REPORT

on the

THE SOUTH AFRICAN PARTNERSHIPS PROGRAM VISIT

of

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in cooperation with

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Studies of Method

(The Use of Diffraction to Measure Residual Stresses in Cemented Carbide Composites)

and

Methods of Study

(The Use of Writing to Develop Critical Thinking in Engineering)

Summary

My Partnerships Program visit, based at the University of the Witwatersrand (Wits), was successful both professionally and personally. This was in large measure due to the diligent groundwork and support of my collaborator, Prof. Silvana Luyckx. In fact, the agenda was so full that the month-long visit I proposed was extended over the entire six weeks of my stay as I participated in two meetings in July. I presented five talks each on the technical and pedagogical aspects of my visit. Technically, a research project was initiated for an MS student of Prof. Luyckx that addresses the characterization of surface grinding stresses in tungsten carbide-cobalt composites. This class of materials is important for the machining of metals, mining, and the production of synthetic diamonds. I also met with representatives of the national reactor facility at the AEC laboratory at Pelindaba, De Beers Diamond Research, CSIR (formerly Council for Scientific and Industrial Research), and the Department of Physics at Wits. I returned with a comprehensive set of samples that will be used for an MS thesis project at MU. Also, as a result of discussions, I have new ideas for proposals that I will pursue, most likely in collaboration with Prof. Luyckx. With regard to the pedagogical component of my visit, there was interest in my use of writing in engineering, as well as our Campus Writing Program and the Writing Across the Curriculum movement in general. I was invited to make presentations to the Wits engineering faculty, Wits writing personnel, the School of Professional and Development Management, a workshop for new faculty, and to physicists at the annual conference of the South African Institute of Physics.
I. Technical Component - The use of diffraction to measure residual stresses in cemented carbide composites

Cemented carbide composites, high performance materials used for mining and drilling, comprise the materials system that was the technical focus of my visit. Wits began as a mining institution and Johannesburg was literally built on gold mines so that cemented carbides are of interest to South Africa. My collaborator, Prof. Luyckx, has worked with cemented carbides for many years. The basic objectives were to talk about my work, learn about their work, give advice in areas of interest, and develop ideas for the future.

Technical activities:

- I helped established the MS research program of L. Foxcroft, a student of Prof. Luyckx, who works at De Beers. The work deals with residual stress measurements in surface-ground cemented carbides. Such stresses are suspected of playing a role in premature failures. The measurements will primarily involve x-rays, with supporting neutron measurements. The x-ray measurements are being initially attempted using the x-ray diffraction facilities at the the AEC reactor site at Pelindaba, and may also be attempted in the Physics Department at the University of Cape Town. I am to monitor progress, provide input from MU, and be the external reader. I also will receive a sample to use in trial measurements at the Advanced Photon Source, the new synchrotron at Argonne National Laboratory, which may offer unique advantages in the study of such materials.
- I consulted with Dr. A. Venter, the scientist in charge of the neutron stress program at the Safari-I reactor at the Atomic Energy Commission (AEC) laboratory at Pelindaba. He sought advice on running their program, and showed me the progress they have made to date, which is substantial.
- I had discussions with Dr. P. Haupt, Facility Manager, Advanced Materials and Processing Programme, at CSIR. He is in charge of finite element (computer) modeling of, among other things, residual stresses, and is interested in the possibilities of neutron stress measurements as a means of validating calculated values.
- I met with Prof. D. Comins, Wits Physics Dept., on ways to calibrate Raman measurements of residual stresses in materials such as diamond and boron nitride.
- I obtained a comprehensive set of samples for use in the MS thesis of D. Coats, a new student of mine at MU. The samples are tungsten carbide-cobalt (WC-Co) cutting tool materials with WC grain sizes ranging from 0.6 to 5 micrometers and Co contents ranging from 10 to 40 weight percent. They have been extensively characterized at Wits with respect to grain size, abrasion resistance, wear, mean free binder path, and contiguity. The idea is to determine the residual stresses in the twelve-sample matrix and attempt to correlate the values with the parameters cited above.
- As a result of numerous discussions with Prof. Luyckx and others, I learned of two areas of potential research in cemented carbide composite materials: the effects of thermal fatigue on residual stresses, and the presence of macrostresses in large WC-Co anvils used to make industrial diamonds.
- It was agreed to pursue future collaborations. At this point I plan to pursue a study of the effects of thermal fatigue on thermal residual microstresses, and possibly macrostresses, in cemented carbides. The National Science Foundation supports
international interactions, while the Department of Energy is perhaps the most fruitful programmatic source of support.

