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Strategies to reduce environmental impact of hardmetal production ☆

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ABSTRACT

As energy, environmental remediation and raw material costs for hardmetal production escalate with increasing demand, the need for developing and implementing technologies for reducing environmental impact becomes more urgent, while, at the same time, reducing material cost. A range of technologies can be employed for recycling hard and soft hardmetal scrap which consume less energy and require lower capital investment than for virgin powder. Performance and processing targets with recycled materials must be equivalent to those from virgin material. Conventional solvent based processing can be replaced by water based processing of hardmetal compositions to reduce environmentally damaging emissions and associated costs. This will be particularly useful as government regulations move to reduce or eliminate emission of organic solvents. Raw material consumption can be reduced by employing near-net-shape or net-shape technologies, since many hardmetal parts are finished by hard grinding, which generates grinding sludge.

1. Introduction

Hardmetals play a critical role in myriad industrial processes including manufacturing, energy production, construction, wear resistant applications, etc. As a result, sustainable hardmetal production is of paramount importance in supporting the modern industrial base, especially as it expands with global population growth and elevated standards of living. Concurrently, reduction of environmental impact has become more urgent as harmful emission remediation costs have escalated, or has been completely outlawed. A majority of W production is used to meet the demand for hardmetals, so considerations for W supply chain are critical to hardmetal production. Over the last decade, W precursor prices have undergone a dramatic escalation as shown in Fig. 1, showing an eight times increase [1,2]. At the same time, industrial electric costs (as a measure of energy costs) have seen a 30% increase over the same period [3], although recent trends are flat, possibly due to developments in oil shale exploration.

Furthermore, the availability of W bearing ores has become more restrictive due to non-uniform geographical distribution as shown in Fig. 2. Over 2/3 of world reserves of W are in China and Russia [1]. Although tungsten production and demand are in balance, about 90% of production is located in the same two countries [1].

Therefore, it is important that strategies be developed to reduce environmental impact of hardmetal production, while simultaneously increase supply and lower cost. This must be done without sacrificing form and function of the end product.

Hardmetal manufacturing process is schematically shown in Fig. 3, starting from ore/concentrates to hard shaping. This paper will examine technologies for reducing cost and environmental impact, and increasing W availability during each of the processes in the manufacturing chain. However, change in one process may require modification in a subsequent process to ensure process and product performance remain unchanged. Therefore, a holistic approach is required which considers the entire process chain for benefits balanced by costs.

2. Raw material production

Greater recycling of hardmetal scrap in raw material production is one way to simultaneously reduce cost, energy consumption and environmental impact, while concurrently increasing W availability. By one estimate, 35–40% of W used is recycled [1], however, recent trend is for greater recycling. A range of technologies can be employed for recycling hard and soft hardmetal scrap, which consume less energy and require lower capital investment than by using ores and concentrates. (Note: 'Hard' scrap refers to sintered parts, which may have been crushed to smaller pieces; 'Soft' scrap refers to powder scrap produced as grinding sludge or scrap powder). As stated before, performance and processing targets with recycled materials must be equivalent to those from virgin material. Both 'soft' and 'hard' hardmetal scrap can be cleaned and oxidized to provide high W content feedstock

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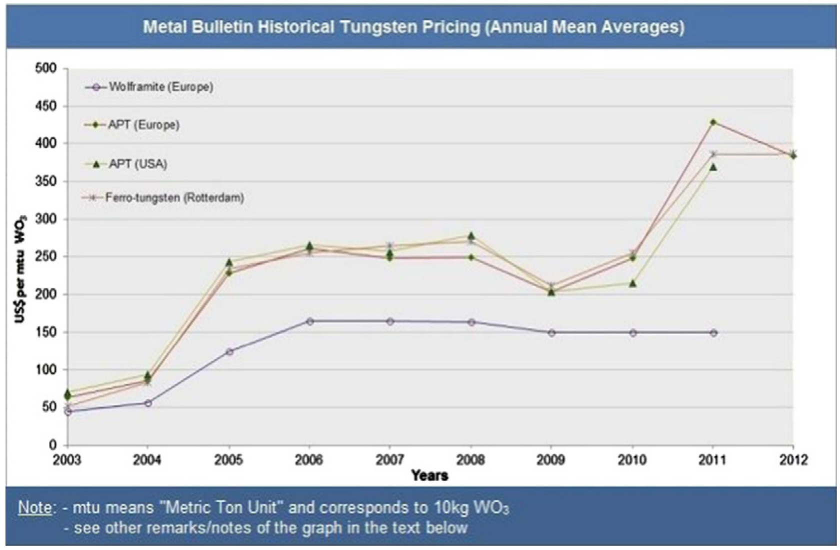

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Fig. 1. WO_3 cost escalation over 10 years.

