Example Case-studies

For Stichting LustrumExcursie Francken

1 Account Case Study SKF

Guus Winter

The Svenska Kullagerfabriken (Swedish bearing factory), better known as SKF, is as you might guess a bearing making company, originated from Gothenburg, Sweden. Nowadays SKF is a worldwide company, being represented in 32 countries. One of those countries is our little country, the Netherlands, and SKFs only research centrum in the world is situated in Nieuwegein.

My job was to investigate the behavior of inclusions in bearing steel during in-situ (inside a SEM) tensile tests. Inclusions are micrometre sized particles originated from impurities and precipitates as MnS, Al2O3 et cetera which are embedded into the steel matrix. They are formed while the bearing steel is produced and play an important role in the strength of a bearing. We used an experimental technique, called Digital Image Correlation (DIC), to see displacements at microscopic level. DIC com- pares two images taken with a SEM and calculates the displacements with an accuracy of about 0.2 pixels. With this technique we could look at the local displacements around an inclusion during a tensile test. The inclusions at the surface were ob- served with an ESEM and by using Electron-dispersive X-ray spectroscopy (EDS) the chemical composition of the inclusions could be derived. The inclusions at the surface were between 1.1 and 11.5 m in size. Most inclusions turned out to be Ca-S, but also some traces Al, Si, Mn and O were found. The DIC-analysis showed that the deformation inside the inclusion always larger was than the deformation of the steel matrix around it when the sample was stressed.

Digital Image Correlation turned out to be a powerful method for observations of inclusions behavior in bearing steel. I have presented the results at SKF in Nieuwegein and they were very pleased with my research, which immediately gave rise to a few questions of some of the employees of SKF whether other problems could be analyzed using Digital Image Correlation in future research.

I would like to thank Erik Vegter and SKF for provding the case and the Materials Science department of the Zernike Institute for Advanced Materials of the University of Groningen for facilitating this research pro- ject. Of course I want to especially thank dr. V. Ocelik and prof. dr. J.Th.M. De Hosson for supervising my research.

Account Case Study SKF

by Alexander Raaijmakers and Ivo van der Werff

Introduction

This case study was done for SKF, a Swedish company that has specialised in producing high quality ball bearings. Bearings consist of an outer cylinder, some rolling marbles and an inner cylinder. This inner cylinder endures most of the loads and forces and is therefore most likely to fail. SKF has done research to increase the lifetime of rollers. Some mathematical models have been constructed, which contain various parameters. Two of these parameters are the diameter and concentration of certain carbon impurities, called e-carbides. The objective of this study was to determine these parameters for a number of steels, using electron microscopy.

Methods and materials

Electron microscopy is based on exposing the material to an electron beam. SEM (Scanning Electron Microscopy) gathers images by scanning the electrons that are scattered on the material, TEM (Transmission Electron Microscopy) gathers images by scanning the electrons that pass through the material. E-Carbides are tiny carbon impurities with a size of a few nanometers and a hexago- nal structure. These e-carbides would therefore only be visible by TEM, which is capable of very high resolu- tions. They could also be recognised by their diffraction pattern, due to the hexagonal structure. SEM images give less detail, but are useful in studying the general structure of the material.

Results

The SEM images gave useful informa- tion. The materials consisted of a martensite structure containing spherical car- bon impurities. EDS (Energy Dispersive Spectroscopy) and diffraction patterns showed that these consisted of (Fe,Cr)7C3. TEM analysis revealed a number of different car- bide structures. However, none of them could be identified as e-carbide. The most interesting result was a carbide presence between the laths of the martensite. The light and dark lamellas are caused by the alternating orientation of the martensite matrix. On the boundary between them, small deposits of cementite have been found. Also, some Moire patterns were observed by TEM, all aligned in the samedirection. These indicate presence of precipi- tates in the martensite matrix, all sharing the same orientation-relation to the surrounding martensite matrix.

Conclusion

In none of the materials e-carbides have been identified. However, several other carbides have been observed. Moire patterns give indirect evidence of the presence of precipitates having a distinct orientation with respect to the martensite matrix. The most striking result is the presence of cementite between the lamellas of the martensite. More research would be necessary to learn about the details of these structures.

Abstract Case Study SRON

Laurens Even

In this bachelor project research is performed on the design of a prototype low temperature superconducting (LTS) flux pump system. With such a system a superconducting electromagnet can be charged to high currents, while only a low current power supply and cryogenic wiring is necessary. The flux pump could find potential as an application in the SAFARI instrument for the SPICA satellite, but it can also be used for cryogenic energy storage or for offsetting a magnetic field. As a satellite application the flux pump can reduce parasitic heat load on the cold stages of the satellite.

Within this thesis we continued the work on an existing flux pump design from a previous bachelor project. This design had previously shown some essential performance characteristics of a flux pump system, but the actual flux pumping was not observed. In this thesis work we investigated the possible causes of this and implemented improvements. These improvements have resulted in a working flux pump system. The main improvement (which was found in a late stage of the project) was the correction of the winding orientation of a secondary coil in the transformer. Other improvements are: (1) the optimization of the transformer cooling, such that higher critical currents in the primary transformer superconducting wire could be achieved, and (2) the increase of the self-inductance of the primary coil of the transformer by replacing the original aluminum transformer core (that will induce eddy currents) by a Vespel polyamide core. For the characterization of the transformer performance we have used a two-phase lock-in measurement technique to determine the self-inductance and mutual inductance of the primary and secondary coils as a function of frequency.

