A REVIEW OF REFRACTORY BOND SYSTEMS FOR MONOLITHIC REFRACTORIES

Chris Parr, Josh Pelletier, Christoph Wöhrmeyer, Carl Zetterstrom, Magali Szepizdyn – Kerneos SA

A plethora of bonding systems has been developed for monolithic manufacturers, either as proprietary systems or commercial products. Each of the these systems displays a series of intrinsic characteristics that can be exploited advantageously by the monolithic producers.

This paper will provide a state of the art review of the different bond systems by their function and the delivered performance in a variety of model systems. A number of composite/combination binder systems will be explored via an extensive literature review and experimental data along with a perspective of the evolution and development of bond systems over the last 20 years. A specific focus will be given to bond systems for monolithic castables. Results will show the different comparative characteristics for each system and their advantages as well as the tradeoffs that have to be made. This then gives rise to the notion that there is no one universal bond system but rather intrinsic characteristics have to be adapted to each situation and application in terms of placing technologies and installed performance. Conclusions will explore future needs and development options.

EFFECT OF ADDITIVES ON THE PROPERTIES OF MAGNESIUM PHOSPHATE CEMENT

George D. Gower, P.E. – Refractory Minerals Co., Inc.

The effects of various additives on the Magnesium Phosphate cement system are investigated. Magnesium Phosphate cement is comprised of Mono Magnesium Phosphate and a source of MgO (Fused or Dead Burned). This is a rapid reaction requiring additives to slow the setting of the Cement. In addition, additives may be used to vary strength and expansion characteristics. Utilizing a standard test mix the effect of additives on set time, flow, strength and expansion are studied.

CEMENT HYDRATION AND STRENGTH DEVELOPMENT - HOW CAN REPRODUCIBLE RESULTS BE ACHIEVED?

Dale Zacherl – Almatis

The consistency of high alumina cements, with regard to setting and strength development, is a key quality feature which distinguishes different brands available in the market. The quality testing of cement must take into account inherent variation of the cement setting behavior which occurs, for example, in neat cement testing. When testing in castables the ambient conditions such as temperature, humidity, and a covering of the samples can have an influence on the strength development. The paper discusses results obtained in calorimetric testing of different cement test grogs and of castable testing under practical laboratory conditions with different cement content and additives in the test castables.

COMPARISON OF THE PROPERTIES OF CEMENT AND CEMENT-FREE CASTABLE BOND SYSTEMS

Sam Bonsall – Vesuvius USA

Low and ultra-low cement castables perform well in a wide variety of applications. Several cement-free bond systems were evaluated in comparison to cement bonds with respect to physical properties, ability to repair (veneer over existing castable), and installation/drying behavior. The results will be used to reach objective conclusions on the advantages and disadvantages of each system.

HOW DO STEELMAKERS CHOOSE REFRACTORIES – THE ROLE OF BONDING SYSTEMS

Tom Vert – ArcelorMittal Dofasco

Steelmakers are under extreme pressure with a high risk process, in an oversupplied competitive marketplace with low margins, with very little control of their costs and refractories are one of the only controllable components left. Selection of refractories is a balance of many factors including safety, environment, production, costs, etc. and selection of an engineered ceramic with detailed technical data including bonding systems can allow steelmakers a better understanding as to the probability of success. Also, refractory suppliers, raw material suppliers and universities need to develop tests that will simulate real life processes and not good QAQC tests if they want to increase trials, increase product success, and increase profits! The presentation will attempt to address these issues and a path forward for the future.

FINDINGS ON RELATIONSHIPS BETWEEN PARTICLE PACKING, ULTRAFINES AND RHEOLOGY OF REFRACTORY CASTABLES

Bjorn Myhre – Elkem

Particle size distribution has been found to influence the flow of modern castables, in the sense that by varying parameters in the distribution deliberate composition of vibratables or self-flowing mixes can be readily made. There still exist a quest regarding the rheological behavior at high shear though, which is particularly important and essential in high-shear applications like pumping and shot-creting. In this paper theeffect of Partice Size Distribution (PSD) on flow of castables is treated, as well as the importance of the particle shape. Particularly for the the sub-micron fraction is demonstrated that the use of a spherical alumina instead of plate-like reactive alumina eliminates dilatancy. Thus by using spherical alumina, the tendency to dilatant behavior can be eliminated also in silica-free alumina castable compositions.

ACTIVATED ALUMINA BINDERS IN REFRACTORY COMPOSITIONS

Scott Barnhouse – Alteo NA

Activated Alumina (AA) can be used as a binder in zero cement and ultra-low cement refractory systems. The history as well as the advantages and disadvantages of AA as a refractory binder will be discussed.

