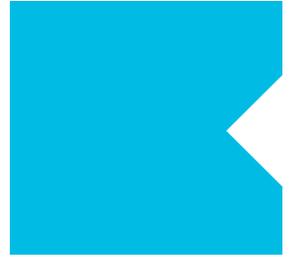


Fakulteit Ingenieurswese
JAARVERSLAG

2016

Faculty of Engineering
ANNUAL REPORT



UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

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Outreach Programmes



Priyan Bhawan (links) en Oscar Chang (regs) by hul tutor, Tawanda Ewing (middel), in die Studiesentrum.

Priyan Bhawan (left) and Oscar Chang (right) with their tutor, Tawanda Ewing (middle), in the Study Centre.

Die Fakulteit Ingenieurswese is een van Suid-Afrika se vernaamste voorsiensers van ingenieurs van hoogstaande gehalte. In die afgelope jaar het die Fakulteit sy plek aan die voorpunt van uitnemende onderrig sowel as basiese en toegepaste navorsing én as vennoot van die bedryf verder versterk. Hoogtepunte sluit in die uitbreiding van die navorsingsprofiel, verdere ondersteuning aan studente, en grootskaalse verbetering van infrastruktuur.

Behoud van momentum van uitnemendheid

Die Fakulteit se studente het weer 'n hoë module-slaagsyfer en gradueringskoers gehandhaaf. Altesaam 494 BIng-grade, 15 nagraadse diplomas, 214 magistergrade en 36 doktorsgrade is in 2016 toegeken. Een van hierdie graduati, Riccardo Swanepoel, wat in Desember sy graad BIng (Chemiese Ingenieurswese) cum laude verwerf het, het met sy uitsonderlike studierekord die Kanseliersmedalje verower. Sy gemiddeld oor vier jaar was 94,1%. Hy het geskiedenis gemaak deur die eerste chemiese ingenieurstudent te word wat 100% vir sy ontwerpprojek behaal het, en het boonop 42 van sy 44 modules met onderskeiding geslaag.

Omdat uitnemendheid in ingenieurswese lank nie meer net op sterk tegniese en denkvaardighede berus nie, maar ingenieurs ook op alle vlakke goed mondeling én skriftelik moet kan kommunikeer, word die Fakulteit se studente deeglik op dié gebied vaardig gemaak deur die module Professionele Kommunikasie. 'n Onderafdeling van die module behels die verbetering van leesvaardighede en -begrip deur

middel van die leesprogram Labonline. In 2016 het meer as 600 studente dié leesprogram deurloop, en is 'n dramatiese verbetering in studente se leesspoed, -vlak en -begrip gemeet.

In 'n verdere stap om uitnemendheid te ondersteun, het Ingenieurswese in Augustus sy ruim, moderne en doelgemaakte Studiesentrum geopen. Hierdie uitmuntende fasiliteit bied die ideale omstandighede waarin ingenieurstudente op hulle eie óf in groepe kan studeer of ontspan. Dit bestaan onder meer uit individuele werkstasies, 'n paar rekenaarterminale en 'n informele sit- en geselsarea. Een van die belangrikste kenmerke is die nege werkkamers waar studente groepwerk kan doen – 'n belangrike komponent van ingenieursopleiding wat ook by die vereistes van die Ingenieursraad van Suid-Afrika (ECSA) aansluit.

Daarbenewens het die Fakulteit die afgelope twee jaar doelgerig gewerk om inligtings- en kommunikasie-tegnologie in gebruik te neem, wat nou gemengde leer moontlik maak. Dosente se onderrigvaardighede word ook deurlopend opgeskerp met gereelde onderrigforums oor interessante en nuttige onderwerpe om hulle beter vir hul taak toe te rus.

Die momentum van uitnemendheid word voorts gehandhaaf deurdat die Fakulteit se navorsingsprofiel jaarliks verbeter. In die verslagjaar het die getal navorsingsgrade (MIng en PhD) weereens stewig toegeneem. Tog is dit nie net getalle wat merkbaar verbeter het nie, maar ook die internasionale profiel van veral publikasieuitsette. Die Fakulteit se Scopus-voetspoor het die afgelope vier jaar meer as verdubbel.

Om voortgesette uitnemendheid te verseker, is

The Faculty of Engineering is one of South Africa's leading suppliers of top-quality engineers. Over the past year, the Faculty further strengthened its position at the cutting edge of excellent teaching as well as basic and applied research, and as a partner of industry. Highlights include the expansion of its research profile, further support for students, and large-scale infrastructure improvements.

Sustaining our momentum of excellence

The Faculty's students again maintained a high module pass rate and graduation rate. A total of 494 BEng, 15 postgraduate diplomas, 214 masters' and 36 doctoral qualifications were conferred in 2016. The exceptional academic record of one of these graduates, Riccardo Swanepoel, who was awarded his BEng (Chemical Engineering) degree cum laude in December, was recognised with the Chancellor's Medal. Mr Swanepoel maintained an average of 94,1% over his four years of study. He made history by becoming the first chemical engineering student to score 100% for his design project, and also passed 42 of his 44 modules with distinction.

Since excellence in engineering no longer solely relies on strong technical and cognitive skills, but also requires competence in verbal and written communication at all levels, the Faculty's students are properly trained in this field through the Professional Communication module. A subsection of the module entails the improvement of reading skills and comprehension by way of the reading programme Labonline. In 2016, more than 600 students completed this reading programme, and exit assessments revealed a dramatic improvement in students' reading speed, level and comprehension.

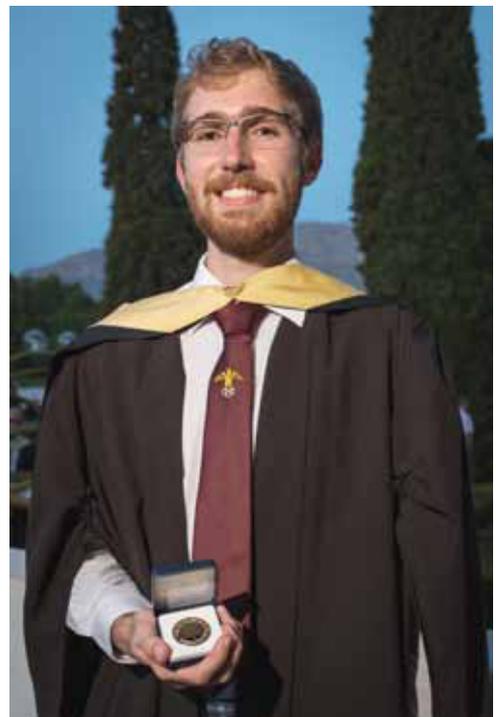
In a further step to support excellence, Engineering opened its spacious, modern and purpose-built Study Centre in August. This outstanding facility offers the ideal conditions for engineering students to study on their own or in groups, or just to relax. The centre contains individual workstations, a few computer terminals and an informal seating and social area, amongst others. One of the most important features is the nine workrooms intended for group work, which constitutes an important component of the training of

engineers and also aligns with the requirements of the Engineering Council of South Africa (ECSA).

In addition, the Faculty has purposefully started implementing information and communication technology over the past two years, which now enables blended learning. Lecturers' teaching skills are constantly honed with regular teaching forums on interesting and useful topics so as to better equip them for their task.

The momentum of excellence is further sustained by annual improvements in the Faculty's research profile. In the reporting year, the number of research degrees (MEng and PhD) again showed steady growth. Apart from a marked improvement in numbers, however, the international profile of especially publication outputs has also been significantly strengthened. Over the past four years, the Faculty's Scopus footprint has more than doubled.

To ensure sustained excellence, Engineering continues to seek ways in which to further support the sustainability of its activities. For example, academic as well as support staff experienced an exceptionally heavy workload in the past couple of years, and academics in particular show signs of fatigue.



Riccardo Swanepoel, Kanseliersmedaljewenner 2016.

Riccardo Swanepoel, winner of the 2016 Chancellor's Medal.



Aphiwe Jikazana, alumna en eerstejaar-mentor.

Aphiwe Jikazana, alumna and mentor to first-years.

Ingenieurswese voortdurend op soek na maniere om die volhoubaarheid van sy werksaamhede verder te ondersteun. Akademiese sowel as ondersteuningspersoneel se werklas was byvoorbeeld die afgelope paar jaar besonder hoog, en veral akademiци toon tekens van uitputting. Daadwerklike pogings die afgelope vier jaar om die werklas te verlig, sluit in die aanstelling van 60 nuwe, meestal jong akademiци. Dit het tot 'n vermindering van 20-25% in die werklas op die akademiiese korps bygedra.

Vorbereidingswerk vir die opstel van die Fakulteit se meesterplan en herinrigting van die gebouekompleks is ook in 2016 voltooi. Die omvangryke plan behels 'n algehele herinrigting, opknapping en verdigting van die fasiliteite, wat op 'n meer kostedoeltreffende wyse vir meer studente en personeellede sal voorsiening maak.

Voortgesette uitnemendheid vereis natuurlik ook volhoubare finansiering. In 2016 was die Fakulteit se derde- en vierdegeldstroominkomste 'n stewige R185,4 miljoen, 37% meer as in 2015. 'n Hoogtepunt was die toekenning van R30 miljoen van die Suid-Afrikaanse Nasionale Padagentskap Beperk (SANRAL) vir die voortsetting van die Leerstoel in Plaveiselingenienswese. Selfs indien dié eenmalige skenking buite rekening gelaat word, is die vergelykbare groei van 2015 tot 2016 net bo 15%, wat in die huidige stram ekonomiese klimaat steeds 'n baie goeie prestasie is.

Verbreiding van toegang

Die Fakulteit maak veral erns met die Universiteit se strewe om studente van toegang te voorsien wat hulle in staat stel om suksesvol te studeer. Studente ontvang dus ruim ondersteuning op akademiiese én emosionele

gebied om hulle vir die uitdagende en veeleisende ingenieursprogram toe te rus. Dié steun sluit onder andere in die tutorprogram vir eerstejaars wat met tegniese modules sukkel, en die aanstelling die afgelope twee jaar van twee deelydse opvoedkundige sielkundiges wat studente op akademiiese en emosionele gebied bystaan. In 2016 is 'n alumna van die Fakulteit, Aphiwe Jikazana, aangestel om as mentor vir eerstejaars op te tree. Weens haar eerstepandse ondervinding as ingenieurstudent, kon sy studente bystaan, raad gee en na kundiges verwys in geval van meer ingewikkelde probleme wat gespesialiseerde aandag verg. Ook het die Fakulteit die afgelope dekades reeds die gebruik dat die dekaan as die "vader" van eerstejaars gereken word, en eerstejaars en hul ouers word aangemoedig om hom te nader met enige probleme wat studente se akademiiese sukses kniehalter.

