Effect of Laser Power and Scanning Speed on the Surface Characteristics of Ceramic Tile

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ABSTRACT: Laser marking is the process to embark identification by providing irradiance energy on a surface. It has many advantages over mechanical marking techniques as this process is non-contact and capable to produce intricate sign. In this study, fiber laser has been used to mark ceramic tiles with different laser power and scanning speed. Surface analysis has been carried out to differentiate contrast level and surface roughness of each marked area. The results show that increasing laser power resulting better surface contrast with significant visible of marked tiles. Increasing scanning speed resulting increasing surface contrast at the 8W laser power. Ceramic tile unable to be marked at lower laser power of 4 W due to insufficient energy to ablate the surface.

Keywords: *Laser Marking; Ceramic Tiles; Engraving*

1. INTRODUCTION

Marking is the process to embark identification on a surface in the form of numbers, logos, symbols or codes. Marking process can be accomplished by different technique such as sticking, painting, scratching or sand blasting [1]. For ceramic tiles, marking process normally achieved by mechanical processing where the mold being engraved with identification to secure powder residue after tile stamping. Such process requires controlled mould accuracy as ceramic normally encountered with shrinkage after sintering [2]. In addition, mould that developed with special patterns is somehow difficult to make.

In the advancement of machine tool technology, laser marking has been recognized as process that capable to provide efficient surface alteration on the product. Laser marking is a process where laser energy being irradiated on the surface to provide ablation that delaminate the affected area. Such process has been successfully used to mark steel-based product such as stainless steel, titanium, aluminium and mile steels.

Technically, laser marking process influenced by the laser power, laser speed, frequency, hatch size and the properties of material to be marked. Each material has different physical characteristics such the melting temperature, hardness, specific heat, thermal conductivity and thermal sensitivity that determine the surface transformation after being lasered [3]. For metal-based product, microstructure transformation or photochemical ablation could be appeared due to metallurgical reaction with laser radiation. For nonmetal, products such as ceramic, deep engrave with nanoparticle emission could be produced to the air after exposed to the laser radiation [4].

The current study aims to characterize surface profile of ceramic tiles after being marked with fiber laser. Series of laser radiation being bombarded on the tile surface with different power and scanning speed. Surface characteristics will be assessed based on the contrast level and surface roughness. This study enables the understanding of laser mechanisms governing to surface integrity of ceramic, which may facilitate more efficient tile marking process in the future.

2. METHODOLOGY

Ceramic tile with dark coating and bright substrate was prepared within the size of 0.3 m width and 0.4 m length (Figure 1(a)). The tile was marked by Han's Yueming Fiber Laser with 4-16W laser power and 500-2000 mm/s scanning speeds (Figure 1(b)). The data of images and surface roughness of each marked surface was captured by digital camera and surface roughness tester respectively (Figure 1(c)).

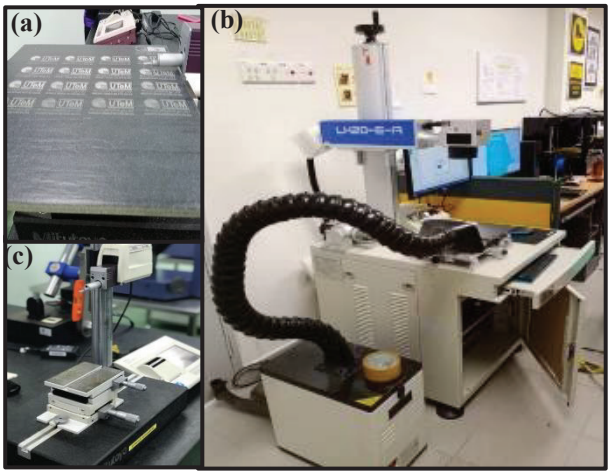

Figure 1 (a) Ceramic tile (b) Laser marking machine (c) Surface roughness tester (Mitutoyo Surftest SJ-301)

