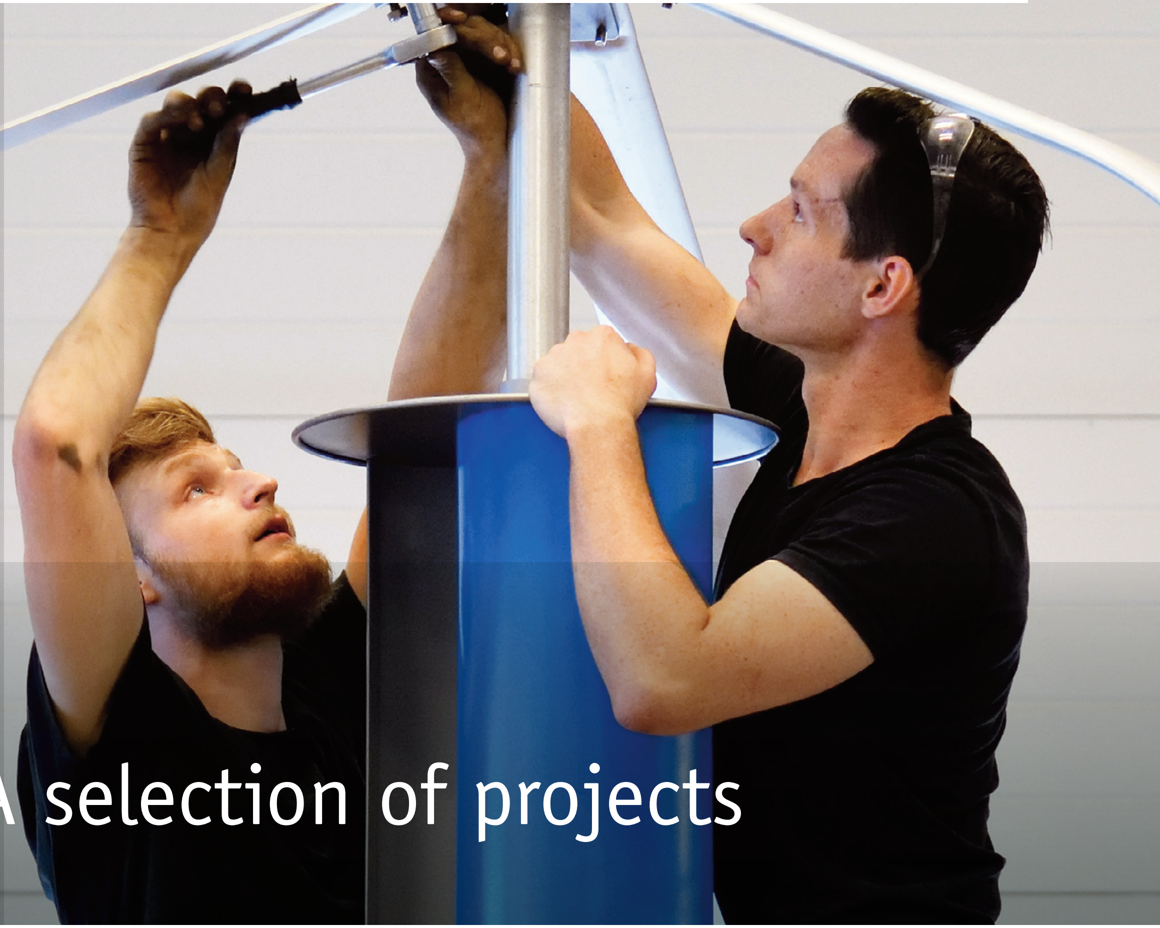
2019

Innovative technological solutions designed by PDEng trainees



TU Delft Delft University of Technology

TU/e Eindhoven University of Technology

University of Twente.

Wageningen UR For quality of life

A selection of projects

4TU. School for Technological Design STAN ACKERMANS INSTITUTE

What do a new steering system for trailers, a web-based personal dashboard for doctors and an imaging catheter, which provides real-time, cross-sectional, in-depth tissue images to detect bladder cancer have in common? They were all designed for organisations by PDEng trainees of 4TU.School for Technological Design, Stan Ackermans Institute. A collaboration between the universities of technology of Delft, Eindhoven, Twente and Wageningen. Is your company facing a challenging technological design issue that needs unraveling? Our trainees may be an attractive option.

