PROJECT THEMIS: FROM METAL POWDERS TO BODY PARTS, PERSONAL CARE AND MEDICATION

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ABSTRACT

This contribution to the Koerner Symposium chronicles Bob's primary research activities and accomplishments over the 1969-1979 time frame. It serves as a precursor to later research and development which established Bob as an internationally recognized authority in geosynthetics. In particular, it is a review of his research and seminal findings in powder metallurgy via Project Themis, and subsequent synergistic research on porous pacemakers, deodorants and briquetting. Current research in Materials Science & Engineering builds on the concept of triaxial compaction introduced by Bob in the early 1970's.

INTRODUCTION

Project Themis was a U. S. DOD funded study to Drexel University's Metallurgy (now Materials) Department. It was a multi-disciplinary effort involving seven faculty, numerous students and extended for a four year period from 1970 to 1974. The focus was on powder metals insofar as atomization, compaction, sintering, forging, finishing, production and economics was concerned.

Upon conclusion, the different team members either continued in this area or moved into other disciplines. Koerner's effort branched sequentially from metal powders, to porous medical implants, to various organic powders, to coal/charcoal briquetting. This paper describes these activities.

POWDER METALLURGY AND PROJECT THEMIS

Based on the powder metallurgy background of several members of Drexel's Metallurgy Department, a proposal was written in 1970 and accepted by the U.S. Department of Defense under the title of Project Themis; Contract No. DAAA-25-69 CO136. The contract was for 4-years. Each year was heavily funded since numerous faculty and students were involved. It was by far the largest research contract that Drexel had up until that time. As events transpired, the following topics and faculty became involved:

1. Project Director - Dr. Alan Lawley, Materials Engineering Department
2. Powder Atomization - Dr. John Tallmadge, Chemical Engineering Department
3. Powder Compaction - Dr. Robert Koerner, Civil Engineering Department
4. Sintering - Dr. Richard Heckel, Materials Engineering Department
5. Forging - Dr. Michael Koczak, Materials Engineering Department
6. Mechanical Properties - Dr. Howard Kuhn, Materials Engineering Department
7. Economics - Dr. Richard Haas, Economics Department

Weekly meetings were held with a different investigator presenting his results in the interim since his last presentation. These activities kept the group extremely active and resulted in many journal, conference and symposia proceedings papers, along with the associated oral presentations. Additionally, there were many masters and doctoral degrees that stemmed directly from the project. Several patents resulted, one being for the "triaxial compaction of metal powders" by Dr. Koerner.

POROUS METAL IMPLANTS

The move from powder metallurgy into porous metal implants for pacemakers and biotelemeters was immediate. These energy sources were typically an aluminum anode and a platinum or palladium cathode. Both were isostatically compacted from powders at high pressure (30-50 ksi) and then sintered. They were then laboratory evaluated by Dr. Richard Beard and Mr. Joseph DeRosa of the Electrical Engineering Department. Eventually, Dr. Stephen Dubin, Drexel Veterinarian, did in-vivo measurements by implanting the small cells into rabbits, with the ultimate goal of compatibility (due to excellent tissue ingrowth) and long life (a 10-year time was envisioned). Again, numerous papers and theses resulted from this activity. The efforts had sponsorship by the Biomaterials Program of NSF (Grant GH33748), the National Heart and Lung Institute (Grant HE05417), and the National Institute of Health (Grant RR 7129).

ORGANIC POWDERS, e.g., DEODORANTS

During the 1970's, numerous organic powders were evaluated from a compaction (isostatic and triaxial stress states) perspective. Simulated mock explosives were triaxially compacted in an attempt to increase explosive energy through extremely high density compaction. The effort was moderately successful until real explosives were attempted during which a bunker in Amarillo, Texas was destroyed.

Coffee powders were also evaluated for their minimum and maximum densities and the effects of temperature and relative humidity. The goal in this activity was to control instant coffee powder flow in automatic dispensing machines.

Lastly, with Dr. Michael Koczak of Drexel's Materials Department, compaction of personal care products (aka, stick deodorants) was undertaken. In all, five single constituent powders were isostatically compacted and tested (Avicel PH-105 MCC, aluminum chlorohydrate, talc, zinc stearate and sodium bicarbonate) and seven blends of powders. The different blends of powders included Avicel PH-105 in percentages ranging from 50 to 80 percent. Along with the basic tests indicated, compression ratios and scanning electron micrographs also were obtained.

Between the aromas of coffee powders and deodorants, the soils and materials laboratories at Drexel never smelled so good.

COAL AND CHARCOAL BRIQUETTING

In the latter 1970's, the International Briquetting Association (IBA) approached Dr. Koerner with the invitation to analytically investigate the behavior of coal and charcoal briquettes for industrial and home use. The technology was extremely empirical at that time. A finite element study resulted which subsequently led to laboratory tests for confirmation purposes. In addition to the associated papers, Koerner received the inaugural Neal Rice Award from the IBA. This activity also led into the editorship of five IBA conference proceedings. Clearly, the research moved the IBA into a more technically-correct position than it had been previously. It continues today as a viable organization with annual meetings and conferences.

SUMMARY

Project Themis was most significant to Dr. Koerner in that it opened the door to investigate a wide range of non-soil powders and particles in a large and interactive team setting. Koerner's step into a new and different system was challenging yet rewarding. Once the first step was taken, the road to additional powder research and development was obvious. With the road map from project Themis, it was both logical and straightforward. It was certainly an exciting and interesting period in the 1970's when these activities transpired.