MULTI-ANNUAL RESEARCH PROGRAMMES

SUCCESS STORIES

DIWEAR – WEAR RESISTANT DUCTILE IRON

Since its foundation in 1992, the SAM department (Science et Analyse des Matériaux) of the CRP Gabriel Lippmann has evolved into an internationally renowned centre of excellence in, among others, the characterisation of materials. It was in that capacity that they were contacted by the Innovation Centre Iceland (ICI) and their partner, the foundry of Thorgrimur Jonsson, several years ago. The groups from Iceland had developed an entirely new method of casting ductile iron (grey iron specially treated to alter the shape of the graphite components, thus vastly increasing the toughness and strength of the material): instead of the usual homogenous casts, they were able to reinforce components locally, where the wear is most severe, allowing for drilling and milling in non-reinforced sections. The developed components would further have a functional gradient in composition, thus avoiding cracking and delamination at sharp boundaries. Another advantage of the technique was the use of smaller quantities of alloying elements, allowing traditional recycling of the cast iron parts.

Their new technique clearly worked, but in order to perfect it, the group from Iceland required a better understanding of both the microstructural and tribological properties of the ameliorated materials. It was thus that in 2007 a new project came into life within the INTER - ERA-Net MATERA programme of the FNR: the Wear Resistant Ductile Iron – DIWEAR project is a collaboration between the two Icelandic groups, the CRP Gabriel Lippmann and the Centre for Tribological and Technical Diagnostics of the University of Ljubljana and is bound to be completed in May 2009. The DIWEAR project leader, Dr Nathalie Valle, was joined by Dr Mayerling Martinez Celis, a post-doctoral researcher specifically recruited for the project. Whereas the SAM team was responsible for characterising the microstructure of the samples, the team from the University of Ljubljana were studying their tribological behaviour, which is in essence the science of interacting surfaces in relative motion, among others friction, lubrication and wear.

When iron is cast, the cooling speed during fabrication or thermal treatment determines the types of its components: according to the used technique, atoms will associate in different ways and display different compositions, concentrations and stoichiometries (the relation between the quantities of substances that take part in a reaction or that form a compound). Those properties eventually define the material's characteristics. By combining their results, the SAM team and their Slovenian partners should be able to establish the direct effect of the microstructure on the material's tribological properties.

The microstructural analysis has to be run over a variety of scales reaching from a general overview by optical microscopy down to the nanometre scale observed by transmission electron microscopy (TEM). "Samples prepared for TEM microscopy need to be cut into slices a thousand times thinner than a human hair. Seeing as we were working with materials specifically designed for their resistance, cutting them up was not that straightforward and could actually require quite a bit of patience sometimes," recalls Dr Nathalie Valle. Further analysis was carried out with one of the technological gems of the SAM department, the secondary ion mass spectrometer (SIMS). In this technique, the sample surface is bombarded with an ion beam; the sample disintegrates and emits its constituting ions. The following analytic process produces an image of the exact elemental distribution at the sample surface, at a scale of 10-50 micrometers across with a resolution of 50 nm.

When asked about the final results of the study, Dr Valle has to keep quiet however: "We have got exciting results, but since we were working on an entirely novel technique, we cannot divulge anything until our Icelandic partners have obtained the patent for the production process." The papers on microstructural work should hopefully be published in the near future, after submission to specialist journals such as Wear and Materials Science and Engineering. Once the production process in Iceland has been refined and the new ductile iron materials are on the market, we can also be expecting exciting new developments in fabrication – overall a very rewarding collaboration!