Introduction

Our best MSc students are trained to become a technological designer, during a full time two year traineeship. After successfully completing the programme they are entitled to use the academic degree Professional Doctorate in Engineering (PDEng). The different PDEng programmes all fall within the 3rd cycle of higher education, as do the doctorate PhD programmes.

Putting theory into practice

The trainees spend their first year following a dedicated curriculum, which involves courses, interactive workshops and group and practical assignments. Often in close cooperation with industrial and health care partners. In the second year the trainees carry out an in-company design assignment. University experts act as supervisors, providing state-of-the-art technology, advising on the structure and execution of the project and monitoring that the goals of the project are realised. During the design project, the trainees demonstrate their skills in being able to turn knowledge into innovative business solutions for the high-tech industry or health care sector. In some programmes courses and design project run parallel.

Selection of interesting design projects

To demonstrate the value of the outcome of the PDEng design projects, we've made a selection of the latest design projects for you and combined them in this publication. We hope you enjoy reading about the projects produced by our talented PDEng trainees. For more information about our programmes please visit www.4tu.nl/sai.

With best regards,

Prof.dr. Paul Koenraad
Director 4TU.School for Technological Design,
Stan Ackermans Institute (4TU.SAI)

Company: VDL Enabling Transport Solutions
Project: E-Bus multi-zone Thermal management system Design
PDEng trainee: D. Occello, program Eindhoven – ASD

Automotive Systems Design

Battery capacity and cost are a decisive factor for the competitiveness of e-buses when compared to traditional diesel buses. In order to reduce cost, battery size is typically minimized. This limited battery capacity is challenged even more during winter months, when buses need to be heated to provide a comfortable environment for the passengers & the driver. With the current technology, up to 60% of the total range of the electric buses that operate in the region of Eindhoven (NL), can be lost during extremely cold days.

The result of such a variability in range is that fleet operators need to introduce buffers & redundancies in the scheduling, thus increasing planning complexity & operation costs. On the road to increase its competitiveness, VDL is developing energy management systems that aim to reduce the energy consumption of its e-buses.
This project contributed to this goal by designing a Thermal Management system architecture and modeling useful system dynamics which will aid the development of the energy-saving strategies of the future.

Company: Princess Máxima Center for pediatric oncology
Project: Máximal transferring, a pediatric oncology data set
PDEng trainee: T. van Bruxvoort, program Eindhoven – CI

Clinical Informatics

The Princess Máxima Center is the result of centralising pediatric oncology in the Netherlands. It integrates care and research to cure as many children and adolescents with cancer as quickly as possible, without compromising quality of life. Care delivery takes place close to the patient in a Shared Care hospital. Highly complex care takes place in PMC. There is a need for unambiguous agreements about registering, using and exchanging information in Shared Care.

A core and Shared Care data set has been designed, where possible based on Clinical Building Blocks. It identifies information needs in collaboration with Shared Care. The focus is on information valuable to patient, family and healthcare professionals. The models are established by interactive meetings with representatives of all key disciplines, including Share Care. Gap analysis and compliance testing in the applicability of data sets was performed. The results from this project prove a solid basis for further discussion and optimisation about the challenge that is called interoperability.

Company: Samsung
Project: Ultrasound-based strain mapping for quantitative characterization of uterine peristalsis outside pregnancy
PDEng trainee: Yizhou Huang, program Eindhoven – DEES HSD

Design of Electrical Engineering Systems

About one in six couples experience infertility problems in their reproductive lifetime. In-vitro fertilization (IVF) is today the most advanced assisted reproductive technology. In Europe alone, it represents the last resort for over 2.5 million couples with infertility problems. Unfortunately, the failure rate of IVF treatment remains higher than 70%. This may be partly ascribed to the effect of uterine (peristaltic) contractions during and after embryo transfer. However, no method is currently available for noninvasive and quantitative characterization of the uterine activity outside pregnancy.

In collaboration with Samsung, Ghent University Hospital and Catharina Hospital in Eindhoven, this PDEng project aims at implementing a dedicated measurement tool for the characterization of uterine motion outside pregnancy based on ultrasound speckle tracking and strain analysis. This tool is able to analyze the uterine motion recorded by an ultrasound scanner one hour before embryo transfer in order to predict the success of embryo implantation with an accuracy of 93.8%. Therefore, this tool can support clinicians with making the critical decision between transferring the embryo or waiting for a better period, when the uterus is more receptive.