Boonop wil die Fakulteit met sy taalimplementeringsplan verseker dat taal nie 'n struikelblok vir toegang tot ingenieurstudie is nie. Die taalplan behels dat die eerste jaar (en ook die tweede jaar so ver moontlik) in parallelmedium aangebied word, en dat kennisoordrag in die senior jare ten minste in Engels sal geskied, met ondersteuning aan Afrikaanssprekendes. Die Fakulteit wil steeds ewe toeganklik wees vir alle studente, ongeag of hulle voorkeuronderrigtaal Afrikaans of Engels is.

Bevordering van impak op die samelewing

Benewens sy gevestigde samewerkingsbande met en kontraknavorsing vir die ingenieursbedryf, bevorder die Fakulteit Ingenieurswese ook sy impak op die samelewing deur verskeie gemeenskapsinteraksieprojekte om die instelling se sosiale impak te versterk. Dit sluit in verskeie interaksies met die skolegemeenskap, waarvan TRAC die grootste is. Dié suksesvolle program wil onderrig in wetenskap, toegepaste wiskunde en tegnologie op hoërskoolvlak ondersteun en verbeter, en leerders motiveer om beroepe in die wetenskap, ingenieurswese en tegnologie te volg. TRAC het in 2016 bykans R14 miljoen in finansiering van 'n verskeidenheid eksterne befonders ontvang.

Vooruitskouing

In die jaar wat voorlê, sal die Fakulteit Ingenieurswese geesdriftig deelneem aan die hersiening van die Universiteit Stellenbosch se Institusionele Voorneme en Strategie om Visie 2030 te help verwesenlik. Die Fakulteit sal ook aktief meewerk om die US 'n volwaardige Afrika-universiteit te maak.

Concerted efforts over the past four years to alleviate the workload include the appointment of 60 new, mostly young academics. This has helped reduce the burden on the academic corps by 20-25%.

Preparations for drafting the Faculty's master plan and the refurbishing of the buildings complex were also completed in 2016. This comprehensive plan entails a complete refurbishment, upgrade and densification of the facilities so as to accommodate more students and staff more cost-effectively.

Of course, sustained excellence also requires sustainable funding. In 2016, the Faculty's third and fourth-stream income totalled a solid R185,4 million, 37% more than in 2015. A highlight was the award of R30 million from the South African Road Agency Limited (SANRAL) for the continuation of the Research Chair in Pavement Engineering. Even without counting this once-off donation, comparable growth from 2015 to 2016 was just over 15%, which still is quite an achievement in the current tough economic climate.

Broadening access

The Faculty is particularly serious about the University's aim of providing students with access that enables them to study successfully. Therefore, students receive ample academic and emotional support to give them the tools to cope with the challenging and demanding engineering programme. This support includes the tutor programme for first-years struggling with technical modules and, for the past two years, the appointment of two part-time educational psychologists who assist students academically and emotionally. In 2016, an alumna of the Faculty, Aphiwe Jikazana, was appointed to serve as mentor for first-years. Due to her first-hand experience as an engineering student, she has been able to assist and advise students, as well as refer them to experts in the event of more complex problems requiring specialist attention. Over the past decades, it has also become custom for the Dean of Engineering to be regarded as the "father" of all first-years, and first-years and their parents are encouraged to contact him in the event of any problems that may be hampering students' academic success.

Moreover, with its language implementation plan, the Faculty wishes to ensure that language does not serve as a barrier for access to engineering studies. In terms of the language plan, the first year (and the second

year as far as possible) is offered in parallel medium, and knowledge transfer in the senior years occurs in at least English, with support for Afrikaans-speaking students. The Faculty wants to remain equally accessible to all students, regardless of whether they prefer Afrikaans or English as their language of teaching.

Enhancing our social impact

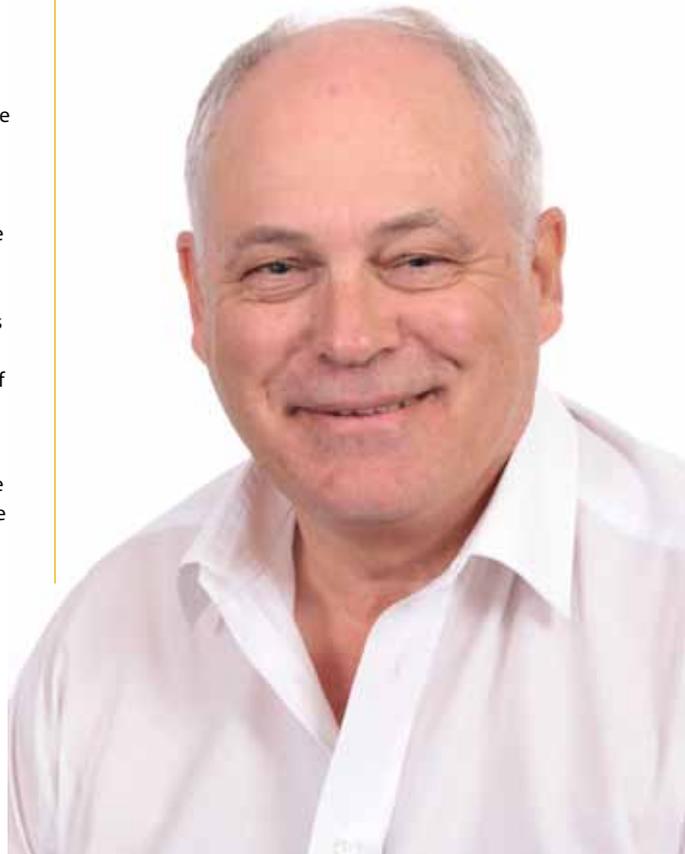
Apart from its established collaboration with, and contract research for, the engineering industry, the Faculty of Engineering also strengthens its impact on society through various social impact projects. These include various interactions with the school community, the largest of which is TRAC. This successful programme seeks to support and improve science, applied mathematics and technology teaching at secondary-school level, and further aims to motivate learners to pursue careers in science, engineering and technology. In 2016, TRAC received nearly R14 million in funding from a range of external funders.

Looking forward

In the year ahead, the Faculty of Engineering will enthusiastically take part in reviewing Stellenbosch University's Institutional Intent and Strategy towards realising Vision 2030. The Faculty will also actively collaborate to make SU a full-fledged African university.

Prof Hansie Knoetze
Dekaan: Ingenieurswese.

Prof Hansie Knoetze
Dean: Engineering.



Organogram

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TRAC South Africa – Eradicating Poverty

TRAC South Africa is a national, non-profit intervention programme of Stellenbosch University that provides support in Physical Sciences to learners in disadvantaged communities.

TRAC has been a flagship programme of Stellenbosch University since 2008 and functions from within the Department of Civil Engineering. The objective is to support and uplift science, applied mathematics and technology education in South African secondary schools.

More than 20 000 learners are exposed to the TRAC programme annually.

TRAC focuses on:

- Curriculum-based academic intervention (Grades 10 tot 12).
- Vocational guidance on engineering and artisan disciplines.
- Assistance in obtaining funding for tertiary studies.
- Monitoring and mentoring learners' progress.
- In-class training of educators.

In 2016, TRAC recorded 668 822 formal exposures in the 20 TRAC laboratories located nationally. The reach of TRAC has expanded exponentially since 2005, when 26 619 exposures were recorded.

In 2014 and 2015, the national pass rate of TRAC's participating Grade 12 learners in Physical Sciences was 64,1% and 65,2% respectively. In 2016, this pass rate increased to 70,6%. In 2016, the Department of Education's national pass rate for Physical Sciences was 62%. This statistic (of the Department of Education) includes all schools in the country, whilst TRAC works

exclusively in disadvantaged, poor schools. Hence the TRAC Physical Sciences pass rate of 70,5% in 2016 can be regarded as quite remarkable.

The TRAC programme places great emphasis on informing, encouraging and assisting learners to enrol at tertiary institutions and the number of TRAC learners venturing into tertiary studies has shown consistent growth. In 2017, 1 760 learners registered for first-year tertiary studies.

Many TRAC learners come from severely challenged socio-economic backgrounds and do not have financial means to further their academic careers past Grade 12. TRAC, through active collaboration with about 130 bursary companies, has managed to successfully facilitate bursaries for the number of learners depicted below:

2010	2011	2012	2013	2014	2015	2016	2017
56	107	164	297	386	405	628	809

Currently TRAC has 10 financial partners namely Murray & Roberts, Joy Global Foundation, Group Five, Gautrain Management Agency, Tracker Connect, Department of Transport, ININ (USA), Nordex Acciona, the Ben & Evelyn Lipshitz Charitable Trust, and Eskom Foundation. Stellenbosch University provides funding, facilities and services.