The final flux pumping system (V3.0) operates at 4 K, and consists of a transformer with a 4950 turn primary coil (L_p = 4.4 mH self-inductance), a 2 x 10 turn secondary coil (L_s = 0.5 µH, and a 900 turn load coil with an estimated self-inductance around 13.5 mH), all made with superconducting wire. The current in the load coil is monitored by measuring the magnetic field that is generated by the coil with a fluxgate meter. The primary coil has been operated with a maximum current (ramp) of 0.5 A (500 mA/s). The measured and calculated current gain of the flux pump are both around 0.16 mA per cycle for a 50 mA primary current. With this system a current of at least several amperes should be achievable in the load coil (resulting in a magnetic field in the order of at least dozens of milliteslas), but we have limited ourselves to a maximum of 60 mA, because of limitations in the range of the flux gate sensor (not higher than 590 µT).

The coupling factor ($0 \leq k \leq 1$) describes the coupling between the primary and secondary side in a transformer, where a value close to 1 would be ideal. For the final flux pumping system k is estimated to be around 0,45.

Account Case Study for Philips

by Marten Koopmans and Bauke Steensma

We worked together on our bachelor research in the last quarter of the academic year of 2014-2015 and handed it in as one project. Although this is rarely seen, it was accepted by the faculty as the case study was in collaboration with Philips and the project was too large for a single person. The department of Philips in Drachten is focused on consumer lifestyle, especially in the shaving equipment business. Our project came to be when Philips was looking for a new method on polishing their metals used in their shaving heads. They managed to get their hands on a few notes of a congress on plasma polishing , a term that was likely invented by people from eastern europe experimenting with a technique that produced a supposedly mysterious 'plasma' that polished material.

The main questions in the case study for Philips were the working and material removal mechanisms behind the plasma polishing, and how to master these to create polished metal surfaces. Philips provided us with a basic setup that met the specifications of the setups proposed by the (mostly eastern european) companies. It was our job to figure out as much as possible about the process taking place in the polishing setup at the Philips campus in Drachten. In our search for the answers we were supported by the material science group and their facilities such as the confocal microscope and the SEM (scanning electron microscope). Our attention first turned to the available theory on the proces. This turned out to be rather little. Most of the articles published only experimental findings and none of the underlying mechanisms were touched. Although at first we were convinced of the plasma creation, we very soon realised that there wasn't any evidence to support the creation of plasma. This made our experimental procedure very interesting, as the working mechanism was unknown and we had to device experiments in order to rule out various candidates for the main polishing mechanism. Also, since the work was done for Philips, we had to keep an eye out to produce as shiny samples as possible.

Our setup consisted of a DC power supply connected to a cathode and an anode (which was our sample) in an electrolytic solution. The main things measured were the mass difference, shininess and the roughness of the samples before and after polishing. By tweaking many parameters such as the voltage and temperature, by using different electrolytes and also by using different materials we figured out a lot of the prerequisites and many of the working mechanisms of the process. Unfortunately, due to the confidentiality of the project, we arent able to go into further detail on these conclusions.

During our case study it was very enjoyable figuring out many intriguing details of a relatively unknown process with the help of the material science group and it was furthermore a pleasure working in Drachten together with people from Philips and old board members of T.F.V. 'Professor Francken' such as Rudy Schuitema. Cheers!

Account Case Study NAM

by Jisk Attema and Evert-Jan Borkent

During this case study at the Nederlandse Aardolie Maatschappij BV (NAM) a test unit at the Underground Gas Supply (UGS) in Norg was examined. The UGS is used for the storage of gas from the small gasfield through- out the Netherlands. The oversupply of gas during summer months is pumped into the ground under a layer of salt. This gas can be used on cold winter days when the capacity of the regular network is not sufficient. Part of the UGS is a test unit that can test production from a well. The well is tested on its flow-rate, gas composition and gas-liquid ratio (the well produces a mix of gas, condensate and water). The capacity of the production line of the UGS is recently enlarged while the test unit is designed for the former capacity. The aim of this case study is to determine if the test unit can handle the current production capacity and if not, what the bottleneck of the system is and how this problem can be solved. The system consists of piping, valves, coolers and a gas-liquid separator. By looking up the specifications of all the equipment and calculating the effect on the pressure, temperature, speed and density of the gas at the increased capacity, the maximum capacity of all the different parts of the test unit can be determined. It was found that the only bottleneck was the gas-liquid separation vessel, as at high flow-rates the liquid and gas are not separated. Separating the flow and the gas-liquid ratio measurement can solve this bottleneck without any investments. Another problem was an orifice plate that measured the flow, because it was unclear if this plate would measure the flow accurate enough at higher flow-rates. This last problem still has to be studied further. All the other equipment can handle the increased gas-flow at the proposed production capacity. Therefore it can be concluded that the capacity of the test unit is high enough to test the wells at the current production capacity.

Abstract Case Study SRON

by Hilbert van Loo

In this bachelor research an earlier proposed design for a CTE-based heat switch/launch-lock is characterized and redesigned to properly test its capabilities. In earlier research the design was only made but never tested properly. The goal is to combine the properties of a thermal switch, i.e. the switching between a high and low thermal conductance on a certain temperature, with the properties of a launch lock, i.e. the locking of a sensor during the launch of a satellite and releasing once in orbit. Furthermore it is also important that the device is very reliable, which is why it is based on the effect of thermal expansion/contraction.

In this research the thermal conductance, mechanical properties and release properties are tested. An ON-state conductance of >0.5W/K and an OFF-state conductance of <5.0 103W/K are achieved. Furthermore as a launch lock, the device is able to lock a sensor of 0.4kg with maximum vibrations of 40g, however vibration test should still conclude whether this holds upon longer exposure to cyclic loads. Also different configurations showed release temperatures, in the range of 130K to 220K, to be in good agreement with calculated values. This makes it easy to alter the device to release on different temperatures.

More research should be done to check whether this device is suitable for real life space applications, however the measurements show a good potential and enough possibilities to further improve this design.