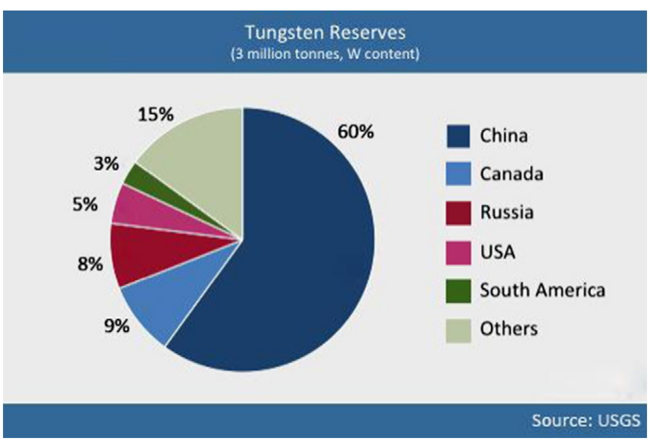

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Fig. 2. Global W deposit distribution.

for ammonium paratungstate production, a common precursor for virgin W metal powder. A consideration for this approach is the development of a separate value stream for additional recoverable materials which accompany the scrap, such as Co, Ti, Ta, and Nb [2].

Hard scrap can also be recycled by other, lower cost, means, however with limitations in quality and use. In the cold stream processes, hard scrap is crushed and screened to generate powder which can be used to make grade powder. This process leaves chemistry and grain size unchanged, but may increase some impurities, such as Fe, as a result of the crushing process. The zinc process is an established method to convert sintered hardmetal scrap into powder by first bloating it by making a Co–Zn amalgam, followed by Zn evaporation, crushing and screening [2,4]. The resulting powder can be subsequently milled to produce grade powder. WC particle size and impurities/alloying additions remain unchanged, and therefore, its use is limited to compositions with similar grain size and chemistry. Also, Zn contamination needs to be controlled. High temperature bloating, crushing and screening of sintered hardmetal scrap also yield powders which can be used in making hardmetal powders. Chemistry of hardmetal in this process remains unchanged, but a relatively large grain size results due to the high temperature used. Also, intensive energy consumption is maybe a concern. Selective dissolution of Co in an electrochemical bath is another process to obtain WC powder from hard scrap, where relatively pure WC can be obtained with original grain size. However, consideration must be made for recovery of Co and other additives and disposition of solvents.

Considerations for powders produced by recycling hard scrap include carbon control and microstructure, since some of these processes may cause oxidation of powder, and pressing and sintering behavior may be different for recycled powders than those made with virgin powders.

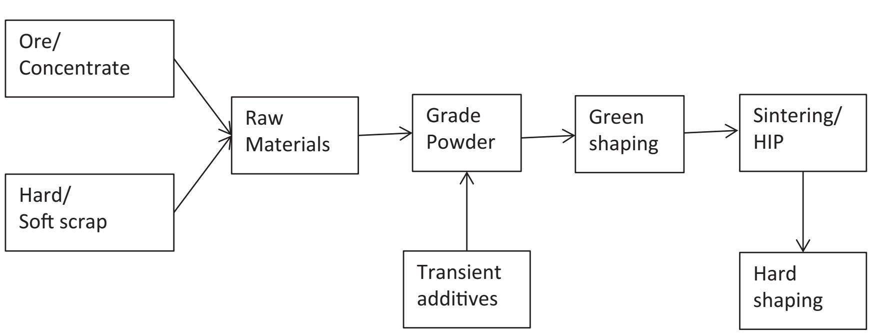

Fig. 3. Overview of hardmetal manufacturing process.