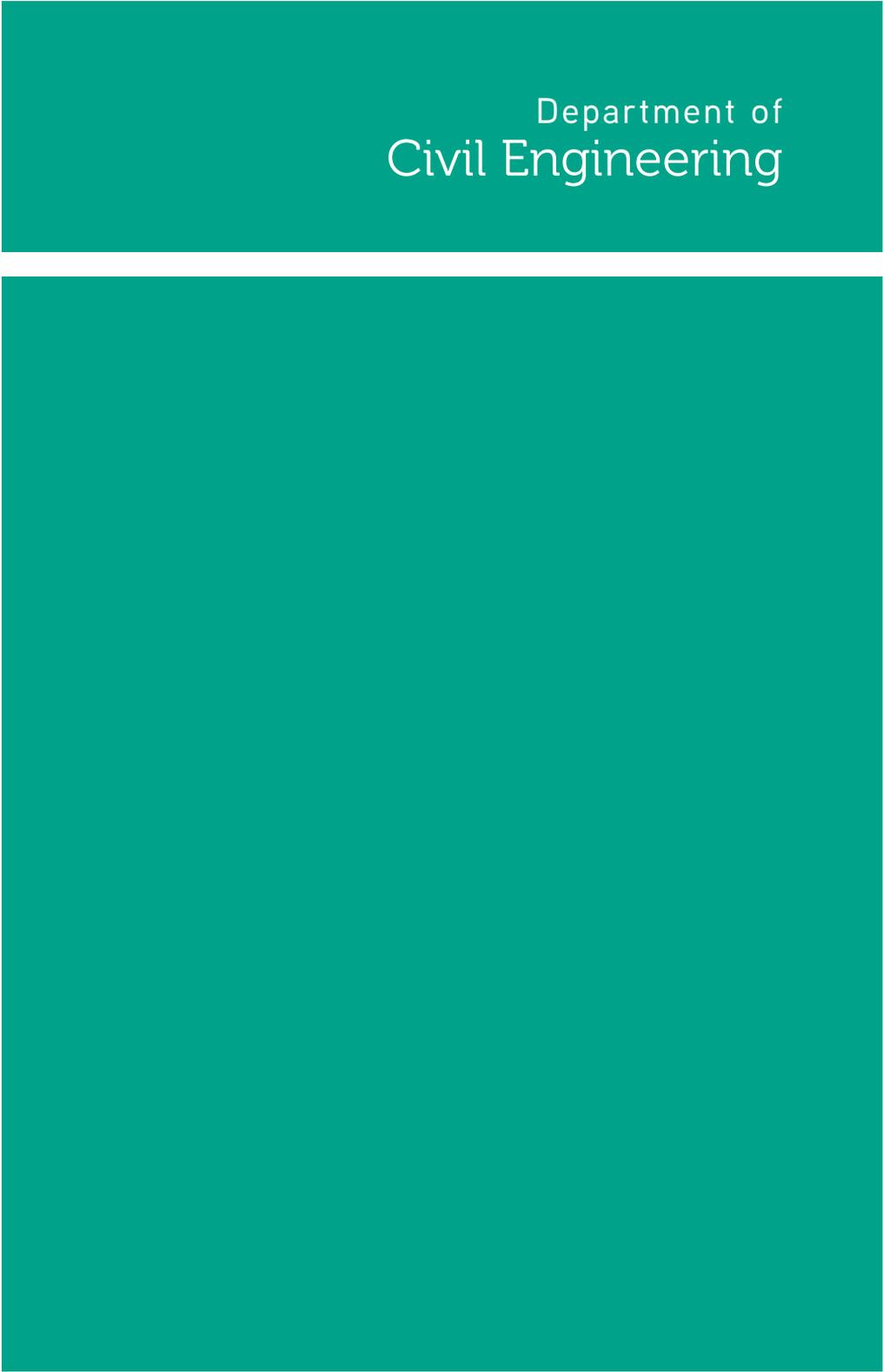
Contact: Debbey Olivier, Executive Director
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www.trac.sun.ac.za
www.youtube.com/watch?v=DiLdPA8_R58



TRAC learners performing experiments in one of the TRAC schools in the Western Cape.



Department of
Civil Engineering



5 Highlights



Postgraduate students in Pavement Engineering preparing for an asphalt competition that includes sustainable, energy saving binders.

R30 million endowment by SANRAL

One of the greatest highlights in the Department of Civil Engineering in 2016 was the R30 million endowment by the South African National Roads Agency Ltd (SANRAL) for the continuation of the Chair in Pavement Engineering, established in 2001. The SANRAL Chair offers specialised postgraduate courses to students and practitioners in the pavement/road industry to keep them abreast of new trends and developments in the global environment. It is also responsible for teaching at undergraduate level, creating awareness about pavement engineering among students and for managing the asphalt and pavement research laboratories. The research undertaken includes innovative material investigations, performance analysis, road rehabilitation, recycling technologies, and sustainable road construction practices, to name but a few. Prof Kim Jenkins has been the incumbent of the Chair since its inception.

Unit for Construction Materials

The Unit for Construction Materials (UCM) was launched in April 2016. This Unit strives to be a centre

of excellence and a top research unit for construction materials in South Africa for teaching, research and consulting. The UCM is interested in all aspects of construction materials, but the four main areas of the current focus are: eco-friendly construction materials; fibre reinforced concrete; fresh and young concrete; and high performance concrete. The Unit, which is run by Prof Billy Boshoff, Dr Riaan Combrinck and Wibke de Villiers, has several national industry partners and international collaborators.

Holsloot diversion weir study

Prof Gerrit Basson of the Institute for Water and Environmental Engineering (IWESU), based in the Department, was contracted during 2016 to do a hydraulic design of the upgrade of the existing diversion structure on the Holsloot River. The intention was to increase the diversion to the Brandvlei Dam for irrigation in order to improve the firm yield of the system by about 30 million m³/a and to supply new BEE farms. Numerical models and physical models in the Civil Engineering Hydraulics Laboratory were used to simulate the river hydraulics and to determine the increased capacity required by the diversion canal, as

well as the corresponding weir height extension. It was anticipated that the upgrade would result in additional damming and flooding of the vineyards during large floods and thus additional drainage was proposed by means of an unlined earth canal excavated along the existing canal. The project was completed for the Western Cape Department of Agriculture and the National Department of Water and Sanitation.

Better water services for V&A Waterfront

In another project the Institute for Water and Environmental Engineering was approached by V&A Waterfront to provide specialist input regarding water services. The precinct is supplied with potable water from the City of Cape Town. Pressure reducing valves were installed at both bulk connections prior to the start of the project to help reduce water leakage. Pressure and flow were monitored and reported online in real-time from strategic points in the system. Prof Heinz Jacobs was the project leader, while Prof André Burger (Department of Process Engineering) provided expert input regarding desalination. Firstly, the team investigated reduction of water demand by consumers, with a focus on water demand management and water conservation. Secondly, advice was needed to help the Waterfront become more self-sufficient in terms of supply options by 2030, which included (treated) greywater reuse, rainwater, groundwater, and future desalination options.

Increasing sustainability of pavements in informal settlements

Asphalt and seal surfacings in informal settlements fail within five years with the result that surfacing layers of roads in informal settlements need to be repaired or replaced three times more often than other areas. Closer investigation revealed that most of the serious distress develops in areas adjacent to communal standpipes or in areas where greywater is disposed of adjacent to the road. Mew Way in Khayelitsha (Cape Town) was identified as a particularly problematic road displaying these symptoms. A representative body

from industry, Sabita, was approached to coordinate a task team of pavement engineers and researchers to find a sustainable solution. Prof Kim Jenkins and his research team developed an experimental test matrix that included 90 combinations of asphalt technology,

incorporating different mix compositions at different void contents, with and without various polymers, waxes and anti-stripping agents. Laboratory evaluations included accelerated simulation of damage to asphalt, by subjecting compacted asphalt to dynamic pulses of heated water or greywater. A Moisture Inducing Simulation

Tester (MIST) device, developed in the Department of Civil Engineering, delivered the pulses of greywater at elevated temperature and pressure. The degree of retention of the asphalt performance properties was then evaluated using indirect tensile strength tests. The research has yielded asphalt mix designs that provide significantly improved performance and resistance to greywater.

Research Output	
Journal Articles (subsidised)	23
Proceedings International	54
Proceedings National	4
Chapters in Books	3
Research Reports	2
Doctoral completed	4
Master's completed	69



Prof Kobus du Plessis
Chair: Civil Engineering.

Fires in Informal Settlements



Full-scale shack test carried out by final-year student, Gerhard Olivier.

Large-scale informal settlement fires regularly ravage communities throughout South Africa, and the rest of the world, where approximately one billion people live in such settlements. In spite of the extensive research that has been conducted by social scientists, geographers, disaster management and associated fields, negligible engineering research has been conducted investigating factors such as fire spread rates, fuel loads, fire modelling, testing of alternative construction materials, requirements for fire breaks, the amount of water required to extinguish fires, etc.

In 2016, the newly formed Stellenbosch University (SU) Fire Engineering Research Unit undertook full-scale burn tests on shacks to understand how they burn, along with identifying which fire or smoke alarm technology is most suitable in such confined spaces. This project was possible thanks to the generous support of the Western Cape Disaster Management, Fire & Rescue Services (WCDM), with tests being conducted at the Breede Valley Fire Station (courtesy of Rodney Eksteen and JJ Pretorius). The research results justified the roll-out of 1 200 photoelectric smoke alarms in the Wallacedene TRA informal settlement in Cape Town, with the roll-out being sponsored by Santam. Feedback from the settlement is showing that the smoke alarms have already saved lives. The SU research was presented to Premier Helen Zille and

Minister Anton Bredell at the launch of the WCDM smoke alarm project called “Hear the beep where you sleep”. Some of the investigation work was conducted by a final-year civil engineering student, Gerhard Olivier, who won second place overall at the SA Institution of Civil Engineering’s (SAICE) IP Showdown.

As an exciting next step the SU team, in conjunction with the University of Edinburgh, have embarked on a project to test, understand, and develop engineering methods for predicting and reducing fire spread in informal settlements. This research work will be supported by a grant from the Engineering and Physical Sciences Research Council (EPSRC) in the United Kingdom, and is being carried out in conjunction with WCDM. Of the total grant received, R4,3 million has been allocated to SU. Multiple shacks, and even small suburbs, will be built and burnt to destruction to understand the many technical aspects regarding temperature development, rate of fire spread and other such factors.

This new EPSRC research project will tie in with existing research at SU where a “standard shack fire test” is being developed by an MEng student, Antonio Cicione, to allow for the systematic evaluation of new solutions proposed for informal settlements. New construction materials, paints, alarms and other such systems are currently being introduced in settlements without testing being conducted to ascertain whether they are safe and suitable or not. It is hoped that the shack fire test method being developed may become a benchmark that developers all over South Africa can use.



Reconstruction work at Imizamo Yethu after a fire which destroyed over 2 000 homes.

Research Themes

Structural Engineering

Research on construction materials, steel and concrete structures, structural reliability, the application of civil engineering informatics in general and steel structures in particular, as well as sustainability of the built environment. Research in fire engineering includes computational investigation of structural performance in a fire, physical investigation of fire behaviour, monitoring of temperatures generated and structural performance. A new research field is the sustainability of the built environment including durability of materials and structures, objective modelling and subsequent minimisation of environmental impact.

Civil Engineering Informatics

Focuses on the needs of the civil engineering practice in an information-driven environment. Application of Information Technology in civil engineering is concerned with collaborative engineering, intelligent modelling of the design process in structural engineering, support systems for engineering management and technical aspects of urban engineering.

Water and Environmental Engineering

Fields include water resources development, flood hydrology, environmental water requirements, the design of large hydraulic structures, river hydraulics, sediment yield and fluvial morphology of rivers, reservoir sedimentation, coastal engineering, port engineering, hydrodynamic river and lake water quality modelling, water and wastewater treatment and water services which include water demand and water conservation, end-use modelling, alternative water sources, peak flows, stormwater quality, small-scale water treatment systems, hydraulic modelling of water systems, system pressure, pressure management, leaks and intermittent supply. Further research areas are the response of catchments to extreme rainfall events and associated changes in runoff as a result of catchment changes and the use of stochastic data in water resource modelling.

