Titanium Carbide Cermet as Ballistic Protection Material

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Declaration:

Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree.

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Titaankarbiidkermis ballistilise kaitse materjalina

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TTÜ
KIRJASTUS

ABSTRACT

Titanium Carbide Cermet as Ballistic Protection Material

In this study, titanium carbide based cermets were investigated as alternative material for ballistic protection. Firstly, reactive sintering technology was implemented to improve the mechanical properties and to reduce the manufacturing costs of TiC based cermets. Secondly, the material was assessed by ballistic performance and compared to other materials that are currently on the market.

Different aspects of material preparation showed that as compared to conventional methods, reactive sintering technology enables similar or in some cases superior mechanical properties to be achieved. Powder milling, chemical composition and sintering regimes were developed to acquire a set of properties suitable for ballistic performance against hardmetal projectiles.

Ballistic testing methods were also developed to compare TiC based cermets to Al_2O_3 and SiC ceramic materials. Single tile testing experiments were designed to closely resemble the conditions of a tile in a full armour panel solution. In addition, armour tiles were tested in an armour panel configuration where the final thickness of the tiles was optimized. It was concluded that TiC based cermets are able to destroy the hardmetal core of the 7.62x51 AP round at a mass efficiency between SiC and Al_2O_3. These results indicate that TiC based cermets could offer an alternative material in designing armour solutions at a competitive weight and cost.

LÜHIKOKKUVÕTE

Titaankarbiidkermis ballistilise kaitse materjalina

Käesolevas töös on uuritud titaankarbiidkermiseid alternatiivse materjalina ballistilise kaitse eesmärgil. Esmalt rakendati reaktsioonpaagutuse tehnoloogiat saamaks materjale, mille omadused oleksid samaväärsed või paremad võrreldes tavatehnoloogilisel meetodil valmistatud kermistega. Reaktsioonpaagutust rakendati toomaks alla materjali hinda. Teisalt on uuritud titaankarbiidkermiste ballistilist võimekust võrreldes teiste turul laialdaselt pakutavate soomusmaterjalidega.

Materjali arenduse tulemused näitasid, et reaktsioonpaagutuse tehnoloogia on võrreldes tavatehnoloogiaga võimeline saavutama titaankarbiidkermiste korral mehaanilisi omadusi, mis on samaväärsed ning isegi paremad. Materjali valmistamisel optimeeriti pulbri jahvatust, keemilist koostist ning töötati välja spetsiaalsed paagutusrežiimid saamaks kermise, mille omadused on sobilikud töötamaks soomusmaterjalina kõvasulamist südamikuga kuulide vastu.

Ballistilised katsetused töötati välja, et võrrelda omavahel titaankarbiidkermiseid alumiiniumoksiidist ja ränikarbiidist soomusplaate. Üksikute plaatide katsetustel püüti katsetingimused viia võimalikult lähedale olukorrale soomusplaadis. Lisaks katsetati soomusplaate ka soomuspaneelis, mille alusel oli võimalik optimeerida lõplik soomusplaadi paksus. Tulemused näitasid, et titaankarbiidkermis on võimeline purustama kõvasulamist südamikuga 7,62x51 soomustläbistava kuuli. Titaankarbiidkermisest soomusplaatide kaal on ränikarbiidi ning alumiiniumoksiidi vahepeal. Seega on titaankarbiidkermis konkurentsivõimeline soomusmaterjal nii kaalu kui ka hinna osas.