CARBIDES & CERMETS FOCUS AREA

Objective: To assess the feasibility of manufacturing WC-Fe-based alloys using LENS technology

Different crack restraining methods were investigated and the influence of these methods in restraining cracks were analysed. A prototype was manufactured using near optimal parameters and the component performance was tested using a commercial performance matrix and compared with a conventionally manufactured component. The student started drafting the PhD thesis for submission in 2021. A journal paper is under review and a conference abstract has been accepted. (E. Molobi, N. Sacks and M. Theron)

Objective: To assess the feasibility of additively manufacturing WC-Ni-based alloys using LENS technology

The student submitted his PhD for examination in March 2020 and graduated in December 2020. One journal paper was published, and another journal paper is still under review. (B. Davoren, N. Sacks and M. Theron)

Objective: Production and development of NbC based cermets for wear applications

Production of NbC and WC based cermet cutting inserts for automotive grey cast iron machining. Successful production of NbC based cermets with Mo/Fe/Ni alternative binders via conventional sintering for physical and mechanical testing. NbC and WC based cermet cutting inserts were laser surface modified. Conducted highspeed (3000 RPM) face milling tests on automotive grey cast iron. (R.M. Genga and C. Polese)

Objective: Investigation of binder strengthening of WC-Co for hard-facing applications

Most of the experimental work was completed on the WC-10wt% Co samples with Cr_3C_2, VC and Ru made by spark plasma sintering (SPS). This included SEM-EDX, XRD and hardness and wear testing. The student spent much time in lockdown helping to make masks at Wits for PPE. The EDX analyses were repeated but have not been written up. Five drafts of the MSc have been read by the supervisors, and the student has repeated the EDX analyses. However, the student has lost family members from COVID-19 and is struggling to complete. (S.T. Luthuli, L.A. Cornish and D.J. Whitefield)

Objective: To study the effect of Ru additions to WC-VC-Co (AMSEN sponsored)

Even though the student graduated in 2019, he had worked on a paper which was accepted by the International Journal of Refractory Metals and Hard Materials. (L. Chipise, P.K. Jain (U. Botswana) and L.A. Cornish)

Objective: Investigation of different concentration gradient methods for the reduction of tungsten carbide (WC) precipitate formation in polycrystalline diamond compacts (PDCs) (Element Six supported)

There was a problem with the registration at Wits, and the project was adversely affected by the COVID-19 lockdown and possible retrenchment. However, despite this, several activities were accomplished. Work on the creation of the WC-free PDC was completed, which studied different additive methods to reduce the levels of WC precipitates in the diamond structure. The addition of the cobalt layer was more effective than carbon and cobalt-carbon variants. Preparation of a manuscript, “A method to reduce tungsten carbide (WC) precipitates in the diamond structure of polycrystalline diamonds”, was 90% complete. The research proposal was expanded as required after reviewing at Wits. The proposal now covers the effect of reduction of WC precipitates in the diamond structure on the leachability of PDC, as well as the effect of other variables on the leach rate: pressure, sintering temperature, sintering time, cobalt content and grain size. The proposal also includes the possibility of integrating all these factors to develop a leaching model for PDCs. Thus, the proposal title was revised to: “Mathematical modelling of the leaching of Polycrystalline Diamonds (PDCs) for integration into the product design process”. (A. Ndlovu and L.A. Cornish)

Objective: Residual stress assessment of LENS additively manufactured WC-Ni-based alloys

Lens produced WC-Ni-based samples were investigated with X-ray diffraction (XRD) at Necsa. Samples attached to the stainless steel baseplates were prepared with xz and xy surfaces respectively polished to 1 micron flatness at Stellenbosch University to facilitate XRD investigations. Due to extensive porosity in the samples, the XRD stress analyses provided qualitative results only. It is proposed that additional batches of samples be manufactured that have less porosity. (A. Venter, B. Davoren and N. Sacks)

Objective: To determine the influence of powder characteristics and processing parameters on LPBF of WC-Co

The student submitted his PhD research proposal for review on 31 July 2020. Based on feedback from the review panel, the candidate was requested to revise and resubmit his proposal by 17 September 2020. The panel approved the research proposal on 27 September 2020. The student has commenced with the literature review as well as the review of related in-house studies. (P. Govender, D. Blaine and N. Sacks)

Objective: Effect of phase binders on properties of SPS WC compared to HIP sintered WC-Co

The student has manufactured WC samples with different binder compositions and additives. The binders included cobalt, nickel and iron with 0.8wt% additive additions of either VC or Cr_3C_2. The properties of SPS WC-X (X=Co or Ni or Fe) cemented carbide are being compared with those that were HIP sintered. The properties of SPS WC-X materials are also being compared with HIP sintered materials doped with Cr_3C_2 and VC. The work would have been further along but due to the 4 month lockdown there was a significant delay in on campus work. (S. Sibaya and D. Whitefield)

Objective: Interfacial microstructure and mechanical properties of WC-Co oxyacetylene brazed joints using an Ag-based filler alloy

The student has completed his research work, made the examiners' corrections and has made his final submission to the faculty office and is awaiting graduation. He also experienced a 4 month delay where students were not allowed on campus just when he was trying to finish his last experimental work. (N. Mphasha and D. Whitefield)

Objective: To assess the tribocorrosion characteristics of tungsten carbide with different binder compositions exposed to organic acid environments

Four different tungsten carbide hardmetals with varying chromium and nickel concentrations in the binder were investigated for corrosion characteristics as well as initial tribocorrosion behavior. In addition, the dry sliding wear rates were also determined. The student wrote the proposal, as well as a first draft of the literature review. The experimental results will be published as a journal article in the coming year. (Q. Basi and J van der Merwe)

Objective: To design a theoretical tool to assist a hardmetals manufacturing company to adopt additive manufacturing technologies

The research proposal was submitted in June 2020. An extensive literature review was done, and initial modelling work commenced. The concept of technological readiness was explored with the goal of using a readiness model to analyse the current readiness of cemented tungsten carbide additive manufacturing technologies. An international conference paper was presented and published in the proceedings. (A.J. Burger, N. Sacks and S.S. Grobbelaar)

Objective: To evaluate the South African Hardmetals sector's innovation systems performance for additive manufacturing

The research proposal was submitted in June 2020. An extensive literature review was done. Submitted an ethics application which is required to interview subject matter experts for case

studies. Established case study methodology and conducted initial online interviews. An international conference paper was presented and published in the proceedings. (M. McClelland, N. Sacks and S.S. Grobbelaar)

Objective: To develop a business model framework for the Hardmetals Additive Manufacturing Sector in South Africa

The research proposal was submitted in June 2020. An initial literature review was done, and the outcomes were used to refine the research project scope and also used to set the criteria to undertake a systematised literature review. Identified a relevant case study to use in further research work. An international conference paper was presented and published in the proceedings. (A. van Heerdan, N. Sacks and S.S. Grobbelaar)

Objective: To develop cemented tungsten carbide coatings for abutment screws

The research proposal was submitted in July 2020, with the oral defence in September 2020. An extensive literature review was done. The student started to draft the initial manufacturing plan to produce samples. Attended two online writing workshops. Slow research progress was made as student experienced some personal difficulties during the COVID-19 pandemic. (S.S. Ndinisa and N. Sacks)