Transportation and Geotechnics

Research is carried out on road safety and Intelligent Transport Systems (ITS). Road safety research includes road crash causation, the influence of human factors, the role of geometric design, speed, public transport safety, and pedestrian safety factors. Research in ITS focuses on public transport user information, multimodal data base development, appropriate technology applications in developing countries and freeway management information applications for travel time estimation and incident management systems. Student-orientated research in pavement engineering includes accelerated testing of asphalt including MMLS testing and beam fatigue tests, environment-friendly bitumen stabilised materials researched using triaxial and fatigue tests, development of a performance-related seal design method for bitumen and modified binders, and a mix design and analysis system of asphalt bases.

Geotechnics focuses on the upper quaternary sands of the Cape Flats and its engineering geological characterisation in terms of its compressibility, shear strength, hydraulic conductivity and volumetric behaviour during shear (liquefaction potential). Ongoing geological investigations at Matjiesfontein are also carried out in support of the construction of the Space Geodesy Observatory.

Construction Engineering and Management

The focus is on the management and development of multidisciplinary capital projects. It includes an investigation into the skills needed to initiate and manage such projects as well as ways in which these skills can be transferred and developed. The division investigates the use of prefabricated elements and modular construction as well as the way in which it can be used together with in situ concrete to accelerate delivery.

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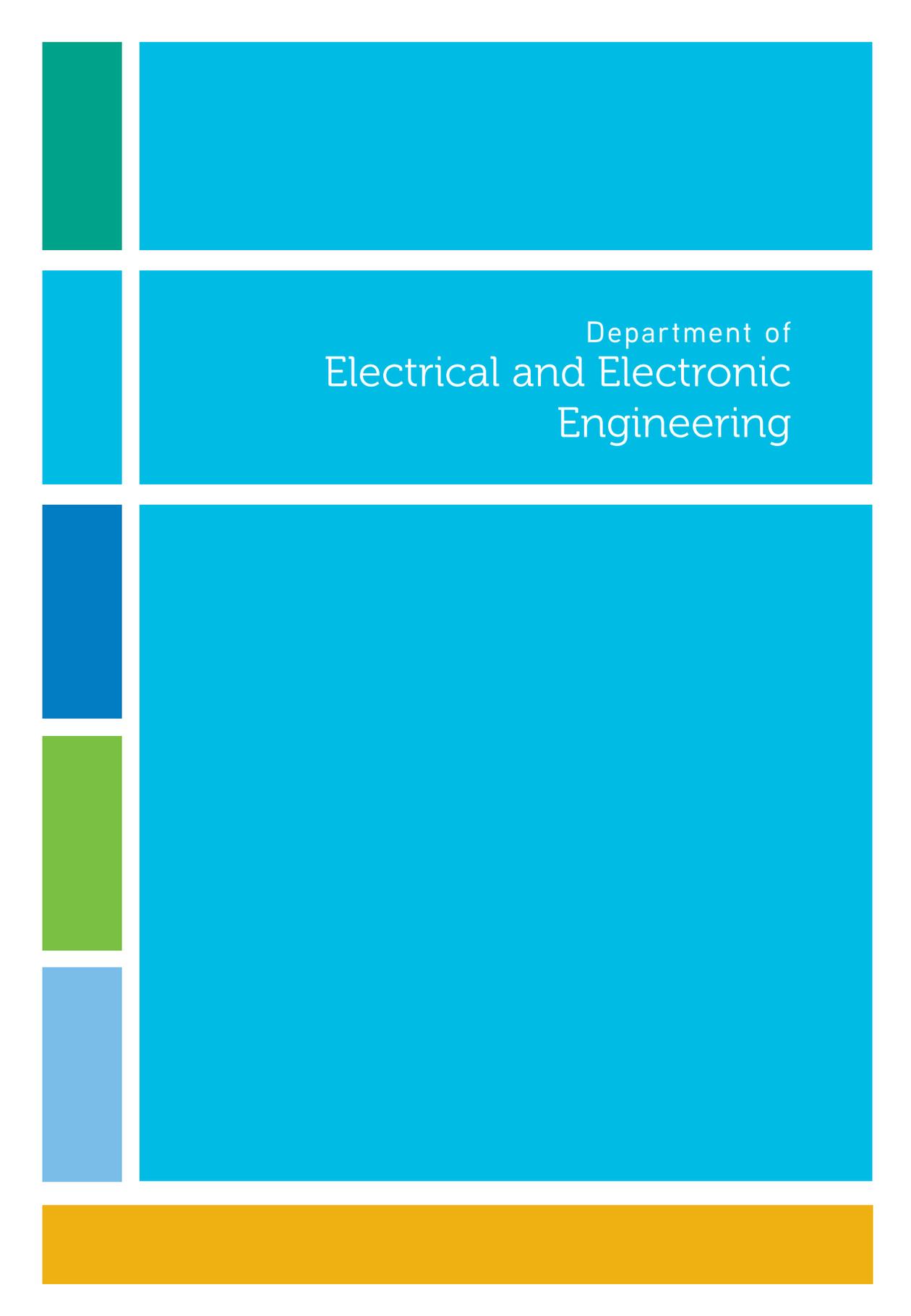
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Department of
Electrical and Electronic
Engineering

5 Highlights



Prof David Davidson, the researcher with the highest NRF-rating in the Faculty of Engineering.

Highest NRF-rating in Faculty

Prof David Davidson, incumbent of the SARChI-SKA Research Chair in Engineering Electromagnetics, received a B1-rating from the National Research Foundation (NRF) which now makes him the researcher with the highest NRF-rating in the Faculty of Engineering. For a researcher to qualify for a B1-rating, all reviewers have to be firmly convinced that the researcher enjoys considerable international recognition for the high quality and impact of recent research outputs, with some reviewers indicating that the researcher is a leading international scholar in the field. Prof Davidson became a Fellow of the IEEE in 2012, in recognition of his contributions in the field of computational electromagnetics. He received a President's Award from the Foundation for Research

Development (now the NRF) in 1995 and a joint IEEE-SAIEE Distinguished Volunteer Award in 2015 for major contributions to electronic engineering in South Africa. His research interest now also includes radio astronomy engineering.

Researchers honoured

Prof Dirk de Villiers and Thinus Booysen were two of 45 top researchers at Stellenbosch University who were honoured for making the biggest contribution to accredited publications. The two categories in which they excelled (as early career researchers 42 years and younger) were the largest contribution with regards to the Department of Higher Education and Training's publication subsidy units and the largest number of accredited research publications in collaboration with their national and international research partners and

students for the 2014 output year. Prof De Villiers's field of expertise is design and modelling of antennas and microwave passive devices and Prof Booysen's is the internet of things, applied to transport, energy and water.

NRF research grants

Three prominent researchers in the Department were the recipients of substantial grants (spread over three years) by the National Research Foundation. Prof Dirk de Villiers received a grant of R300 000 in the category research development grant for Y-rated researchers. The title of his project is *Reflector antenna design by surrogate model optimisation*. Profs Petrie Meyer and Coenrad Fourie were awarded development grants in the category competitive programme for rated researchers. The title of Prof Meyer's research project is *Multimode active antenna arrays for MIMO systems* with a grant that amounts to R1,38 million. Prof Fourie's project, *Automated layout of million-gate energy-efficient SFQ integrated circuits*, received a grant of R757 000. The three researchers, who will act as project leaders of the respective projects, will be supported and assisted by strong teams of national and international experts.

Young academics appointed

The past few years, the Department of Electrical and Electronic (E&E) Engineering has seen sustained growth in its total number of undergraduate students. The Department has therefore been fortunate that it was able to appoint a number of bright young lecturers in 2015 and 2016 to help carry the increased academic load. In 2016 four joined the academic corps of the Department, namely Dr Willem Jordaan, Dr Carlo van Niekerk, Fred Mwaniki and Karen Garner. Dr Jordaan joined the Department after completing his PhD

studies at Stellenbosch University, while the latter three gained industry experience before joining academia.

Student achievements

Students from this Department traditionally fare extremely well in the annual Jac van der Merwe Competition for Innovation. This competition,

sponsored by MultiChoice, rewards the final-year Matie Engineering student whose final-year project is the most innovative. In 2016 Giles Maybery of E&E shared the first prize with Jana Smit of Civil Engineering. For the past 15 years E&E has yielded six winners, two joint winners, and one joint

winner (from another department) who did his final-year project under the supervision of an E&E academic.

Research Output	
Journal Articles (subsided)	30
Proceedings International	74
Proceedings National	21
Doctoral completed	12
Master's completed	46



Prof Maarten Kamper
Chair: Electrical and Electronic Engineering.

Optimising Wind and Solar Renewable Energy in the Context of Grid Support



A wind generator (left) and outdoor solar PV research facility (right) at Stellenbosch University's experimental farm, Mariendahl.

Onshore wind farms and solar photovoltaic (PV) plants represent a substantial proportion of the renewable energy capacity allocated by the Renewable Energy Independent Power Producer Procurement (REIPPP) programme launched in South Africa in 2011. The power generation profiles of these sources, however, are highly dependent on stochastic variables such as weather conditions and exhibit marked diurnal and seasonal cyclic behaviour. High penetration of wind and solar power consequently presents serious challenges to grid operators in the sense that wind and solar PV power cannot be dispatched on demand, as is the case with traditional power plants. Furthermore, due to the flat feed-in tariff offered by the REIPPP programme for wind and solar PV energy, independent power producers maximise the return on investment by locating plants for maximum cumulative energy production, irrespective of time of use requirements. The increasing penetration of wind and solar energy implied by a growing renewable energy programme requires a vigorous research effort to develop optimisation strategies to address concerns pertaining to the grid integration of these sources.

The Department of Electrical and Electronic Engineering, together with the Centre for Renewable and Sustainable Energy Studies (CRSES), are engaged in ongoing research that targets some of the grid integration challenges posed by wind and solar resources in the South African context. These studies include optimisation of the wind and solar PV mix and geographical optimisation of capacity allocations, with the view to maximise the cumulative power contribution whilst minimising variability in the

context of grid support. Recent developments include the development of clustered wind maps, where wind map locations from the Wind Atlas of South Africa (WASA) dataset are grouped according to the temporal similarities of the associated simulated wind turbine power profiles.

