A SYSTEMATIC METALLURGICAL COMPARISON AMONG CVD COATED WC-CO CUTTING TOOL INSERTS FROM FIVE DIFFERENT SUPPLIERS

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A thesis submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfillment of the requirements for the degree of Doctor of Philosophy.

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DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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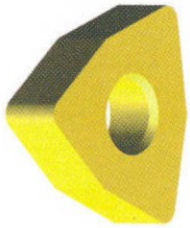
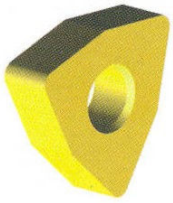
(Signature of candidate)

_____ day of _____ (year) _____

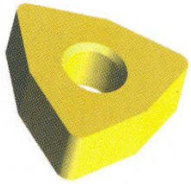


It's hard,
hard, not to sit on your hands,
burrow your head in the sand,
hard, not to make other plans
and claim that you've done all you can,
all alone
and life
must go on.

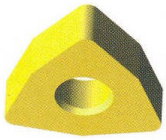
It's hard,
hard, not to break down and cry,
when every ideal that you tried
has been wrong.
But you must
carry on.



It's hard,
hard, when you're here all alone
and everyone else's gone home.
Harder to know right from wrong
when all objectivity's gone
and it's gone.
But you still
carry on.



'cause you,
you are the only one left
and you've got to clean up this mess.
You know you'll end up like the rest
bitter and twisted - unless
you stay strong
and you
carry on.



Yann Tiersen, "Les Jours Tristes"

ABSTRACT

The aim of this project was the assessment of the differences between coated hardmetal cutting tool inserts from five of the main producers in South Africa. These producers were given the names of suppliers 1, 2, 3, 4 and 5.
The tools were all for turning steel. The project involved investigations of the microstructure and composition of the substrates and of the coating systems of the tool inserts, as well as of the interface between substrate and coating. The results from the inserts from the five different producers were compared in an attempt to determine the reasons for their different performance.

As far as the substrates were concerned, the properties investigated were the microstructure and composition, Vickers hardness and crack resistance. The results showed large differences among the inserts. For example:

- Vickers hardness ranged from HV30 1591 (supplier 1) to HV30 1350 (supplier 5)
- Crack resistance was found to be between 0.43 kg/μm (supplier 1) and 1.02 kg/μm (supplier 5)
- Inserts from suppliers 3 to 5 showed a graded outer layer, whereas those by suppliers 1 and 2 did not
- All substrates consisted of W, Ti, Co and Ta, except the substrate of supplier 5 which included Zr, but no Ti

As far as the coatings were concerned, the microstructure and composition of the coating layers were determined by FESEM, EDS, microprobe analysis and X-ray diffraction. The coating layers were examined for cracks and porosity, and the interface between substrate and coating was examined by SEM. Vickers hardness of the system “substrate/coating” was measured, as well as abrasive wear resistance by means of “pin-on-disk” tests. Again, large differences were found. For example:

- The number of coating layers ranged from two layers (supplier 1) to five layers (supplier 5)
- Vickers hardness of the systems “substrate/coating” measured from HV30 1672 (supplier 1) to HV30 1410 (supplier 5)
- High porosity was found in the coatings from supplier 2, while those of suppliers 1 and 4 showed no or only rare porosity
- Cracks in the coatings were a common feature of all coatings, although in different amounts

The interfaces between the substrate and the coating were examined to assess the adhesion. This was done by Rockwell indentation tests, three-point-bending tests and scratch tests. The general result of the adhesion tests is that the inserts of supplier 3 exhibits the best adhesion.

The performance of the tool inserts in cutting could not be determined in the laboratory for lack of suitable equipment.

The tool inserts were ranked on the basis of the properties investigated, which allows to predict which insert is more resistant to each of the multiple wear processes occurring in cutting.

ACKNOWLEDGEMENTS

I am indebted to my supervisor, Prof. Silvana Luyckx, for giving me the opportunity to work in the interesting world of material engineering and I like to thank her for expert guidance in the fascinating field of microstructures, EDS and XRD analyses, abrasion, adhesion, etc., as well as for stimulating discussions, encouragement and assistance throughout my entire research project.

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The micrographs of the coating layers from the cutting tool inserts were to a large extent taken on the FESEM at the CSIR in Pretoria, where Loukie Adlem and Sara Prins provided me with excellent training on that instrument and always assisted me with any problems regarding my analyses.

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