Company: Televic Conference
Project: 60 GHz wireless mesh protocol for multimedia conferencing applications
PDEng trainee: F. Núñez Serrano MSc PDEng, program Eindhoven – DEES ICT

Design of Electrical Engineering Systems

In recent times, the popularity of Wi-Fi has had an unstoppable growth. Therefore, the two main Wi-Fi spectrum bands, 2.4 GHz and 5 GHz, are daily becoming more and more overcrowded, and therefore there is more interference. This interference growth is affecting the reliability of the Televic wireless conference system, called Condfidea. Furthermore, if this trend proceeds, it may become impossible to build a conference system based on the 2.4 and 5 GHz frequency bands.

To maintain the leading role in the conference market, Televic Conference is searching for new wireless technology and architecture. The worldwide unlicensed 60 GHz band seems to be the best substitute technology, because it solves the interference problem and has high bandwidth (several GHz) worldwide which is ideal for video.

In this PDEng project, we have defined a 60 GHz wireless mesh protocol suitable for conferencing applications. We have studied different simulators to analyze and evaluate our protocol, and finally, we have checked how we can implement this protocol with available COTS modules like the Qualcomm Atheros WiGig module.

Company: Dow Benelux B.V. (Terneuzen)
Project: Long-Term Strategy for CO2 Reduction
PDEng trainee: K.T. van Kempen MSc PDEng, program Eindhoven - PPD

Process and Product Design

Climate change is one of the greatest challenges of our time. All industries must drastically reduce their carbon footprint to limit global warming. To meet the Paris Agreement, Dow Terneuzen aims, by 2050, to cut its CO2 emissions to more than 80%. This PDEng project provides a recommendation for a long-term strategy towards this goal.

The production site of Dow Terneuzen is one of the largest energy consumers and CO2 emitters in the Netherlands. To decrease its emissions to more than 80%, large modifications and investments are required. Various combinations of technologies for CO2 reduction are analyzed. These technologies must be implemented step by step. The time schedule for implementation highly affects the economics and the speed by which CO2 emissions can be reduced over time and is affected by many factors. A computer model is developed and used to compute over 20 million different scenarios, from which the optimal combination of technologies and planning for implementation can be selected. This approach allows to be used for other production sites as well.

The result of this project is a recommendation for the best technologies for CO2 reduction of Dow Terneuzen and a planning for implementation of these technologies over the period 2018-2050.

Company: Rijnstate
Project: Dashboard for Medical Technology: Stimulate proactivity and provide transparent information
PDEng trainee: N.T. Kruis MSc PDEng, program Eindhoven – QME

Qualified Medical Engineer

Consider hospital therapies and try to name one that does not involve medical technology. It is probably hard to find an example. With so much medical technology used in hospitals, more responsibility about quality and safety comes down to the users. Although users (mostly nurses and medical specialists) are often short in time; they need information about the current status of equipment in order to determine if the technology is safe to use. Without that overview they struggle to monitor if technologies are safe to use. Therefore, information about medical equipment should be transparent, easy accessible for all stakeholders and part of regular monitoring.
In addition, behavioral change should be initiated to inspire users to use the available information and optimally assure the quality and safety of medical technology.

Within this project a dashboard was designed and implemented to stimulate stakeholders to act proactively regarding safety of medical technology. The required information, such as risk status or maintenance deadlines, was visualized transparently. Crucial to the project were the methods used to design the dashboard. The methods used puts the users in key position of the design. This contributes to the awareness of quality and safety assurance and to the dashboard itself. The visualized information incite action and stimulate proactive behaviour.

The project implemented a dashboard that is regularly used in management reports and life cycle management of medical technology.

Company: Brainport Smart District
Project: Design of a future-proof concept for the heating system of the Brainport Smart District
PDEng trainee: Johann Goethe Alrutz Barcelos, program Eindhoven – SBC

Smart Buildings & Cities

In the context of the increasing pressure for the Netherlands to become a natural gas free country due to sustainability targets and earthquakes in Groningen, heating based on renewable energy source is essential towards a sustainable future. The challenge in the decarbonisation of the heating sector becomes evident when considering that three-quarters of European energy used for heating comes from fossil fuel.