The introduction of advanced optimisation strategies for allocating future wind and solar generation capacities is crucial for ensuring the technical and economic viability of increased penetration of renewable energy in the local grid. In this context, the recent research has focused on the use of mean-variance portfolio theory for distributing wind power capacity in such a manner that the wind resource provides optimal generation during periods of high electrical energy consumption and/or when solar power is at a minimum or unavailable. The results obtained for a case study of the current REIPPP allocation, for instance, show that the quality of the wind energy contribution could have been improved considerably, both with reference to capacity factor and variability, using such methodologies.

From the perspective of the system operator, the technical and economic challenges posed by increased penetration of renewable energy remain contentious issues, especially in medium- to long-term energy planning scenarios. This is not only impacting negatively on implementation of the current REIPPP programme, but poses a real threat to the scope of the programme in future. Academic institutions are well positioned to contribute to the long-term success of renewable energy by addressing some of these concerns through applied research and education.

Research Themes

Robotics

In the Electronic Systems Laboratory (ESL), research, development and projects concentrate mainly on the control of remote sensing platforms. These platforms include satellites (e.g. CubeSats), manned and unmanned aerial vehicles (UAVs) as well as autonomous underwater vehicles (AUVs) and unmanned ground vehicles. As most of the research is done as part of a larger system, students are exposed to the full breadth of the management and technical activities required in complex system development.

Electromagnetics

Current activities focus on the following projects: RF and microwave antennas for communications and radar systems, FEM, FDTD and MoM modelling of antennas and wave propagation in complex electromagnetic environments, development of numerical methods and software for simulation of electromagnetic fields, free-space and near-field measurement techniques, optimising complex antennas and microwave components, the Karoo Array Telescope (KAT) and the Square Kilometre Array (SKA). Other activities include superconducting elements, nanosensors, electromagnetic compatibility, microwave filters and non-linear circuits. An antenna and microwave laboratory, supported by sophisticated instrumentation and powerful computing facilities, provides the infrastructure for research work.

Electrical Energy

This division focuses in research on electrical energy in terms of conversion, distribution, control and management, and renewable energy. Specifically, attention is given to multilevel power electronic converters, electrical machine design and drive systems, energy efficiency, and the measurement and management of electrical energy. In renewable energy, the focus is on photovoltaic solar energy, wind generator systems, system identification and grid integration. The facilities include world-class laboratories and instrumentation for prototype testing and measurement. The Department has the only high-voltage laboratory in the Western Cape for amongst others advanced insulator tests and research.

Telecommunications and Informatics

This division works in a variety of areas that involve the manipulation of information-bearing signals. This comprises both extracting and embedding information in the signal (digital signal processing), the transmission of such signals over large distances (telecommunication) and through complex networks (communication networks), and the automatic learning and recognition of the signal content (machine learning) with particular focus on speech and image signals, as well as specialised sensor signals.

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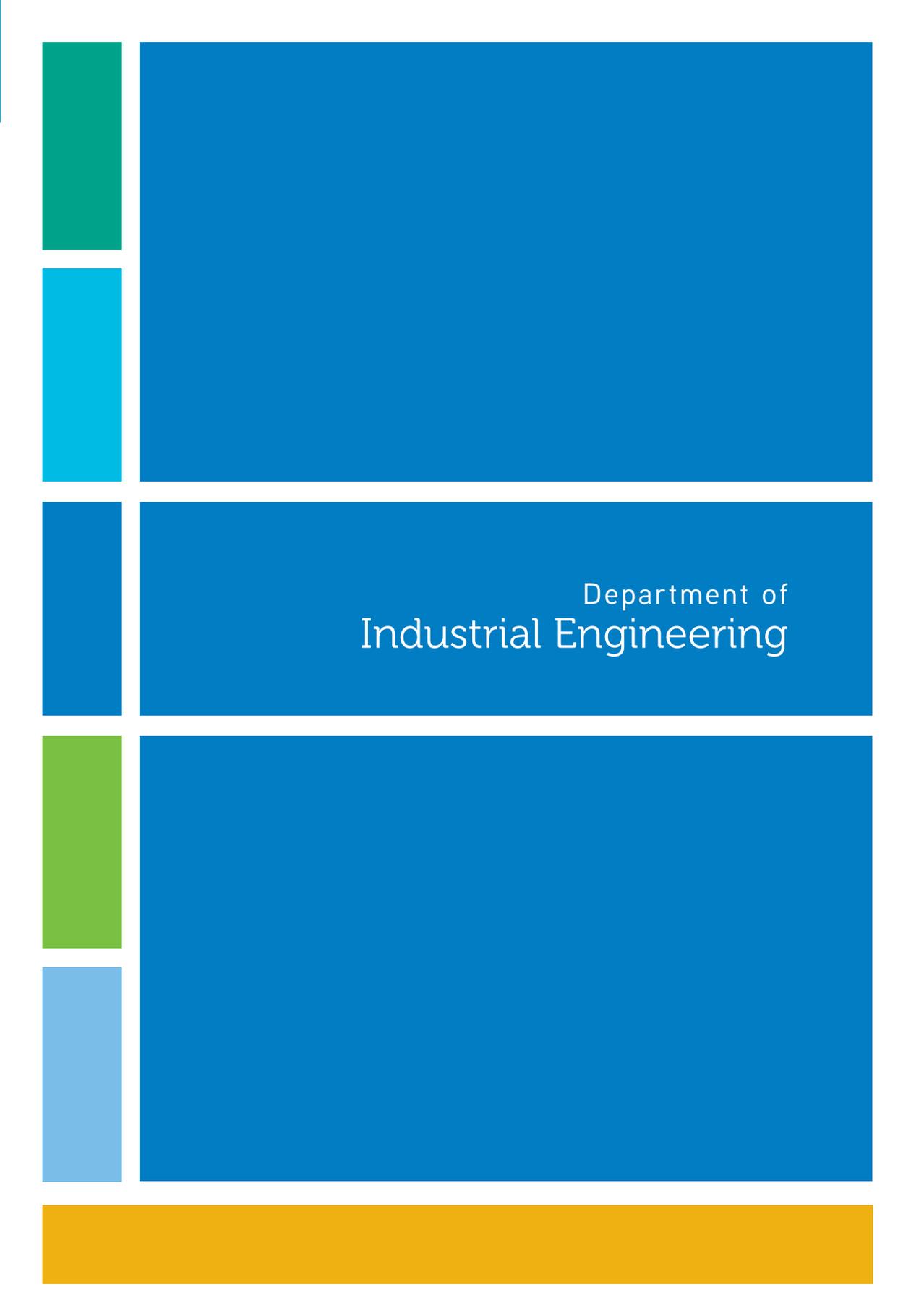
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Department of
Industrial Engineering

5 Highlights



Christiaan van der Walt during a visit to Oxford University.

Greening the future

The collaboration of the Department of Industrial Engineering (IE) and the School of Public Leadership (SPL) in the Faculty of Economic and Management Sciences, has led to the development of the Western Cape Green Economy Model (WeCaGEM). The model, based on the system dynamics approach, aimed to investigate the implications of a transition to a low-carbon, resilient economy in the Province, with an emphasis on the investment requirements for such a transition. Six master's students formed part of the research team, and focused on various sectors in the Province: road and rail infrastructure; agriculture (livestock and food crops); energy (electricity and biofuels); and water. The latter, which was the topic of Aliza Pienaar and supervised by Prof Alan Brent and Imke de Kock (IE) and Prof Josephine Musango (SPL), was submitted to the annual *Mail & Guardian* 2016 Greening the Future competition, and won the category: Green Economy Modelling.

Large interdisciplinary research project

Three members of this Department, Imke de Kock, Wouter Bam and Louzanne Bam, are part of

Stellenbosch University's largest interdisciplinary research group on Health Policy in Africa involving several faculties. The project is funded by Janssen Pharmaceutica. The purpose is to investigate countries on the African continent, to determine the how, what, why and where in terms of health system policies, and how they support markets for pharmaceuticals and devices. The end goal is to recommend and potentially influence the formulation of health policy, to support access to pharmaceuticals and health technology in Africa and to promote specific goals of the United Nations. These include ensuring healthy lives and promoting the well-being of people of all ages, as well as reducing inequality within and among countries. In this project, the Industrial Engineering team joins forces with their peers in the Faculty of Medicine and Health Sciences, the Faculty of Economic and Management Sciences and the Stellenbosch University Business School.

Outstanding student

Over the years the Department has had many bright students. One who has certainly made his mark as an outstanding student, is Christiaan van der Walt who won a Rector's Award for academic achievement from Stellenbosch University – an award reserved for the

top students of each faculty. He also won a (Paul Roos) Rhodes Scholarship to enable him to go to Oxford University in September 2017 in order to read two further master's degrees after his current one in Industrial Engineering with the Stellenbosch Unit for Operations Research in Engineering (SUnORE). These further master's degrees comprise one in applied mathematics and scientific computing (2017–2018), and another in applied statistics or economics (2018–2019).

Research combats threats at sea

An interesting research project carried out in the Department was how to deal with numerous threats at sea, such as piracy, illegal fishing practices and the pollution of marine life. This is important as coastal nations in Africa have to deal with these threats and do not always have the capacity or ability to detect these dangers early and to guard their maritime jurisdiction areas. As part of his PhD studies, Dr Alexandre Colmant (under the supervision of Prof Jan van Vuuren) developed a semi-automated decision support system that could contribute towards the efficient allocation of maritime law enforcement resources such as patrol and military vessels and armed helicopters to investigate potential threats in real-time. Although there may be less reliance on humans to make important decisions regarding potential threats at sea when using this system, it does not entail that such human operators will become redundant. By combining their expertise and experience with the system, operators can use this system as a guideline to validate and/or justify their decisions, especially if the level of uncertainty pertaining to the observed maritime scenario is high. Furthermore, it may even reduce operators' stress levels typically associated with making difficult decisions.

Prof Corne Schutte
Chair: Industrial Engineering.

Young academics appointed

In 2016 several young academics joined the

Department of Industrial Engineering thereby bringing youth and energy to supplement the experience and drive of the mature academic staff. Dr Brian van Vuuren and Denzil Kennon were appointed as lecturers, and Devon Hagedorn-Hansen and Nthabiseng Moloko as junior lecturers. This continues the trend in the Department the past two years to appoint

young academic staff. Another important appointment in 2016 is that of Melinda Rust as Postgraduate Manager. With Industrial Engineering's concerted effort the past few years to excel in the field of research, she is the ideal candidate with her vast experience and expertise to manage the Department's postgraduate aspects.

Research Output	
Journal Articles (subsidised)	57
Proceedings International	38
Proceedings National	32
Books	3
Chapters in Books	1
Doctoral completed	6
Master's completed	38



Innovation for Sustainable Development



Key stakeholders at the first inno4sd.net symposium in Brussels, Belgium (November 2015).

