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Effect of local remelting and recycled reinforcement size on abrasive wear of manual arc welded hard-facings

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The lifetime of metal cutting and machining tools cermet inserts can be as long as just 15 minutes. The material loss during that time is insignificant (just a few percent), and the remaining part of the insert can be recycled. Hard-facings created by covered electrodes with manual arc welding can be used for abrasive and erosive wear conditions. The higher recycled particle size and local remelting influence hard-facings quality and reduce wear loss. It can be explained by diffusion taking place between grains and binder at a higher temperature. A scanning electron microscope was applied for the characterization of wear mechanisms.

Keywords: WC particles, recycling, local remelting, abrasive wear, manual arc welding

1. Introduction

The metal cutting and machining tools inserts can be crushed into powder (recycled) and used to reinforce coatings to increase their wear resistance. Such coatings were already produced by well-controlled automated plasma or laser technologies and their properties investigated [1]. However, the information about manual arc welded hard-facings is scarce. Manual arc welding is used very often in agriculture to protect or repair tillage tools [2]. The conditions of the weld pool are less controlled and significant or complete melting of reinforcing particles, defects, and generation of thermal stresses, especially in the case of thick multi-layered coatings, takes place. This study aims to investigate manual arc welded hard-facings reinforced by recycled cutting and machining tools cermet inserts in abrasive and erosive wear testing conditions.

2. Methods

The cermet inserts were crushed by disintegrator to recycle and re-use critical raw materials such as tungsten and cobalt. Six fractions of powders were prepared by sieving and used for production of six types of covered electrodes (180-2000 μm). The electrodes were applied for manual arc welding to prepare hard-facings. Besides, the effect of local remelting was studied. Samples were split into two groups and half of the samples of each powder size was left without local remelting while another half was additionally thermally treated. The local remelting was done in the following way: the whole sample was heated up to 300 ºC and then locally heated up to 1600-1800 ºC (melted) by non-consumable tungsten electrode in an argon gas shield. The bulk sample temperature was in the range of 500-1000 ºC. After treatment, the samples were placed in the chamber (350 ºC) to cool down to room temperature (cooling rate 3 ºC·min^{-1}) to reduce thermal stress. Three types of laboratory wear tests were performed: (1) low stress (soft) abrasion test done with rubber-lined steel wheel (ASTM G65-04 standard), (2) the medium stress abrasion test done according to the same standard but steel wheel was used instead of a rubber-lined one, (3) the high-stress conditions were created by erosive wear testing at room and high temperature (350, 450, 550 and 650 °C) with varied impact velocity (30, 50 and 80 m s^{-1}) and impact angle (30° and 90°). The Hardox 400, high manganese (Mn) and AISI 316 steels were used as reference materials.

3. Discussion

The recycled reinforcing particle size and local remelting influence hard-facings quality. Coatings with 355-500 μm size of hard particles have the lowest wear loss. Such behavior can be explained by diffusion between grains and binder at higher temperatures, where binder has a larger amount of hardening phase (W, Ti, Mo, Nb). The conditions during erosion testing and abrasive wear testing with rubber or steel wheel can be somehow similar depending on impact angle. Erosion testing with 30º and testing with rubber wheel establish intensive scratching by abrasive particles, while erosion testing under 90º and abrasion with steel wheel include a significant portion of indentations. The developed hard-facings with recycled composite reinforcement and without local remelting have 1.1-3.4 lower wear rates (depends strongly on impact velocity) than those produced from solid WC particles (that were not recycled) [3]. The SEM analysis of hard-facings after a higher attack angle shows that developed hard-facings have reduced resistance to fatigue processes.

4. References

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