Smart districts, such as Brainport Smart District (BSD), are seen as powerful examples of how our society can organize itself and reduce the dependency of fossil fuels. BSD is planned to be the smartest district in the Netherlands and is the perfect place to implement a modern, renewable heating system that could influence the way that the world thinks about sustainable development. In addition, BSD's living lab environment will create an optimal condition for new sustainable heating systems to be tested and optimized.

However, selecting a new renewable heating system for a smart district is not a trivial task. Different stakeholders involved in the heating sector often have conflicting preference over the requirements of the heating system, creating difficulties in the decision-making process. Therefore, this project developed a design approach to select the most robust heating system for

BSD, taking into account the district's goal and principles and, simultaneously, the requirements of the main stakeholders in the heating sector.

In order to have more confidence in uncertain aspects, the robustness of the heating systems included different future scenarios, such as climate change, expansion of the district, public policies, occupancy behavior inside the district, cost and emission progression of different heating systems. The design approach proposed by this project is being used by BSD's energy design team in their decision-making process towards a heating system for the district.

Company: Thermo Fisher Scientific
Project: Intelligent Microscope
PDEng trainee: Dmytro Kondrashov MSc PDEng, program Eindhoven - ST

Software Technology

The Advanced Technologies department at Thermo Fisher Scientific conducts research on how Artificial Intelligence (AI) technologies can be used for electron microscope software. The project aimed to create a prototype of an Intelligent Microscope (IM) - a technologically advanced microscope empowered by AI. The main motivation for the project was to explore possible ways of interaction with the IM. The IM is an AI-web software system that understands predefined user voice-commands, controls the electron microscope, detects objects on the obtained microscope images, and highlights specific entities requested by a user.

The IM is capable of detecting and highlighting specific types of objects on microscope images in the life science domain, such as cells and mitochondria. Moreover, it is able to interpret information about detected objects, such as object size and distance between objects. These use cases provide examples on how microscope users can utilize the IM for cell image exploration. Even though the presented use cases are unique, the system is not limited to mitochondrion and cell detection only. One of the main implemented requirements for the IM is extendibility to other use cases.

The Intelligent Microscope project answered the questions, how AI can be integrated into electron microscope software and how an electron microscope can move up the knowledge pyramid by providing microscope users with an understanding of an image context.

The GEM-tower is a green energy solution for festivals to replace fossil fuels and will help festivals to be more sustainable.

Company: The Cirqle
Project: Managing UX Debt Using a Design System
PDEng trainee: J. Van de Velde MSc PDEng, program Eindhoven – USI

User System Interaction

Startups often operate in uncertainty with company objectives and product requirements susceptible to rapid change. To remain competitive, they intentionally occur a limited amount of technical debt. This allows companies to develop software faster, with the understanding that the compromises made negatively affect product quality and user experience. The lack of an integrated user-centered design approach managing this negative impact poses a risk to the product and the company as a whole. It leads to fragmented user experience and a disconnect from changing user needs. Over time, the accumulation of this debt becomes a great weight that hinders growth and causes users to seek out competitors. The aim of this project is to increase product quality without losing agility. At the Cirqle, we developed a user validated design system; a collection of functional user interface patterns that are used as a set of building blocks while developing software. Three products have been rebuilt and evaluated.

End products showed an increase in design consistency and redundancies in the development process were diminished. Furthermore, this led to an increase in the team’s efficiency; more resources could be dedicated to user-centered design activities and new features were released at a faster pace.

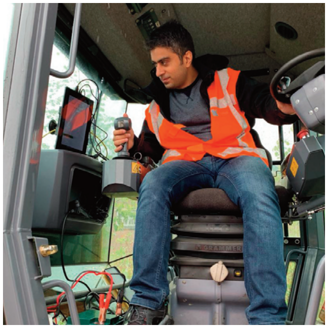
Company: ASPARi
Project: Modernizing process control systems in pavement operations
PDEng trainee: Afshin Jamshidi, program Twente – CE

Civil Engineering

Problem: The contractual structure of Dutch construction industry has changed significantly over the last 3 decades. As a part of these changes, contractors have to provide longer guarantee and warranty periods. To this end, major contractors in the Netherlands together with the University of Twente formed a large consortium (ASPARi) to build up joint momentum towards advancing the industry as a whole and to consult professionalizing the paving process. The current project falls under the umbrella of ASPARi initiative and intends to improve/modernize the technological instrumentation used for the monitoring of paving processes.

