Postgraduate Studies: Current Research Fields in the Mechanical and Mechatronic Engineering Department



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Research themes for 2023

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Materials Engineering Research Group

- Characterisation of materials using computer vision (digital image correlation) and machine learning
- Additive manufacturing of superalloys: Process and property optimisation for aerospace applications
- Powder characterisation and process development for metal powder technology, such as laser bed powder fusion and sintered powder metals





Assoc. Prof Debby Blaine dcblaine@sun.ac.za

Engineering | EyobuNjineli | Ingenieurswese

Dr Melody Neaves melzvanrooyen@sun.ac.za 





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SA Agulhas II Flagship for Vessel 4.0





- This polar ship is prone to wave slamming which causes "jellyship", a lasting vibration of her structure. A flexible model must be constructed to mimic the dynamic bending response and the measurement system of the full-scale vessel. This scale model will be used to evaluate and develop methods for the monitoring of hull fatigue damage.
- 2. Digital services for propulsion system health monitoring. Become part of an international research project (South Africa, Norway, Germany) where sensor placement, signal processing and pattern recognition techniques will be used to inform the condition and operational safety margins of the SA Agulhas II

Masters and PhD topics available



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Contact: Prof Annie Bekker (annieb@sun.ac.za) 4/23

GIBELA Gibela Engineering Research Chair Digital services for health monitoring of rolling stock

GIBELA will manufacture 600 trains locally for the South African Rail Sector. The company is responsible for maintaining this fleet of trains for the next 19 years.

NEW - in 2022 the Gibela Engineering Research Chair is established. The chair will focus on innovative monitoring technologies / sensors and signal processing / data analysis / maintenance optimisation to develop South African digital services for structural health monitoring in the rail sector.

Fully funded Master's and PhD bursaries available.

Contact: Prof Annie Bekker (annieb@sun.ac.za) & Mr Pieter Conradie (pieterc@sun.ac.za)







5/23

Propeller load estimation on the SA Agulhas II

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Large proportion of incidents in icy waters related to ship propulsion failure or damage

Research focus:

- Full-scale measurements on board the SAAII
- Development of models for load estimation
- Integration of results for operational decision making





Contact: Dr Brendon Nickerson (nickersonbm@sun.ac.za) & Prof Annie Bekker (annieb@sun.ac.za)







Industry 4.0 in the South African context (MAD)





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www.sun.ac.za/mad

- Digital twin based solutions for industrial systems
- Manufacturing | Automotive | Healthcare | Mining | Agriculture | Facilities
- Integration of humans within cyber-physical I4.0 environments



Materials, Optimisation and Design (MOD)



8/23

The research group's members work on a diverse group of projects related to structural analysis and optimisation. Finite element analysis, numerical design optimisation, material characterisation for numerical modelling purposes, meta-modelling, etc. are all of interest.



Bulk Materials Handling using the Discrete Element Method (DEM)





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- The modelling of granular materials with the focus on bulk materials handling
- Applications in the mining and agricultural sectors: design of new and improving of existing systems and equipment
- Collaboration with local industry and international universities
- Possible funding for Master and PhD students



Prof Corné Coetzee ccoetzee@sun.ac.za





Discrete Element Modelling of Conveyor and Transfer Chute





Discrete Element Modelling of Fertiliser Spreader

Discrete Element Modelling of Soil Tillage

Agricultural engineering postharvest technologies



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10/23

Prof Corné Coetzee ccoetzee@sun.ac.za





- Finite element modelling (FEM) to investigate and improve the structural integrity
- Computation fluid dynamics (CFD) to analyse and improve the cooling efficiency
- Close collaboration with the department of horticultural sciences at Stellenbosch and local manufacturers of packaging materials
- Funding for Master and PhD students



Biomedical engineering - Dr J van der Merwe



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- Endoprosthesis design and biostatistical modelling
 - Data analysis
 - Image processing
 - Modelling
 - Simulation
 - Optimisation
 - Testing and qualification
- Focus
 - South African population and healthcare
 - Collaborate with industry and surgeons