- I attended part of, and gave two talks at, the 44th Annual Conference of the South African Institute of Physics, held in Port Elizabeth. I also attended, spoke at, helped judge student presentations, and participated in a panel discussion at the Annual Powder Metallurgy Symposium, held in Johannesburg.

- A listing of the five lectures (see Appendix A).

II. Writing component - The use of writing to develop critical thinking in engineering

An initial presentation on my use of writing at MU was made two days after my arrival in an effort to generate interest and allow time for further interaction with individuals and constituencies. This strategy, due to Prof. Luyckx, proved successful. Engineering faculty, and some writing staff attended the first talk, which led to a second talk that was aimed mainly at Wits writing personnel, i.e., that included a discussion of the MU Campus Writing Program (CWP) and the proposal process used at MU. These efforts led to invitations to make presentations in the New Faculty Workshop organized by the Wits Academic Development Centre (something like our PET, I believe), and at the School of Professional and Development Management (P&DM). A final presentation was made at the South African Institute of Physics Annual Conference in the extensive educational component of that conference.

Tertiary education in South Africa faces overwhelming challenges with regard to language and its use. The country has 11 official languages: English, Afrikaans, and nine African languages, of which Zulu is the main one. During the questions following one of my talks, after I had referred to English as a Second Language (ESL) classes, a new African faculty member pointed out that English was, in some cases, a fourth language. The student body at Wits is now predominately black African (about 52%) and this has created a language and college preparation problem that is one of the many legacies of apartheid. The Writing Project, initiated by Dr. P. Nichols in the Department of English, is a tutoring center to aid students in the preparation of writing assignments. There is a University commitment to make this a Writing Centre. It would report to a Steering Committee headed by the Vice-Chancellor for Academic Affairs. This would, as I understand it, have a somewhat decentralized structure, with satellites in some Colleges. I suspect that the development of writing skills will be the main issue for some time. Furthermore, although there is interest in the use of writing to promote critical thinking among the faculty, most do not really understand the distinction between learning to write and writing to learn, as is the case in the US as well.

A listing of my writing lectures is presented in Appendix B.
III. Evaluation

My proposal cited evaluation criteria for the technical and pedagogical components of my visit. They are listed below, in *italics*, followed by brief discussions.

**Technically:**

- *A set of WC-Co cemented carbide samples from South Africa has been committed, although the specifics must be worked out. Phase and stress measurements will be made, primarily at the MU Research Reactor Center. The success of the study will be measured by its ability to be published and presented as a contributed or invited talk.*

This is the set of samples obtained for the MS thesis of D. Coats. I have also made arrangements to measure a few of them at Los Alamos to see if pulsed source measurements are more appropriate (they may well be). This study is distinct from Foxcroft’s MS thesis plans, for which I have an advisory role.

In addition, the effect of thermal fatigue on thermal residual microstresses in cemented carbide components is being pursued as a basis for continued collaboration.

- *My talks about our diamond coating work can be measured by (funded) interactions with the South African diamond industry, and by the level of similar work undertaken in South Africa as a result of the stimulation of our discussions.*

I learned that De Beers cannot support work in the US, by law, so that this avenue will not work. In truth, there seemed to be little interest by South African industry in pursuing diamond coating work. However, the investigation of thermal fatigue in cemented carbide (and other particulate) composites emerged as a fruitful avenue, and this is being pursued.

- *The successful transfer of neutron stress measurement capability to South Africa can be measured by whether or not such work is undertaken over the next few years, and by whether or not possible graduate or postdoctoral students seek appointments at MU.*

Aspects of neutron stress measurement methodology were transferred through discussions with the AEC reactor facility at Pelindaba. I consulted at some length with Dr. Venter at the AEC facility, and will continue to interact. He has established a small program and will pursue collaborations within South Africa. The results he showed me were excellent. Capabilities of the method were also discussed with industry, Wits science/engineering faculty, and part of the national physics community.