Solution: According to earlier ASPARi research, the variability in the paving process can be considerably reduced by providing the operators of paving equipment with relevant real-time process quality indicators. By measuring asphalt temperature and equipment location and presenting these data to the operators, operators can base their strategies on the actual data rather than their experience.

Result: At the high level, the system encompasses two main parts, namely server and clients. Clients are in charge of collecting pertinent data and sending the data to the server. Various types of sensors provide data about the weather conditions, equipment movements, asphalt condition (e.g., temperature and compaction), and the human users (i.e., operators and managers). These data are then pushed to the server, which is responsible for (1) structuring the transmitted data into a structured database, and (2) processing the data



and translating them into relevant information that can be pushed back to the clients. Finally, the processed data are transmitted back to the clients. This includes the operators of different pieces of equipment. Once all the data are transmitted to the server, the data processing begins. The data processing consists of several steps, including structuring of the data into a relational database, generation of cooling curve, generation of compaction/temperature contour plots, generation of the priority map, and generation of the operator guidance.

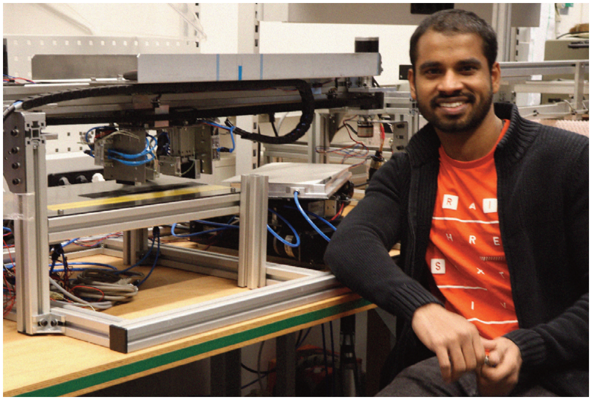
Motivation to do a PDEng: After working in computer industry for years, I was looking for a real international project to find out the differences between works done in my country and other industrial countries. I was looking for a research and industry related project. When I found the PDEng project, I thought it is the best solution for me. A 2-year position which focus on actual industrial need in a university. So far, except the course work which I think it could be more optional, I find PDEng lovely, especially for student who want to join industry.

Company: Fraunhofer Project Centre at the University of Twente
Project: Design and development of a low-cost thermoplastic tailored blank manufacturing system for composite stamp forming process
PDEng trainee: Logendra Dilli, program Twente - Robotics

Robotics

Composite materials are used more and more in cars, aircraft, and road vehicles to reduce the overall weight and increase fuel efficiency. Recent emission standards set for the year 2020 by the European Union (EU) and European Economic Area (EEA) member states, call for novel and inexpensive manufacturing solutions for lightweight structures. One of the major manufacturing techniques used in the automotive and aerospace industry is the stamp forming process. In this process, the required two-dimensional blank material is transformed into a three-dimensional part by pressing it between a top and bottom mould. Currently, these blanks are cut from a large constant thickness laminate resulting in nearly a 50% material waste. This material waste could be reduced by producing individual blanks using thin strokes of composite tapes, thus tailoring the blank to required thickness.

To improve the overall thermoplastic composite technology in the east Netherlands, a consortium of companies each specialized in a technical competency proposed a project with the European Fund for Regional Development (EFRO). A part of the project proposal is to develop a low cost tailored blank manufacturing system for composite stamp forming process. It is my job as a PDEng trainee to investigate, design and develop a new innovative tailored blank manufacturing system. With a background in aircraft structural design and manufacturing techniques, applying the skills learnt over the years to develop a new machine is an interesting challenge for me. Moreover, PDEng is a nice



opportunity to learn new skills in industrial automation, as it helps achieve a well-rounded skill set by working in a multi-disciplinary project environment.

At first, a market study was conducted to identify the similar existing systems and its relativity to thermoplastic stamp forming process. The customer requirements are obtained from the members of the consortium. Using the requirements and the market study as a starting point, a novel blank manufacturing system is designed. The designed system is validated through collaboration with a third-party machine producer. Finally, to prove the concept, a lab-scale demonstrator is built and tested at the University of Twente.