BIOMEDICAL ENGINEERING RESEARCH GROUP

Dr Johan van der Merwe Office M6012 jovdmerwe@sun.ac.za





Biomedical engineering - Mrs Liora Ginsberg

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- Investigations into
 - Initial lymphatics
 - Lymph fluid propulsion
 - Pressure gradient of the lymphatic system
 - Use of FlowNex / CFD / similar



Mrs Liora Ginsberg Office M4031 ginsberg@sun.ac.za



BIOMEDICAL



PIV velocity contour map



Fluent velocity contour map

Vision based measurement systems

- How can we predict the accuracy?
- How can we improve the accuracy?
- How can we design for high precision?
- With applications to:
 - Biomedical Engineering Systems
 - Robotics
 - Manufacturing



Industrial visual inspection



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High precision experiments

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Drone based motion capture



Prof Kristiaan Schreve kschreve@sun.ac.za 13/23

Solar thermal energy research at SU

Solar Thermal Energy Research Group



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POLICY GUIDING STUDIES

- Solar fuels/hydrogen
- CSP for peaking power
- Carnot batteries





2.

CST FOR MINERALS PROCESSING

- Sinter plants
- Low melting metals
- Preheating
- Thermal treatment of ores



MEDIUM SCALE CONCENTRATING SOLAR THERMAL (CST)

- Steam piston generators
- Supercritical CO₂ cycles
- Dry-cooling
- Solarized gas turbines



AUTONOMOUS CSP SERVICES

- Drone positioning
- Photogrammetry measurements
- Drone targets



THERMAL ENERGY STORAGE (TES)

- Rock bed TES
- Engineered packing for TES





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STERG: Infrastructure & resources

Solar Thermal Energy Research Group







Prof Craig McGregor



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Heliostat design and mechatronics









Solar thermal thermo-fluids





Prof Craig McGregor craigm@sun.ac.za



Prof Jaap Hoffmann

Thermal energy storage; solar desalination/sanitation; green hydrogen production



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Solar Thermal Energy Research Group

Dr Willie Smit

Drone services & automation

- Measuring the optical quality of a heliostat
- Closed-loop control of heliostats







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Prof Johan van der Spuy



Cooling fans for CSP plants





Prof Johan van der Spuy sjvdspuy@sun.ac.za

Prof Johan van der Spuy: Large diameter axial flow fans, micro gas turbines

- Simulating and testing large diameter axial flow fans for application in air-cooled condensers
- The development of micro gas turbines for propulsive and renewable power generation purposes.



Prof Johan van der Spuy sjvdspuy@sun.ac.za





A 250 N thrust micro gas turbine, developed by ex-student, David Krige: Owner of Cape Aerospace

The tip vortex structure of an axial flow fan, analysed by Thomas Meyer

> An axial flow fan designed by Francois Boshoff









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Dr Hannes Pretorius

Research

- Dry cooling systems for power generation
- Axial flow fan performance
- Heat transfer analysis from PV panels
- Floating solar PV power generation
- Thermo-economic evaluation on CSP / PV power plants

3 56x+02 3 40x+02 3 41x+02 3 34x+02 3 26x+02 3 10x+02 3 11x+02 3 11x+02 3 04x+02





Augustyn (2017)

Fundamentals

- Thermodynamics
- Fluid Dynamics
- Heat Transfer

Methods

- 1D simulation models
- Computational Fluid Dynamics
- Experimental testing (fans)
- Thermo-economic analysis









Dr Hannes Pretorius M4012 jpp@sun.ac.za





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21/23

Prof Ryno Laubscher

Research areas:

- Combustion modelling and testing (gas turbine combustors, biomass combustion systems, etc.).
- Dynamic and steady-state power cycle simulation (supercritical CO₂ cycle and conventional steam and Brayton cycles).
- Aerodynamics and Aerothermodynamics (shock formation, high-speed flows, supercritical fluid compression).
- Deep learning-based partial differential equation solvers (simulation of Navier-Stokes using artificial intelligence).
- And a little bit of <u>fluid mechanics modelling applied to cardiology</u>.