A 50 YEAR HISTORY OF CONTRACT REFRACTORY DRYOUT / HEATUP SERVICES

Irish Cobane – Hotwork

Contract refractory dryout / heatup services have played an important role in practically all refractory consuming industries and particularly the quality assurance of monolithic refractory linings. Since the invention of the high velocity excess air burner in the UK in the early 1960's and the subsequent use of that equipment to impart controlled uniform heating of refractory lined furnaces and vessels, the technology has been accepted as "best practice" for initial dryout / heatup of refractory linings regardless of whether it is to uniformly heat pre-fired refractory brick linings or moisture removal from monolithic linings. In conjunction with the development of high density, low moisture monolithic refractory products and particularly with the advent of Calcium Aluminate and other chemical binder systems, the ability to perform closely controlled uniform heating using a professional refractory dryout contractor has had a significant impact on the life cycle of both brick and monolithic refractory linings and the ever increasing use of the latter in today's refractory consuming industries.

This paper discusses the invention of the high velocity burner, the role it played in the founding of Hotwork UK (1962) and subsequently Hotwork-USA (1965) as the companies who brought refractory dryout services to the world. Also discussed are the various monolithic refractory binder systems encountered over the years, dryout curves and the challenges encountered in bringing refractory linings into service in a manner conducive to providing maximum service life in the applications for which they were designed.

REFRACTORY CASTABLE BINDER ENGINEERING

Victor C. Pandolfelli – Federal University of S. Carlos – Brazil

Considering that the major volume consumption of refractory castables is for the steel making industry, calcium aluminate cement (CAC) is usually the most common binder. Nevertheless, CAC is not the best option for densification at temperatures in the 800°C-1200°C range, for applications where high thermal shock and erosion resistances are essential properties, such as for petrochemical and aluminum industries. Taking these aspects into account, novel castable formulation concepts were designed aiming to attain sintering at lower temperatures without the drawbacks of permanent liquid phase containing systems. The successful use of colloidal binders and transient phases will be presented as an alternative to attain such requirements, based on the high refractoriness, high erosion and thermal shock resistances, and hot mechanical strength

achieved. The outstanding performance, points out the great potential of these routes to increase the working life and reduce the maintenance stops of the production units. Besides bonding with nano particles and transient phases, some experimental innovative techniques will also be highlighted such as brucite morphology engineering for the development of Al_2O_3-MgO cement-free refractory castable. The use of hydrating agents that could change the $Mg(OH)_2$ crystals shape in the resultant microstructure, minimizing the drawback related to the in-situ reaction expansion and providing suitable green mechanical properties, will be presented and discussed.

THE USE OF PHOSPHATES AS BINDERS AND ADDITIVES FOR REFRACTORIES

Erwin Schmidt – Chemische Fabrik Budenheim KG

The paper presents a brief roundup of various types of phosphates,
their properties and applications as binders for shaped and unshaped refractories,
as well as their application as additives for castables and hardeners for silicates.

BONDING SYSTEM IN MgO-CaO-Fe_2O_3 REFRACTORY FOR EAF FURNACE BOTTOMS

Henry He and Steve Mangin – Magnesita Refractories

Binders with low melting points are often added into the refractory mixes in order to create sintering at lower temperature. These binders can compromise not only the refractoriness but also the erosion resistance. One of the unique bonding systems is the bonding system for electric arc furnace bottom material made of MgO-CaO-Fe2O3. In this bonding system, the dicalcium ferrite (C2F) forms a transient liquid phase to initiate the liquid sintering and densification at a temperature as low as 1300C. However, the liquid phase then disappears gradually with the migration of iron oxide in the liquid into MgO and the formation of magneiowustite, leaving behind ceramic bonded structure with high refractoriness.

There are two ways to achieve this bonding system. One is to add iron oxide into the blended magnesia and doloma, which results in high refractoriness and high erosion resistance to the EAF slag. The other is to use MgO-CaO-Fe2O3 grains, which results in quick sintering and high shrinkage.

CORRELATION BETWEEN MEASURED THERMOPHYSICAL DATA AND MINERALOGICAL CONSTITUTION OF REFRACTORIES

Peter Quirmbach and Hartmut Koerber – Deutsches Institut fuer Feuerfest und Keramik (DIFK)

Thermophysical data concerning different kind of strength, creep and erosion and corrosion resistance obviously correlates with microstructural design. Apart from the right choice of grain parameter the constitution of matrix phase fundamentally influences the binding forces and their impact to product behavior. The correlation determining effect will be discussed in terms of structure-property relations by means of representative examples.

GUNMIX – A NEW MOISTENING SYSTEM TO IMPROVE BONDING IN DRY GUNNING

Christian Wolf – Velco GmbH

For many years the dry gunning procedure is used for the cold and hot repair of refractory linings. By means of the new VELCO development, the **GUNMIX®**-system, the moistening of the gunning mix will be improved considerably, resulting in better physical properties of the gunning mix and less dust and rebound. For small gunning amounts **GUNMIX®** is a cost-saving alternative to labour intensive procedures such as Wet-Shotcreting. Applications for hot and cold installation in steel- , aluminium-, cement industry and waste incineration will be shown.