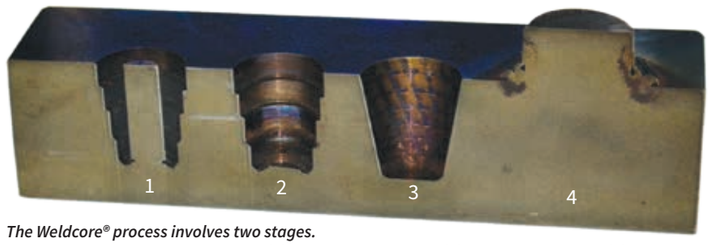
eNtsa: Innovation through engineering

African Fusion visits eNtsa, an internationally recognised research and innovation hub and engagement institute within Nelson Mandela University, and talks to its director, Danie Hattingh, about the global success of its WeldCore® materials testing technology, its world-class high-temperature small punch creep testing facility, and the unit's extended role in developing local business and technical competence.



The Weldcore® process involves two stages.
Sample retrieval: a cored hole is cut (1); the core is extracted (2); the hole is tapered (3). Hole repair: a consumable taper is inserted and the consumable is rotated to form a plug weld (4).

Nelson Mandela University's eNtsa, a registered Engagement Institute within the university, started operations as the Automotive Components Technology Station (ACTS) in May 2002 at the then Port Elizabeth Technikon, which was merged into Nelson Mandela University (then NMMU) in January of 2005. The name 'eNtsa', derived from the word, 'eNtsha' meaning new in one of the local isiXhosa African languages native to the Eastern Cape, was adopted in 2011 with a view to strengthening the industrial focus of its work and commercialising patented technologies.

The current director, Professor Danie Hattingh, was one of the group's original founding members. An active consultant who continually develops networking links with industry, Hattingh employed two Masters students during those early years.

The Weldcore® sample cutting and TFHPP weld repair equipment was developed by Hattingh's team in conjunction with Philip Doubell.

In the mid 2000s, Hattingh and his team were involved with research and development work in aid of high value large-scale engineering projects, most notably with Eskom to develop alternative materials' sampling and weld repair techniques for its ageing steam boiler fleet. From the Eskom side, this work was pioneered by the late Philip Doubell, Eskom's Chief Welding Engineer, who with the eNtsa team won multiple awards for the work in developing techniques for determining the fitness-for-purpose and safe extended life for operating power plant components.

At the heart of this development was the now patented WeldCore® sample extraction and repair technique, which has now been widely adopted by Sasol and Eskom in South Africa as well as international plant operators for assessing the condition of turbine and thick-walled steam piping subject to high pressures and temperatures.

Describing the technique, Hattingh says that WeldCore® is a novel sample and repair technique that involves in-situ material sampling, of high-pressure steam lines, for example, followed by an immediate hydro pillar weld repair to replace the extracted core. This allows a sample to be quickly extracted from a steam line for materials evaluation without compromising the integrity of the piping.

A representative cylindrical metallurgical core sample is removed from the pipe wall while leaving a blind-hole, with the inner wall intact. The hole is then repaired using Tapered Friction Hydro Pillar Processing (TFHPP), a purpose-developed solid-state friction welding technique. Both the sample cutting and the TFHPP repair equipment are mounted onto the same machining frame – developed by Hattingh's team in conjunction with Philip Doubell – enabling sampling and repair to proceed as sequential processes.

"Initially the process was applied outside of the existing welding codes but since achieving incorporation of the repair procedure into ASME IX (2015), the application numbers increased drastically to about 35 sampling tests per a year.

"The total investment in the development phase of WeldCore was R32-million with the main support coming from Eskom and the TIA. The initial research in solid state welding at the Nelson Mandela University started in 2000 and can be seen as the knowledge foundation on which the WeldCore technology was built. Our involvement with the process and the first prototype application dating back to as far as 2006 gives us high levels of confidence in the process," Hattingh tells *African Fusion*.