Methods used in research:

- o Dynamic and steady 1D thermal-fluid network simulation.
- Computational fluid dynamics (ANSYS Fluent and OpenFOAM).
- Deep learning / Scientific machine learning applied to thermodynamics and fluid mechanics.
- o Thermal-fluid focused optimization.







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25.00

- 22.21

19.42

16.63

13.84

11.06

8.27

5.48

2.69

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Temperature profiles in large combustion chamber

Prof Ryno Laubscher M6009 rlaubscher@sun.ac.za

Oxygen predictions by neural network for jet diffusion flames.

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0 1



Comparison of shock pressures predicted by CFD and physicsinformed neural network for nose cone at Ma = 5.

Thermo-Fluids Division - Termovloei Afdeling Mr Richard Haines

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Internal Combustion Engine (ICE) Laboratory

Laboratory and infrastructure:

- ICE laboratory includes test benches for single and multi-cylinder petrol and diesel engines plus a Cooperative Fuel Research (CFR) engine for octane number testing.
- CFR engine has been modified in accordance with DIN 51 756 and SAE 820002 to determine octane numbers of pure alcohols and petrol-alcohol blends.

• Research:

- Alternative fuels and engine testing of alternative fuels (blends) and fuel surrogates for spark-ignition engines.
- Synergistic and antagonistic octane blending behaviour of pure components validated using the CFR engine in accordance with ASTM test methods.
- Heat release modelling and burn rate analysis of fuels using data obtained from instrumented test engines.



Funding available for a bursary and research activities



Mr Richard Haines rhaines@sun.ac.za

Dr Mike Owen

RESEARCH AREAS

- Heat transfer, thermodynamics and fluid dynamics
- Industrial heat exchangers
 - Dry, wet and hybrid cooling
- Renewable and sustainable energy
 - Reducing energy related water consumption
 - Solar thermal energy
- Thermal performance of buildings
 - Thermal performance of buildings
- Fire engineering
 - Simulation and experiment

POST-GRADUATE OPPORTUNITIES

- Multiple topics in thermal energy systems research
- Opportunities for analytical, numerical (CFD) and experimental research
- Always something going on...
- Anything rad, come and talk to me. Bring coffee.





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Dr Mike Owen mikeowen@sun.ac.za M4011











Heat transfer - Prof Josua Meyer Fundamentals of internal forced convection

Motivation: Most of the empirical equations describing heat transfer are approximately a century old. They were developed from analytical work (lots of assumptions) and very "primitive" measuring techniques. Today we have much better tools (instrumentation and CFD).

An example from your heat transfer textbook of Cengel and Ghajar (Chapter 8):

The equation recommended for turbulent flow is the Gnielinski equation:

$$Nu = 1 + \frac{(f/8)(Re - 1000)Pr}{1 + 12.7\left(\frac{f}{8}\right)^{0.5}(Pr^{0.666} - 1)}$$

30 % error

Heat exchangers CSP systems Bioengineering Medical: lungs, etc. Cooling of microchips Heat pipes Aerospace Energy generation Manufacturing Mining, etc

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Prof Josua Meyer jpm2@sun.ac.za 25/23

My students and I developed the Meyer et al (2019) equation which IS now the state-of-the art

 $Nu = 0.041 Re^{1.117} Pr^{0.667} f$ 4 % error

This equation will appear in the 7th edition of Cengel and Ghajar and most other textbooks **DO YOU WANT TO DEVELOP AN EQUATION THAT MIGHT BE IN TEXTBOOKS FOR CENTURIES?!!!**





Thank you. Good luck with post-grad!



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"Mystery creates wonder and wonder is the basis of man's desire to understand" ~ Neil Armstrong