

MATERIALS MICROSTRUCTURAL DESIGN GROUP (GEMM) AT UFSCar

Victor Carlos Pandolfelli and José de Anchieta Rodrigues

Universidade Federal de São Carlos: UFSCar, is the only Federal University located in the interior of the São Paulo State. The main campus has 645 hectares of a 9,478 hectares total (1,549 acres of a 23,421 acres total) located in Sao Carlos (Figure 1). Today, there are 5,430 undergraduate and graduate students, enrolled in either one of the 25 degree courses or in one of the 27 master and doctorate degree programs. The Materials Engineering Department covers majors in Ceramic Materials, Metallic Materials and Polymeric Materials.

HISTORICAL INFORMATION:

The Group for Materials Microstructural Design (GEMM) was founded in 1991 as part of the Materials Engineering Department (DEMa) at UFSCar. The Group established its consolidation based on education activities for undergraduate and graduate levels, an intensive research program, and cooperation with Brazilian industrial sectors.

Since 1993, GEMM has its own laboratory building named Laboratory for Special Ceramics and Refractories, which has 800 m² (8,600 ft²) of useful area (Figure 2). The Group and the University are proud of this building, which was a donation of Alcoa's Philanthropic Institute in Brazil in recognition of the positive cooperation between UFSCar and Alcoa during more than 10 years of interaction. With grants of FAPESP (the most important research financial institution of São Paulo State) it was possible to get a high level infrastructure for high temperature mechanical characterization of refractories (Figure 3).

CHARACTERISTICS:

The aim in education activities is to offer study and work conditions to students so they can develop skills which will give them good bases to compete for jobs in industry as well as in research laboratories. Concerning research, the emphasis is put on the microstructural design of refractories, in particular of castables, and on their thermomechanical evaluation. Both activities education and research, are continuously updated to follow the real necessities of the concerned industries.

Nowadays more than 25 people work inside GEMM, including one technician, 18 graduate students (11 in the doctoral program, 7 in the master program), post-doctoral personnel and senior researchers (4). Emphases are given to the equilibrium between a strong rate of scientific publication in recognized journals and the consideration of the needs of the Brazilian industrial sectors. Since 1990, the Group received 19 awards from Brazilian congresses and industrial associations. Three Brazilian industrial patents are registered which are co-authored by members of the GEMM:

- Process and formulation system for particulate ceramic materials
- Self-flowing refractory castable composition (hydraulic bonding or chemical bonding free) and preparation process
- Novel Rheometer for castable mixes

THE TEAM:

The leader of GEMM is Prof. Dr. Victor Carlos Pandolfelli, a materials engineer who received his undergraduate degree in 1979 and his Ph.D. in ceramics at the University of Leeds in 1989. In 1996 he took his sabbatical in the École Polytechnique, Montreal.

Prof. Dr. José de Anchieta Rodrigues is a physicist who earned his undergraduate degree in 1976 at the University of São Paulo and his Dr. rer. nat. title at the University of Stuttgart and Max-Planck Institut für Metallforschung in 1984.

Dr. Murilo Daniel de Mello Innocentini is a chemical engineer from UFSCar (1991) and obtained his PhD from UFSCar too in 1997.

Dra. Alessandra Pereira da Silva earned her chemical engineering diploma at Universidade Estadual de Maringá in Brazil in 1994 and her PhD from UFSCar in 2000.

MAIN RESEARCH AREAS AND PROJECTS:

- Development of advanced refractory castables
- Development of technical ceramics with high thermomechanical performance
- Evaluation techniques of thermomechanical properties
- Processing of ceramic suspensions (i.e., alumina, SiC)
- Development and characterization of ceramic foams

Currently, the main research projects that the Group is carrying out include:

- 1) Development of Multifunctional Castables - particle size design, rheology and properties (creep and permeability)
- 2) Rheological behavior of castables (self-flowing, pumpable, etc.)
- 3) Development of zero-cement castables (for instance, how to avoid cement adding enzymes)
- 4) Evaluation of permeability of refractories at room temperature and at high temperatures (up to 800° C). A major interest today is to understand the effect of cement, water, fibers, etc, on the permeability.
- 5) Study of the fundamental equations that explain permeability and its main variables. A new effort will expand the permeability equations to consider the wetting angle and surface tension of slags and correlate permeability and corrosion.
- 5) Development and characterization of foam ceramic filters for foundries and steel producers
- 6) Gel casting of porous ceramics
- 7) R-curve, fracture energy and thermal shock parameters of refractory castables and bricks (mainly aluminous compositions).
- 8) Design of alumina-SiC-C dispersion for castables

MAIN INDUSTRIAL PROJECTS:

- 1) Development of alumina-spinel-C brick for steel ladles
- 2) Development of pumpable and shot-creting castables
- 3) Design of refractories for steel ladles (i.e., alumina-C, MgO-C)
- 4) Development of electrofused aggregates (i.e, mullite, mullite-zirconia)
- 5) Development of castables for FCC (fluid catalytic converter) petrochemical units

For further information contact the authors at: Universidade Federal de São Carlos, Departamento de Engenharia de Materiais, Via Washington Luiz, km 235 -13.565-905, São Carlos - SP, Brazil. On the website see: <http://www.ufscar.br/~dema/gemm/index2.htm>



Figure 1. Entrance to UFSCar



Figure 2. Entrance to DEMa building donated by Alcoa (Laboratory for special ceramic and refractories)



Figure 3. Perspective view of the main DEMa laboratory showing MOR, thermal conductivity and RUL/creep testing equipment.

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WHAT IS HAPPENING IN SHOTCRETE PLACEMENT?

By Jim Farrell, Blastcrete Equipment Company

THE CHALLENGE MET

The United States refractory industry is to be applauded for its lead in development and application of formless high temperature concrete. Low moisture and low cement technology that has resulted in formless castable installation has been well accepted around the world.

This "new" technology came about at just the right time. Gunite, or dry shotcrete, had been the standard bearer of formless castable installation until "jet-set" or "shotcasting" came of age with the wet shotcrete process applied to refractory low cement and no cement products. The wet shotcrete process has resulted in less dust and rebound at the nozzle, and higher performance materials.

ANOTHER OSHA CHALLENGE

The Occupational Safety and Health Administration (OSHA) has a proposal on Congress' plate to lower the allowable limit of respirable silica dust by 50% from the present standards. The result could be elimination of the dry shotcrete (gunite) process with materials containing crystalline silica. Results of the November election could have an impact.

Industry acceptance and proven performance of the wet shotcrete process have been sudden and swift, and the timing appears to be fortunate based on the introduction of this new legislation. While the refractory industry has been brilliant in its offer of an excellent alternative to the gunite process, it has not come without a downside. . . higher cost.

THE PRICE CHALLENGE

The price of a gunite machine is approximately \$10,000. The price of a

high-pressure swing tube refractory pump designed to move low cement and no cement refractories is over \$40,000. Add a mixer and the total price can be as much as \$80,000. In most installations, the customer will require a back up machine in case of a break down. This raises the bar too high for many in the business of installing refractories.

THE TECHNICAL CHALLENGE

The challenge to the refractory industry now is to lower the bar on equipment cost by designing materials that do not require the ultra high pressure of a swing tube pump.

Hydraulic peristaltic pumping equipment has been available in the U.S. for many years. Peristaltic pumps operate at 75% less hydraulic pressure than do swing tube pumps, however the cost to build these lower pressure pumps is more than 50% less than the cost of a swing tube pump. These hydraulic peristaltic pumps are also much safer to operate and much easier to maintain and clean than swing tube pumps.

The challenge to the refractory industry now is to develop low and no cement materials that will flow through these lower pressure pumps. Refractory producers who eliminate the requirement for ultra high-pressure pumps to move their materials will create an opportunity for many more installers and customers to afford the equipment to utilize their products.

Note about the writer of this update: Jim Farrell is President of Blastcrete Equipment Co. in Anniston, Alabama. Blastcrete supplies the refractory industry with mixers and machines for the installation of their products. Jim Farrell can be reached via email at jim@blastcrete.com or www.blastcrete.com

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