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The history of the technological progress of hardmetals

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ABSTRACT / SYNOPSIS

The impressive history of hardmetals starts with the Schröter Patent and is then followed by the first hardmetal company, Krupp-WIDIA. Metallwerk Plansee has also played an important part in the search of drawing dies for tungsten wires and later as one of the important hardmetal manufacturers besides Kennametal in USA, Sandvik in Sweden and others.

The further development of hardmetals is characterized by other carbide and binder combinations. TiC-based hardmetals are a great step forward for the machining of steels and so are fine grained hardmetals for a wide spectrum of applications.

With the rising tendency of automation in metal cutting, indexable inserts with quite complex geometries were developed for the application in lathes and milling centers working with computer numerical control (CNC).

Coating technologies by chemical vapor deposition and physical vapor deposition have greatly increased the wear resistance of hardmetals. Coating with aluminum oxide multilayers and with diamond were devised as well as compact non metallic hard materials such as diamond, cubic boron nitride, oxide and nitride ceramics as well as mixed ceramics. Cermets and their special properties are discussed as well as ultrahard ceramics for special applications. Finally a short survey of the literature on hardmetals and hard materials is given.

This paper is a condensed and partly updated version of a book chapter: "Introduction to Hardmetals — History of Hardmetals" by P. Ettmayer, H. Kolaska and H.M. Ortner in the book: "Comprehensive Hard Materials", Elsevier, V.K. Sarin and D. Mari, eds. (in preparation).

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1. Introduction — definitions

1.1. Hardmetals and cemented carbides

The two terms are completely equivalent. However, "Hardmetals" is rather used in Europe (In German, there only exists the word "Hartmetall").

"Cemented carbides" is rather used in USA but also in European English literature.

In the machining industry, the hardmetals that contain a dominant WC-phase are generally named "cemented carbides" since their discovery by Schröter in 1923 [1].

In English at least a number of American and English publications use the term "hardmetals" for the binder free substances as well as for the cemented materials.

1.2. Classification of Hardmetals

The broad variability of hardmetals concerning their composition and properties has on the one hand led to a very wide field of application, and on the other hand, however, to a puzzling multitude of hardmetal grades.

This has led to various classification systems of which the most important are:

- The classification according to the ISO-committee TC 29 of April 1958
- The classification according to the US-Industrial Code (Buick-Hardmetal-Classification)
- The classification according to the DIN 4990 of 1948.

Further relevant information can be found in [2] and [3].

1.3. Cermets

There are several definitions of cermets in use:

According to R.M. German [4] a cermet is a particulate composite consisting of ceramic particles bonded with a metal matrix. The original term was coined by joining ceramic and metal into a single word to describe a composite.

Kolaska and Ettmayer [5] define cermets shortly as sintered hardmetals based on TiC, Ti(C,N) but with the exclusion of WC–Co hardmetals.

D. Mari [6] defines cermets as follows:

The designation "cermet" has been historically reserved for TiC-based hardmetals, to specify the ceramic character (lower electrical conductivity) of TiC in comparison with WC. Among cemented carbides, those based on the system WC–Co are the most widespread, while the most used system among TiC-based cermets is TiC_xN_{1-x}–Mo–Ni.

Finally W. Lengauer [7] gives a more precise definition:

Cermets are based on Ti(C,N) and exhibit, therefore, a purely cubic-face centered hard material phase. They exhibit high wear resistance at high cutting rates if compared to conventional WC–Co hardmetals. They also show high lifetimes and a good surface quality of machined materials. The hard material particles of cermets show a typical core–rim structure which is formed by the varying chemical stability of its components as well as by interaction between the molten binder metal and the hard phases during liquid phase sintering. The cores of the hard material particles are rich in nitrogen and are surrounded by a rim rich in Mo and W. The formation of such a rim improves the wettability by the binder and thereby causes the superior properties.

2. How it all started: the search for a substitute for diamond: the Schröter patent (1923)

The onset of hardmetals was the search for a proper material as drawing die for non-sag tungsten as a substitute of the very costly diamond after the First World War.

The Viennese Franz Skaupy was the head of the "Study group for electrical lighting" at the "Auer Gesellschaft" in Berlin (1907 to 1928) (Fig. 1). He directed his coworkers to use sinter technology for the production of solid WC. He attempted to transform the brittle carbide by sintering into ductile material similarly to tungsten. However, this did not work at all. His work was nearly given up when a coworker

Fig. 1. Prof. Dr. Franz Skaupy (about 1950). Head of the "Study Group for Electrical Lighting" at the "Auer Gesellschaft" in Berlin (1907–1928), a subsidiary of OSRAM.