**Pedagogically:**

- *If elements of what I do at MU are incorporated into a course or courses in South Africa, the discussions can be considered to be successful.*
There was interest in my writing activities, as evidenced by the speaking invitations. I also left my course syllabus and related handout material, as well as information about the Campus Writing Program. I have established communication with a number of individuals and, hopefully, will learn if specific ideas are utilized in engineering, physics, or business classes. I believe there was interest in the way I structure writing assignments and that some will employ similar approaches in an ad hoc way.

- **An ongoing interaction with personnel in South Africa would also be evidence of success.**

I have established contact with writing personnel at Wits in English, education, the Academic Development Centre, engineering, and the school of Professional and Development Management. I will maintain these contacts so that I am aware of activities. It looks like I will have the opportunity to return and personally observe what is going on.

- **Creating a new partnership with the University of the Witwatersrand would be a major outcome of this component of the proposed visitation.**

I would like to think that the writing expertise at MU could be more formally enlisted to facilitate the incorporation of the 70% of South Africans who were excluded for so long, as well as the development of the critical thinking skills of all students, the real goal of WAC.

### IV. Budget

I would like to briefly account for my expenditures in the context of the proposed budget.

- I budgeted $2,600 for airfare to and from South Africa, with a round trip between Johannesburg and Cape Town in between. The total actual cost of these two tickets was about $1750.
- My room and board expenses for the initial month in Johannesburg were covered by Wits, as agreed.
- I budgeted $1100 for a rental car but only spent about $400.
- My budget did not include a materials/printing allocation but I billed about $250 to the grant for talk preparation materials, as I prepared in excess of 200 new color transparencies specifically for the visit.

Thus, I consumed about $2,400 of my $3,700 allocation. My final reimbursement has been received. This report serves to inform Dr. Turner’s office that they can reclaim the difference and close the account.
V. Concluding Remarks

I greatly appreciate the opportunity that was made available to me by MU. It was professionally and personally rewarding. I have already been in contact with some of the individuals I dealt with, and have just been asked to write a letter of reference for a faculty member at Cape Town who is up for promotion. Through this opportunity, I learned about a country of which I had only the vaguest understanding, met a number of gracious and talented individuals, furthered my professional work, and found interest in my use of writing in the classroom.

I am also grateful to the University of the Witwatersrand, and my collaborator, Prof. Silvana Luyckx, whose efforts made the visit possible and successful. As a premier educational institution, Wits is in a position to train future leaders and develop informed citizens in post-apartheid South Africa. Its student body is now comprised of a majority of African students and African representation on the faculty is growing.

I have provided four bursaries (scholarships) for African students in honor of my collaborator, Prof. Silvana Luyckx. They will be awarded annually to needy and deserving African students of her choosing in the amount of 1500 South African Rand each (about $250) for four years, a total of about $1000. Education is surely a key to overcoming the past and developing a successful future.
Appendix A: Presentations on the use of diffraction to measure residual stresses in cemented carbide composites

- **Stress measurements using neutron diffraction**, June 4, 1999, De Beers Diamond Research Laboratory, to technical staff.
- **Stress measurements using neutrons**, July 7, 1999, Winter School, South African Institute of Physics (SAIP), Port Elizabeth, to attendees of the SAIP Winter School.

Appendix B: Presentations on the use of writing to develop critical thinking in engineering

- **The use of writing to develop critical thinking in engineering**, June 3, 1999, Wits, to engineering faculty with some writing staff in attendance.
- **Missouri University’s Campus Writing Program and the teaching of Writing Intensive courses across disciplines**, June 10, 1999, Wits, to writing and engineering staff.
- **WAC at MU**, June 24, 1999, Academic Development Centre New Faculty Teaching Workshop, Wits, to approximately 10 new faculty.
- **Engineering writing**, June 28, 1999, School of Professional and Development Management, Wits, faculty and staff.
- **Engineering writing**, July 8, SAIP Conference, Port Elizabeth, to attendees of South African Institute of Physics Winter School.