Funded by the Horizon 2020 research and innovation programme of the European Union, *inno4sd.net* is an international network that brings together key stakeholders who are interested in innovation for sustainable development. It is an open network with a research-based agenda for learning and for change, which invites multiple perspectives on sustainable development to be established, scrutinised, and deployed.

The mission of *inno4sd.net* is to build a network-of-networks, reaching out to key stakeholders and existing networks from across the world to think afresh about issues of innovation, the green economy, and sustainable development. It is based on the idea that achieving a better world through transformative change requires connections to be made between researchers, businesses, public officials, society organisations, politicians, funders, knowledge brokers, educators, students, journalists and opinion formers; all of whom have a role to play in innovation.

Innovation is important for sustainable development, but the relationship is not straightforward. There is a need for understanding the global web of constraints and repercussions of different innovation pathways, with attention to how the public interest can be better incorporated into innovation processes. There is also a need to explore drivers for systemic eco-innovation that trigger long-term transformations, address all aspects of the environment and resource use (beyond low-carbon and energy considerations), and are thoughtful of poverty eradication and socio-economic development needs.

The core of the consortium consists of organisations highly experienced in empirical research methodologies, which are key to the project, in particular in impact assessments and forward-looking activities. The Department of Industrial Engineering, Stellenbosch University, plays a facilitating role in the project with the harmonisation of the concepts of sustainable development, green economy, and eco-innovation. To this end it has been tasked to lead a work package, with the following objectives:

- To clarify the (operational) meaning of the concepts of eco-innovation, sustainable development and green economy in different parts of the world (meta assessment), for different stakeholders and different Member States.
- To contribute to a harmonised measurement of eco-innovation and green economy around the world.
- To promote a multistakeholder, multiregional dialogue with the aim to identify policy and business needs, and validate locally owned and driven solutions.

Thereby the work package explores synergies and overlaps across the different regions in terms of concepts, research progress, policy agendas, business initiatives, and stakeholder needs around eco-innovation for a green economy and sustainable development. The work package operationalises these concepts by focusing on the key leverage points of overlap and divergence and clarifying how these apply to specific areas of eco-innovation. The project will also develop a concept of measuring eco-innovations in a global context.

Research Themes

Engineering Management

Engineering management includes fields such as project-, risk-, innovation-, quality- and performance management, and feasibility studies in the wider sense:

- Enterprise engineering: analysis of enterprises (design, implement, operate) including knowledge and information-, innovation-, financial- and technology management.
- Sustainable systems: the transition to a more sustainable economy and society, which will place emphasis on management of infrastructure/ technology, including planning and design.
- Health systems engineering: conceptualising novel, engineering-based solutions to the challenges facing the healthcare sector. The research hub is specifically focused on facilitating improved healthcare delivery within the public sector in sub-Saharan Africa.
- Innovation for Inclusive Development (I4ID): analysis, development and evaluation of inclusive innovations, inclusive innovation systems and innovation platforms. The goal is to explore how I4ID may provide solutions to societal problems (access to clean water, healthcare, financial services, etc.).

Manufacturing

This area focuses on development of resource efficient process chains to ensure sustainable manufacturing as value creation system of products, but also for wider application in the services sector:

- Digital design systems: the design thinking approach of product development from conceptual to Computer-Aided Design (CAD).
- Rapid prototyping: transforms these digital designs into physical products using rapid additive- or subtractive technologies.
- Metrology: analysis, development and evaluation of quality for these manufactured products and research advanced methods and technologies to reverse engineer future product innovations.
- Robotics: the application of industrial robots in manufacturing. Human/robot interaction is fundamental for the new industrial revolution called Industry 4.0.

- Micromanufacturing: this involves micromachining (milling and turning) and microassembly of microproducts in which micromaterial handling systems are utilised.

Operations Management

- Physical asset management: the systematic and coordinated activities and practices through which an organisation optimally and sustainably manages its assets and related systems.
- Supply chain management: supply network design, performance management and feasibility studies in the wider sense, to contribute to efficient supply chains.
- The PRASA Engineering Research Chair which initiates and executes research into aspects of maintenance-management and -processes best suited for the rail sector.

Systems Modelling, Operations Research and Decision Support

This area focuses on the development of mathematical models and their incorporation into computerised systems aimed at supporting scientifically justifiable and effective decisions in industry. These models draw from the scientific fields of applied mathematics, statistics, industrial engineering and computer science and are applicable in the context of complex problems which admit a large variety of trade-off solutions. Strong decision support ties exist with a number of industry partners in the agricultural, retail, banking, insurance and military sectors, as well as various parastatals, NGOs and non-profit organisations. Examples are:

- Routing and scheduling decisions for fleets of delivery vehicles.
- Employee duty roster or timetabling decisions for the manufacturing and health sectors.
- Shelf-space allocation and inventory decisions for retailers.
- Crop irrigation and agricultural pest-control strategy decisions.
- Power generator maintenance scheduling decisions in the energy sector.
- Facility location decisions for effective supply chain logistics.
- Optimal facility or production plant layout.

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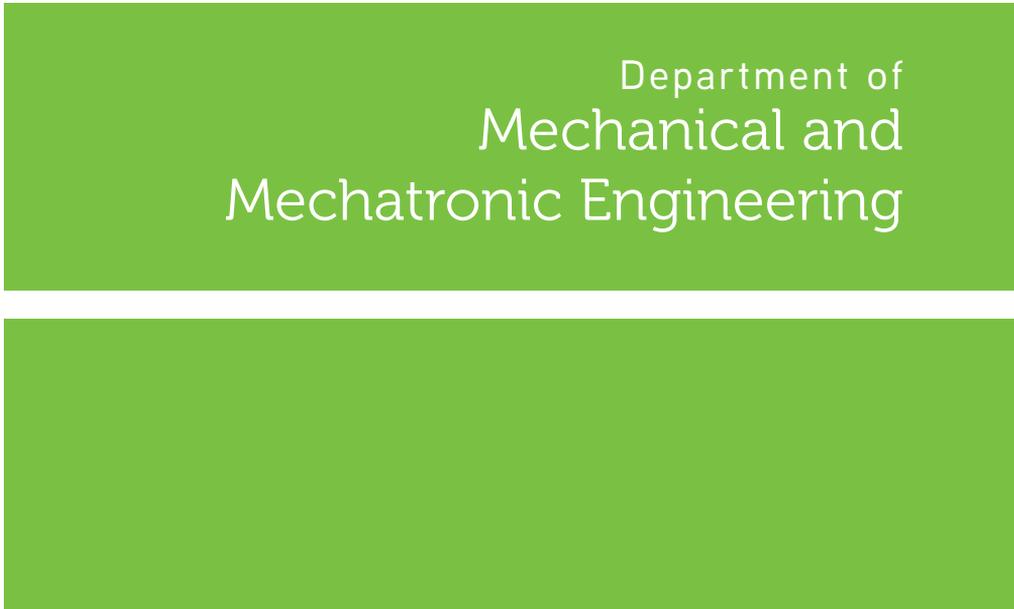
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The Chair of Industrial Engineering, Prof Corne Schutte, with Mattie Landman, the best BEng (Industrial) student in 2016 with an average of 85,9%.



Department of
Mechanical and
Mechatronic Engineering



5 Highlights



Jana Rossouw (left) and Marina Kamper, the top-performing BEng students in Mechatronic and Mechanical Engineering respectively.

Women take top honours in Mechanical and Mechatronic Engineering

2016 was indeed an exceptional year in the history of the Department with two women achieving the highest marks in the two programmes offered by this Department. Marina Kamper and Jana Rossouw, who received their BEng degrees cum laude in December 2016, were the top-performing undergraduate students in Mechanical and Mechatronic Engineering respectively. Ms Kamper achieved a final average of 85,5% and Ms Cilliers 80,6%. What makes this achievement even more extraordinary, is that only 10% of the Mechanical and 15% of the 2016 Mechatronic final-year class were women.

Prof Anton Basson receives Chancellor's Award

Prof Anton Basson (Vice-Dean: Teaching and Quality Assurance) received a Chancellor's Award at the December graduation ceremony. Chancellor's Awards are awarded in recognition of continued contributions to excellence, and focus on sustained excellence in the

fields of research, learning and teaching, and/or community interaction. Prof Basson has been with the Faculty of Engineering since 1993. During his three terms as chairperson of the Department of Mechanical and Mechatronic Engineering, he was the driving force behind the introduction of the Mechatronic Engineering Programme, to which he contributed significantly. He became Vice-Dean: Teaching and Quality Assurance in 2012 and ensured that the Engineering Council of South Africa (ECSA) could not find fault with any of the BEng programmes during its five-yearly accreditation visit in 2013. His extensive experience also makes him a regular member of ECSA accreditation teams visiting other universities, and a dynamic author having produced some 25 journal articles and 45 conference papers. This popular educator has, inter alia, been named the Faculty's lecturer of the year and received a Rector's Award for Excellence in Teaching.

Largest intake of postgraduate students

In 2016, the Department of Mechanical and Mechatronic Engineering had the largest intake (85) of

postgraduate students in its history. Over the past few years the Department has been fortunate to maintain a steady growth in the number of postgraduate enrolments. The 60 postgraduate degrees in Mechanical and Mechatronic Engineering awarded jointly at the December 2016 and March 2017 graduation ceremonies also exceeds the 50 in the previous corresponding period.

Record number of research publications

The Department experienced a 38% increase in its publication outputs compared to the previous year. This increase goes hand in hand with a growing number of postgraduate students and more staff actively involved in research. The record number of 110 research publications, compared to 71 the previous year, is a testimony of the commitment in the Department to do research and to disseminate the results to the public. The Solar Thermal Energy Research Group (STERG) and the Biomedical Engineering Research Group (BERG), with 52 and 30 postgraduate students respectively, had a strong publication output in the areas of solar thermal power generation and biomedical engineering. Very significant contributions were also made in interesting areas such as the packaging of apples and engineering education. Three staff members, namely Profs Theo von Backström, Gerhard Venter and Frank Dinter, excelled with more than ten papers each.

Large development project well underway

The Department's contribution towards the *MinWaterCSP* project, under the auspices of the European Union's Horizon 2020 programme, is well underway. Horizon 2020 is the biggest EU Research and Innovation programme to date. The project focuses on the development of technologies that will assist in reducing the water consumption of

concentrating solar power plants. The project is carried out by a team of 38 members representing 12 partners in an international consortium of six different EU-member and Non-EU countries. A large axial flow fan (9 m in diameter), which was manufactured by one of the project partners, was installed at a South African power station in October and tested by personnel of the Department. The initial test results proved to be very promising and these results will be used for the development of a further fan that will be installed in a full-scale test facility at the

Faculty of Engineering, Stellenbosch University. The construction of this facility will commence in April 2017 and should be completed by the end of 2017. This research project aims to reduce cooling system water consumption by up to 95% relative to wet only cooling systems.

