosion resistance [2, 3]. Burnishing has been successfully applied to many engineering materials

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including steels [4], Inconel [5], titanium alloys [6], and biomedical materials such as nitinol [7], and magnesium alloy [8].

The residual stress distribution plays a significant role on the functionality of a burnished part. The measurement of residual stress is critical for quality assurance. However, the traditional methods such as X-Ray diffraction (XRD) are expensive, time consuming, and tedious [9]. In order, a lot of experimental work needs to be done. A cost-effective and efficient method is needed to find the relationship between process space and residual stress distribution.

Almen strip provides a potential quick method to determine residual stress. Almen intensity is widely used in shot peening to ensure the effectiveness and repeatability. The method was introduced by Almen and Black [10]. The intensity is quantified by measuring the deflection of peened SAE 1070 strips (Almen strip). Due to the residual stress induced by shot peening, Almen strips bend toward the peening direction after release from holder. The arc height (i.e., deflection) can be easily measured and defined as Almen intensity. The dimensions of Almen strips are standardized with length of 76.20 mm, width of 19.05 mm and three available thickness (type A: 1.29 mm, type N: 0.79 mm, and type C: 2.39 mm). The Almen intensity has the advantage that it combines the effects of all the process parameters (peening pressure, shot size, shot material, nozzle size) into one measurement, providing a quick and cost effective testing method for repeatability of the process.

Similar to shot peening, residual stress induced by burnishing is controlled by a set of process parameters including burnishing pressure, burnishing ball size, feed and burnishing pattern. Inspired by the successful application of Almen strip in shot peening, this study aims to investigate residual stress by burnishing Almen strips and measuring the strip deflections. It may provide a fast method to the test of repeatability of residual stress in burnishing process.

The objectives of this research are to: (a) investigate the effect of burnishing conditions on the deflection of Almen strip; and (b) assess the feasibility of using Almen strip in burnishing process.

2. Burnishing Experiment

The burnishing experimental (Fig. 1) was conducted using a Cincinnati arrow 500 CNC machine. The Ecoroll tool with a ceramic ball was used. The ceramic ball rolled over the workpiece surface under the applied hydraulic pressure. A load cell was used to measure the burnishing force.

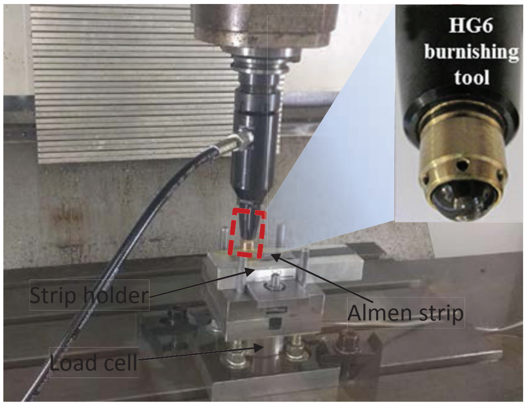

Fig. 1. Experiment setup.

The experiment design was summarized in Table 1. A constant linear speed of 3000 mm/min was used in the experiment. The effect of burnishing force, feed, ball diameter, and pattern was investigated. The schematic of vertical and horizontal patterns on strip deflection and residual stress is shown in Fig. 2. The burnishing direction for