Following sample extraction of cores, typically 8.0 mm in diameter and 15 mm long, the material condition of the piping in use is comprehensively characterised at eNtsa via a series of tests. "Most importantly, we need to establish the extent of the accumulated creep damage and the remaining creep life," notes Hattingh. The core sample is, therefore, first subjected to X-ray Tomography, which reveals aligned void-like defects based on the materials density variations.

"The sample is then cut into several thin discs, which we then use for small punch testing for yield and tensile strengths; micro-Vickers hardness; and for wet chemical analysis.

As a further extension of eNtsa's WeldCore® value chain, the unit has established world-class expertise in small punch creep testing using 8.0 mm discs cut from WeldCore samples. "We have an onsite facility with 11 small punch creep testing systems, which we use for on-going and scheduled testing from all over the world," says Hattingh.

Testing procedures and data evaluation are continuously being developing and a standardisation process is being undertaken in collaboration with international leaders in this field. "We are determined to ensure that our knowledge and service is at the forefront of development. Small punch creep testing is gaining increasing and on-going acceptance by the petrochemical and power generation industries, where high temperature component condition monitoring is becoming increasingly critical to reduce risks, ensure safety and maximise economical plant operation," he says.

As an extension of its WeldCore technology and in support of small punch creep testing, eNtsa has also developed a surface sample extraction machine for EDM (electro discharge machine) boat samples. Designed to collect a smaller sample from steam pipe for small punch creep and other testing, boat sampling also enables microstructural, chemical and mechanical properties to be established that enable accurate predictions of the remaining life of plant to be established and plant performance to be evaluated – all without jeopardising the structural integrity of operating components.

"The prime focus of eNtsa is to stay at the forefront of technology innovation. We aim to be the preferred strategic partner for technology innovation and commercialisation to the benefit of South African industry," Hattingh assures.

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As a vehicle for the commercialisation of WeldCore, EDM Boat Sampling and related technologies for the power generation and petro-chemical industry, a spin-off service company called Mantacor has been established at Nelson Mandela University. "Mantacor's primary objective is to assist the power generation and petrochemical industries to determine and manage the safe operating life of critical plant components," he adds.

Other notable eNtsa programmes of research, development and industrial support include:

- **The eNtsa Composite Innovation Centre (CIC),** which uses finite element analysis (FEA) for the development of lightweight wing structures for light aircraft; builds moulds for the manufacture of wind turbine blades using a large format 3D printer; explores the viability of composites in the automotive sector – by building a pre-preg carbon fibre spare wheel, for example; and performs reverse engineering using sophisticated equipment for shape profiling, superstructure design and for determining possible failure modes.
- **The uYilo e-mobility Programme,** a national TIA funded multi-stakeholder collaborative programme focused on electro mobility technology and research. uYilo offers the support funding, engineering services and coordination required to grow the electric vehicle sector.
- **Supplier development initiative through the TIA funded Technology Station Programme:** eNtsa assists over 120 SMEs/entrepreneurs per year, as well as many of the major automotive OEMS and Tier 1 component suppliers in the local manufacturing industry. "We complete over 400 industry projects per year in support of the local economy, providing much needed engineering skills and capabilities at all levels of the supply chain in South Africa," Hattingh adds.
- **The new eNtsa Training academy:** In keeping with its support for innovation in industry, eNtsa has established a training academy that draws on its specialists and academics to deliver focused and customised training on specific technologies of immediate local interest.
- **SANAS accredited national battery and materials testing facility:** This unit also runs a laboratory that can offer materials and battery testing, a most comprehensive range of battery performance, materials and mechanical testing services as well as environmental testing, such as salt spray tests and weathering simulations.

"We have established ourselves as a strategic partner to industry and have successfully delivered multi-million rand projects and innovative engineering solutions. We believe in 'innovation through engineering' and, by constantly striving towards teamwork, integrity, innovation and excellence, we hope to be contributing towards creating a better world," Hattingh concludes.