Research Output	
Journal Articles (subsidised)	44
Proceedings International	31
Proceedings National	28
Chapters in Books	1
Doctoral completed	11
Master's completed	40



Prof Kristiaan Schreve
Chair: Mechanical and Mechatronic Engineering.

“Nerve” Systems for Ships in Ice



Rosca de Waal (left) and Keith Soal who travelled to the Arctic on the FS Polarstern.

Rosca de Waal and Keith Soal are two of only a handful of South Africans to travel to both the Arctic and Antarctic in the same year. These students from the Sound and Vibration Research Group at the Department of Mechanical and Mechatronic Engineering performed full-scale vibration measurements with forty sensors on the SA Agulhas II polar supply and research vessel on her Antarctic relief voyage during 2015/2016. In March, Mr Soal and a team of technicians installed more than a kilometre of cable for twenty vibration sensors on the German research vessel, FS Polarstern, in Bremerhaven. In July, Mr De Waal joined Mr Soal for more instrumentation in Tromsø from where they embarked on a three-month voyage from Norway to the Arctic.

Polar vessels navigate in remote areas of the ocean under some of the harshest conditions on earth. Rough waves and polar ice cause enormous forces in the hull and propulsion structures. Little is known about the actual magnitude of these forces. As a result, engineers adopt reasonable assumptions based on computer simulations and scale model investigations when designing polar vessels. In the field, ice navigators judge local routes and vessel speed unassisted as a result of limited data transmission or satellite coverage. Several maritime accidents have occurred as a result of human error and structural failures of ships in these environments.

The PhD of Keith Soal focuses on global bending and twisting of the ship hull. Imagine holding the ends of a ruler and repeatedly bending and twisting it. The ruler may survive many cycles of moderate bending or snap if bent too far. Through multisensor measurements, Mr Soal's research monitors how polar vessels accrue bending and twisting loads during operational life-cycles.

Rosca de Waal investigated propulsion system responses as a result of ice impacts on propeller blades. The complex impact and milling of ice causes vibration of the shaft-line assembly. Since sensors are not likely to survive mounting on the propellers, this master's study involved the development of an in-board measurement system and engineering algorithms to determine propeller loads.

In future, it is envisioned that the sensors that capture ship responses will act as an engineering nervous system to analyse and communicate real-time information to officers on the bridge. This nervous system could never replace experienced ice navigators, but could provide valuable information to operate ships in remote and harsh environments with increased safety and efficiency.

Research Themes

Energy and the Environment

In close collaboration with the Centre for Renewable and Sustainable Energy Studies, the Department contributes towards fundamental research into a wide range of energy generation technologies. Addressing transport needs, the group investigates the performance and impact of biofuels and blends in compression-ignition and spark-ignition engines. Uniquely South African solutions to concentrating solar thermal power and energy storage systems are researched. The group's world-leading research in air-cooled heat exchangers and cooling towers is well known. The group can test fans, heat exchangers and cooling tower fills to international standards. This experimental capability, combined with strong computational expertise, enable the group to develop special fans, compressors and turbines, e.g. industrial applications, but also ocean current, wind, and solar energy exploitation-, and air-cooled systems. Two-phase flow expertise has attracted the nuclear industry's interest with the application of heat pipes as passive heat transfer devices. Research covering the energy efficient design of ship propulsion, ship hulls and various turbomachinery is supported by the only 90 m long towing tank in Southern Africa.

Biomedical Engineering

Technologies such as 3D printing, microcomputers and artificial intelligence are opening up new opportunities for engineering in the biomedical field. This group is developing innovative minimally invasive devices to collect healthcare information, mechatronic devices for telemedicine and finding customised solutions for the treatment of specific diseases as well as developing and testing medical sensors for in vivo testing of the human knee's biomechanical properties.

Solid Mechanics

Activities are divided into fundamental research on materials, behaviour of structures and failure mechanisms and criteria. The materials research focuses on powder metal (mainly titanium and its alloys) processing and products, continuous fibre-

reinforced thermoset composites for aviation components and structures, material property extraction using digital image and volume correlation, characterisation of granular materials and qualification of additive manufactured parts for biomedical and aerospace components. The structures research looks for fundamental understanding of the behaviour of structures under static and dynamic conditions and, in the case of vehicles, aircraft or ships, their impact on humans. The research into failure mechanisms and criteria is focused on composite material failure phenomena, fracture and creep deformation of steels.

Mechatronics, Automation and Design

Diverse mechatronic systems such as reconfigurable manufacturing systems, unmanned aerial vehicles, robots and medical devices are researched. The research includes development design methodologies for such systems. It finds applications in automation of assembly systems, inspection and quality control using machine vision, reverse engineering, micrometrology and calibration and maintenance of heliostats for concentrating solar power systems.

Computational Engineering

The group's expertise in optimisation theory and algorithm development, finite element methods (FEM), computational fluid dynamics (CFD), discrete element methods (DEM) and continuum methods is world-renowned. Their work is backed up with excellent experimental work in well-equipped laboratories. The DEM work is applied to mining and earthmoving equipment, particle dampers, conveyors, etc. The optimisation methods are often linked to the FEM and CFD work in applications related to fluid structure interaction, turbomachinery, combustion and various renewable energy technology applications. The group also has expertise in the modelling and simulation of metal casting processes with emphasis on solidification analysis and segregation. Besides workstations and GPU (graphics processing unit)-based computing this work is supported by access to the Faculty's cluster computing resources.

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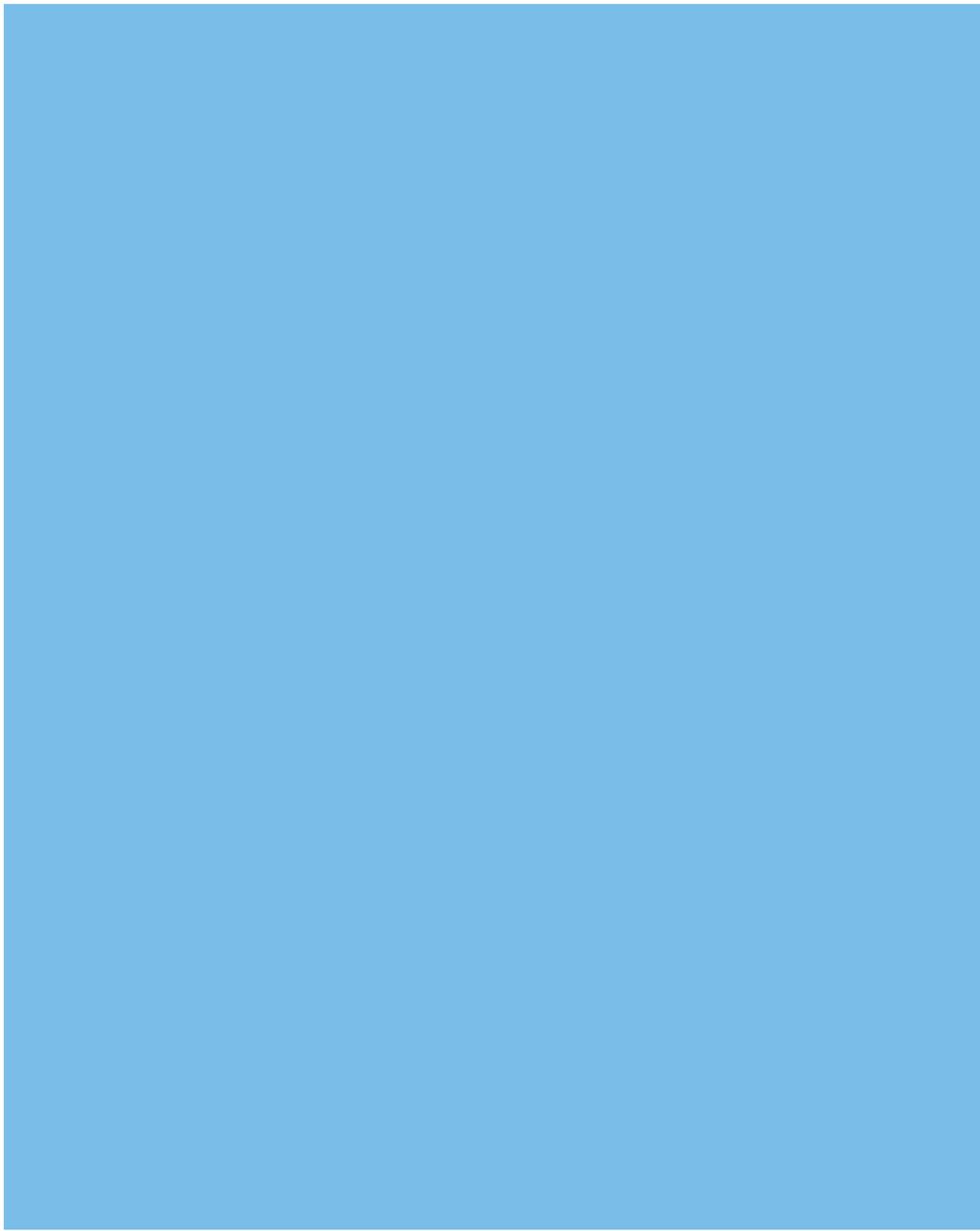
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Department of
Process Engineering



5 Highlights



Prof Johann Görgens and Dr Margreth Tadie.

Highest honour for student

The Department of Process Engineering is extremely proud that one of its students, Riccardo Swanepoel, received Stellenbosch University's Chancellor's Medal for 2016. Mr Swanepoel, who was awarded his BEng (Chemical Engineering) degree cum laude in December, was recognised with this prestigious award for his exceptional academic record. He maintained an average of 94,1% over four years and made history by becoming the first chemical engineering student to score 100% for his design project. Furthermore, he achieved 93% for his final-year project, also the highest mark ever in this Department. Mr Swanepoel will continue with postgraduate studies in 2017 under the supervision of Prof Cara Schwarz.