3. RESULTS AND DISCUSSION

Figure 2(a) shows the sample of engraved tiles based on the laser power and scanning speeds. Appearance of marked surface clearly shows that higher surface contras displayed as the laser power increased. This shows that marking with higher laser power enables local heat to burn the affected surface and provide delamination ceramic coating [5]. Consequently, the bright substrate exposed when the ceramic surface ablated and immersed to the air. In terms of scanning speed, there are two patterns appeared on the marked areas. When the laser power hit with 12 W and 16 W power, there is no significant effect as each tile demonstrated almost similar marking appearances. When the laser power reduced to 8W, a bright high-contrast marking displayed even at lower scanning speed of 1000 mm/s.

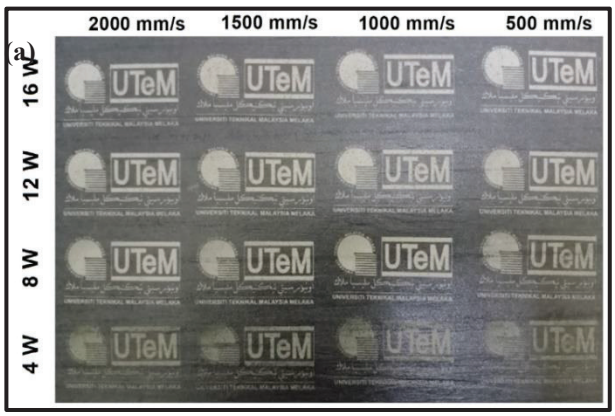

Figure 2 Effect of laser power and scanning speed on the ceramic tile

Further analysis on the surface roughness is shown in Figure 3. In general, surface roughness increased as the laser power increased. Minimum surface roughness recorded at 3.9 µm (Figure 4(a)), showing that the removal ablation layer is thin with lower laser power of 4W. Maximum surface roughness recorded at 10.2 µm (Figure 4(b)) showing that deep engrave take place with higher laser power of 12W. It is expected that high variance of surface roughness recorded throughout the tile area. This is due to uneven surface morphology consequent from powder aggregation and agglomeration [4-5].

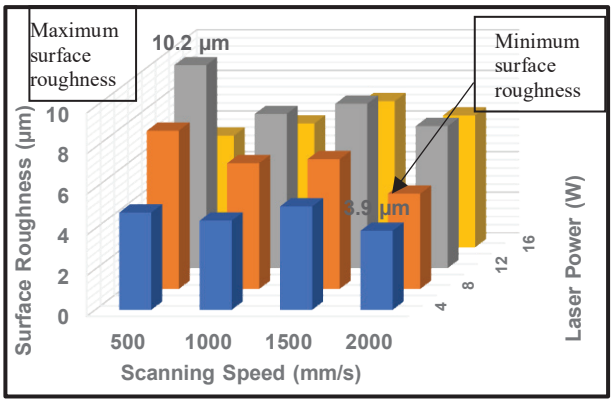

Figure 3 Surface roughness variation according to tool laser power and scanning speed

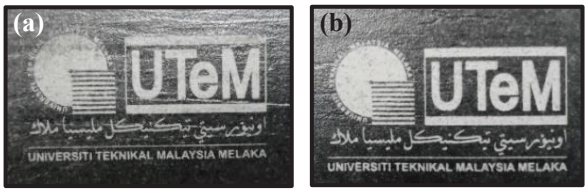

Figure 4 (a) Marked surface at 4 W and 2000 mm/s (surface roughness 3.9 µm) (b) Marked surface at 12 W and 500 mm/s (surface roughness 10.2 µm)

4. CONCLUSION

This paper presents the surface characteristic of ceramic tile after being marked with fiber laser. Conclusions that can be drawn are:

a. Increasing laser power resulting better surface contrast with significant visible of marked tiles.
b. Increasing scanning speed resulting increasing surface contrast especially at the 8W laser power.
c. Ceramic tile unable to be marked at lower laser power of 4 W due to insufficient energy to ablate the surface.

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