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Ferritic Chromium Steel as Binder Metal for WC Cemented Carbides

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Abstract
Fe-based alloys as alternative binders of cemented carbides are of increased research interest. We used ferritic chromium steel AISI430L as metallic component in cobalt and nickel free WC-FeCr cemented carbides. Composites with relatively high binder content of 30 wt% were under investigation. Our focus was on the effect of sintering temperature on the densification and phase evolution and on the influence of extra carbon. With the liquid phase formation around 1150 °C, the near full density of the composites was achieved at 1200 °C. During sintering, M_6C η-phase and $(Cr, Fe)_xC_y$ mixed carbides of different composition dependent on the carbon additions were formed. Addition of carbon to achieve over-stoichiometric carbon level proved opportunity to retard the formation of the η-phase and the $(Cr, Fe)_{23}C_6$ phase and favored microstructural homogeneity. However, final microstructure remained heterogeneous with binder rich areas consisting of Cr- and Fe-based carbides and α-Fe.
Keywords: cemented carbides, alternative binders, phase formation, microstructure evolution.

1. Introduction

Materials science is largely driven by a need for economical and environment friendly material systems. In the hardmetal industry, finding an alternative to cobalt has been a research challenge since WC-Co was established as an excellent engineering material. Relatively high and unstable price and availability of Co [1] have been common motivators whereas recently health and environment considerations have risen. The REACH programme (Registration, Evaluation, Authorisation and Restriction of Chemical substances) in Europe [2] and NTP (National Toxicology Program) in the United States [3] have classified cobalt as very toxic for the human health. Historically, the "second best" choice for a binder metal of nickel suffers also from high toxicity [4].

The use of iron as a binder metal was described already in an early patent by K. Schröter, but due to superior properties of the WC-Co system, further investigation of iron as an alternative was discontinued. Besides inferior mechanical properties, the properties of the W-C-Fe system made it difficult to achieve a favorable two phase structure [5,6]. In 1956, Agte pointed out the importance of carbon balance and a need for extra (overstoichiometric) carbon in the W-C-Fe system [7,8]. During the last three decades of the 20th century, the research of Fe-based binders increased. The potential, properties and, to some extent, the commercial use of Fe-based binder systems have been overviewed in review papers by Norgren et al. [4] and