Remarkable publication milestone

Prof Johann Görgens achieved a remarkable milestone in the 2016 calendar year, with 26 publications to his name – a remarkable number in the engineering context and the highest ever achieved by a faculty member in a year. This publication output reflects the dynamic activities of the Bioresource Engineering group, headed by Prof Görgens. The group is investigating the biochemical and thermal conversion of biomass to chemicals, the simulation of biorefineries and the development of microbial and enzymatic

systems. Currently Prof Görgens is involved in the supervision of 12 PhD and 27 MEng students, supported by 12 Postdoctoral Fellows. In addition to the academic content of his group's work, Prof Görgens has a strong focus on technology transfer and industrial commercialisation. With significant 3rd stream funding the group runs pilot scale work and Prof Görgens is involved in industrial and government consultation on new technologies. He also serves as the Director of the Centre for Process Engineering at the University.

Lecturer of the Year

The Faculty makes an annual Lecturer of the Year Award to an academic who has made a significant long-term impact on the Faculty. This year's recipient, Prof Steven Bradshaw, joined the Department in 1989. As an academic with a strong interest in undergraduate teaching, for many years he served as the Department's Programme Coordinator and is a two-time recipient of the Rector's Award for Excellence in Teaching. He currently chairs the Department and is an active member of the Extractive Metallurgy group, with nearly 70 journal papers to his name. He has been involved as supervisor for nearly 50 postgraduates, and is currently involved in projects on computational fluid dynamics, leaching and recycling of electronic waste.

IMPC Education Commission

Dr Margreth Tadie was elected to the Education Commission of the International Mineral Processing Council (IMPC), a body which aims to maintain

oversight over the various formal activities of the international mineral processing community. The Education Commission monitors global trends of interest to the Council and the international minerals processing community regarding educational developments, skills

development and availability in minerals processing. It addresses growing concerns about the supply and demand of engineers in the minerals sector, and the degree to which they possess the skills needed to make the best use of available tools and technology. In 2013, the Commission reported on the worldwide supply and demand of engineers in the minerals sector. Dr Tadie and her peers from Australia, South America and the United Kingdom serving on the Education Commission will be involved in the second phase where a set of curriculum guidelines for minerals engineering education that meet current industry needs will be established and implemented by education providers around the world through a survey of education providers around the world. Dr Tadie is a previous recipient of an IMPC Young Author's Award and was selected by this body as an Emerging Young Leader in 2015 which led to her being part of the Education Commission team.

SAIMM Gold Medals

In 2016, the Southern African Institute for Mining and Metallurgy (SAIMM) council awarded gold medals for two papers published by Profs Steven Bradshaw and Guven Akdogan, and Prof Jacques Eksteen, who is an Extraordinary Professor in the Department of Process

Engineering. Both award-winning papers appeared in the Journal of the Southern African Institute of Mining and Metallurgy, Volume 115, May 2015. The first paper was titled *Sonic injection into a PGM Pierce-Smith converter: CFD Modelling and industrial trials*. (Authors:

D.K. Chibwe, G. Akdogan, G.A. Bezuidenhout, J.P.T. Kapusta, S. Bradshaw, and J.J. Eksteen). The second one was *Modelling of fluid flow phenomena in Pierce-Smith copper converters and analysis of combined blowing concept* with the authors being D.K. Chibwe, G. Akdogan, P. Taskinen, and J.J. Eksteen).

Research Output

Journal Articles (subsidised)	41
Proceedings International	6
Proceedings National	4
Chapters in Books	4
Doctoral completed	3
Master's completed	21



Prof Steven Bradshaw
Chair: Process Engineering.

The Wonders of Hemicelluloses in Bread Making



Danika Koegelenberg (MEng student) extracting xylan from wheat bran.

Agriculture and agro-processing activities generate a variety of low-value by-products that can be turned into high-value products with advanced fractionation procedures. This is the aim of a project in the Department of Process Engineering titled *Value addition to agro-residues* funded by the National Research Foundation.

Wheat bran, a by-product from grain milling, holds great potential for production of higher value functional and nutritional food ingredients which are in high demand due to increased consumer preference for highly nutritional and healthy food products.

A study carried out under this project by Danika Koegelenberg, under the supervision of Dr Annie Chimphango, demonstrated the functional, nutritional and commercial value of wheat arabinoxylan, a major hemicelluloses, selectively extracted from wheat bran. The arabinoxylans have prebiotic and antioxidant properties in addition to being a source of soluble fibre. The arabinoxylans were added to white bread, which is one of the major staple foods worldwide. Most commercial white breads are to some extent now

fortified with vitamins and minerals to increase the health benefits.

Further improvements have included addition of wheat bran, which increases the insoluble fibre content and decreases the glycaemic index (GI). However, such applications do not utilise the full nutritional and commercial potential of the wheat bran. Instead of adding wheat bran as a dietary fibre component in bread, arabinoxylans were added to bread to function beyond just a dietary fibre.

Arabinoxylans extracted from wheat bran contain arabinose and ferulic acid, which, when added to the bread for the baking process, increase the water holding capacity and antioxidant properties of the bread. The phenomenon creates a basis of adding the arabinoxylan to dough to displace a certain amount of flour, which reduces the starch content without affecting standard bread properties, but instead increases the shelf life. Thus, arabinoxylans do not only improve the nutritional properties and health benefits, but can potentially reduce the overall production cost of bread.

An addition, 0,8% arabinoxylans displaced 2,5% flour, while maintaining the standard bread weight, volume and firmness. Flour replacement by small amounts of arabinoxylans would allow increased production of bread per ton of wheat flour, which would improve the overall economics of bread making. The structural and chemical properties attained from the extraction process of arabinoxylans greatly influence the functional properties as flour replacer and functional food ingredient.

More research is being conducted to scale up and improve the production of hemicelluloses for a variety of other industrial applications.



From the left wheat bran, de-starched bran and xylan.

Research Themes

Extractive Metallurgy

The sustainable production of valuable minerals and metals from ore or metal-containing waste material is critical for a sustainable future. Ore is a complex raw material, requiring a wide variety of treatment processes to unlock valuable minerals and metals. The group undertakes research into the fundamental concepts and application of such treatment processes. Key challenges include changing raw material characteristics (e.g. diminishing mineral/metal content as easy-to-access ore bodies are depleted), minimisation of energy and water usage (to minimise carbon footprint and reduce impact on scarce resources), as well as effectively dealing with the complex behaviour from the intricate flowsheets required to process heterogeneous, multiphase raw materials.

Waste Valorisation

The successful valorisation of wastes will allow to close the loop in the circular economy, moving closer to a sustainable future. Key challenges include separation and concentration of valuable products as well as functionalisation of relatively inert chemicals.

The group is active in three main areas:

- Waste tyre conversion to high-value chemicals (REDISA project).
- Electronic waste processing for metal recovery (lithium, gold, copper).
- Biological waste utilisation (e.g. wastewater, agricultural residues, fishery waste, etc.).

Separations Technology

The Separations Technology research group focuses on understanding the underlying fundamentals of thermal separation processes involving various hydrocarbons. Processes include traditional separation techniques such as distillation and liquid-liquid extraction, but also include advanced processes such as enhanced distillation and supercritical fluid

fractionation. The research group focuses on the separation of compounds where the underlying systems may exhibit azeotropy and association due to hydrogen bonding, and the systems may involve molecules with varying polarity and asymmetrical structure. Ultimately, the aim of the research group is to understand how the structure of a molecule affects its macroscopic behaviour.

Bioresource Engineering

To ensure a sustainable future, biological resources need to be used optimally, and the group focuses on developing industrial processes that are safe, sustainable and profitable. The group's research revolves around the use of biological resources in the development of production processes, and can be subdivided into two classes: processes that employ biological resources (e.g. live organisms like yeasts or bacteria, or active biological molecules like enzymes) to transform raw materials into valuable products, or production processes that use biological raw materials as inputs. There is a strong interdisciplinary focus within the group, and frequent collaboration occurs with other disciplines at Stellenbosch University and with leading foreign institutions.

Water Technology

The group focuses on research and development aimed at addressing current local and international challenges in water provision. The objective is to improve existing water treatment technologies as well as develop new technologies that will contribute to addressing this global challenge. The group's strengths lie in membrane technology for water treatment and reuse (microfiltration, ultrafiltration, reverse osmosis, forward osmosis, membrane distillation and Donnan Dialysis), and in technologies that will be applicable and sustainable in developing economies. Current projects range from investigation and modelling of basic phenomena, to technology development leading to implementation in the field.

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Outreach Programmes



Some of the bright young girls who attended the 2016 Women in Engineering afternoon.

The Faculty of Engineering has several outreach programmes to stimulate interest in science, engineering and technology.

Open Day

The annual Open Day is aimed at creating awareness amongst learners and parents regarding the interesting world of the engineer and the vast career opportunities offered by the different engineering disciplines.

Enquiries: Ms Tanya Ficker
Tel: +27 21 808 9403, e-mail: tanya@sun.ac.za

Engineering Winter Week

During the annual Engineering Winter Week, Grade 11 and 12 learners get a clear picture of the work of an engineer through presentations by lecturers and engineers, as well as visits to industries and laboratories.

Enquiries: Ms Portia Adonis
Tel: +27 21 808 4203, e-mail: winterweek@sun.ac.za

Women in Engineering

At the annual Women in Engineering afternoon, Grade 10 to 12 girls, who excel in Mathematics and Physical Sciences, find out more about engineering as a career for women when women engineers, lecturers and students address them.

Enquiries: Mrs Avril Ford
Tel: +27 21 808 3614, e-mail: aford@sun.ac.za

Top Learners

During sessions, top achievers (Grade 11 and 12) and their parents are informed about engineering as a career and the Faculty's degree programmes.

Enquiries: Mr August Engelbrecht
Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Leadership Development

Senior students follow a leadership module at the Frederik van Zyl Slabbert Institute for Student Leadership Development, which enables them to become well-rounded engineers who are better equipped to make a difference in society.

Enquiries: Mrs Avril Ford
Tel: +27 21 808 3614, e-mail: aford@sun.ac.za

TRAC SA

The TRAC Programme, the biggest community interaction programme at Stellenbosch University, gives support in Physical Sciences in TRAC laboratories countrywide to learners in disadvantaged communities. It also provides vocational guidance regarding careers in the sciences, engineering and technological fields and assists learners in obtaining funding for tertiary studies.

Enquiries: Mrs Debbey Olivier
Tel: +27 21 808 4384, e-mail: debbey@sun.ac.za

Minquiz

Minquiz (organised by Mintek) is a science and technology quiz for Grade 12 learners that promotes careers in science and technology, especially in mining, mineral processing and geology. The Department of Process Engineering provides assistance in the Boland and the Western Cape.

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Koördinate Coordinates
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18° 51' 54" O 18° 51' 54" E

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