Company: TATA Steel IJmuiden
Project: Modelling of oxidation-reduction of steels during annealing
PDEng trainee: Francisco (Paco) Caparros Salvador, program Delft - Process and Equipment Design

Process and Equipment Design

New steels can help to reduce CO^2 emission. These new steels with superior mechanical properties are capable to stand the same mechanical stresses and impacts than traditional steels used in automobiles, but with thinner gauges. Lighter cars means a reduction in fuel consumption, which implies a reduction in CO^2 emissions.
The manufacturing of these new steels have associated technical challenges, being one of the most important the coatability with zinc in a process known as galvanization. The formation of oxides of the alloying elements (selective oxides) in the surface of the steel impairs the wettability of the zinc layer. The selective oxides are produced during the final thermal processing of the steel (annealing) when the concentration of O^2/H^2O is very low.

During my year in Tata Steel, I worked on the development of a model to predict the formation of selective oxides during annealing. The model uses diffusion laws, reaction stoichiometry and equilibria to calculate the distribution of selective oxides in the depth close to the steel surface as a function of the thermal cycle and composition of the equipment atmosphere. This model is helping Tata Steel to a faster development of new steel grades and to a better understanding of the key variables in the process.

In the final stage of the project, I performed some tests in the pilot plant to validate the model. I also used the experiments to gain more understanding on the difference between pilot plant and real process scale results on the steel surface properties.

During this year, I had to interact with a diverse group of people: oxidation/modelling/surfaces experts, managers, lab technicians and university supervisors. All of them brought new learnings to my experience and helped me to develop the model but also my professional and personal skills.

Company: Conxys Technologies
Project: Design solution for in-situ replacement of coaxial cable internals
PDEng trainee: Padmavathi Sridharan, program Delft - Chemical Product Design

Chemical Product Design

Fiber optic cables are rapidly replacing coaxial cables due to higher bandwidth requirements for emerging broadband applications. The ability of fiber optic cables to carry much more data than traditional copper cables, especially over long distances makes them a preferred choice for connectivity in the telecommunications industry. However, installation of fiber optic cables in conventional way of digging is expensive and time consuming. Excavation works which account for almost 60% of the installation costs are a major source of public disturbance and hence not allowed in some cities. Thus, there is a need for upgrading the current coaxial cable into a hybrid fiber optic – coaxial cable in a cost-efficient way with minimum excavation.

A considerable part of Dutch telecom network has been built with coaxial type 3 that are installed underground over lengths between 150 and 350 meters. A "no-dig" method does exist for coaxial cables with soft inner cores. However, this method is not suitable for coaxial type 3 cables due to their structural limitations. In collaboration with Conxys technologies, we have developed a solution for the removal of the copper core and the surrounding polyethylene dielectric and copper foil of coaxial type 3 cable from the outer protective jacket, without compromising the outer jacket. This in turn provides a space, large enough to guide a new fiber optic cable.

The design was started from scratch with a quick process of idea-generation. The potential ideas were proved/disproved with a fail-fast approach. The material properties of the coaxial cable were tested and studied. Mathematical models were built based on the selected design solution to predict their behaviour on a 50-meter cable. This project has challenged me as a PDEng trainee to deliver a proof of concept within a short period of time while keeping in mind a systematic design approach to the problem. The next steps include verifying the results of the mathematical model and further developing the technology for commercial use on longer lengths of cable.

Company: Department of Thermal and Fluid Engineering (TFE) at the University of Twente
Project: Numerical modelling Anaerobic Digestion Processes by Computational Fluid Dynamics (CFD)
PDEng trainee: Hossein Norouzi Firouz, program Twente - Energy & Process Technology

Energy & Process Technology

The global warming and constantly increasing energy consumption, demand an environmentally friendly solution from the fuel and power generation sector. Anaerobic digestion is a main instance of this kind. Anaerobic digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which is combusted to generate electricity and heat, or can be processed into renewable natural gas and transportation fuels.

A range of anaerobic digestion technologies are converting livestock manure, municipal wastewater solids, food waste, high strength industrial wastewater and residuals, fats, oils and grease (FOG), and various other organic waste streams into biogas, 24 hours a day, 7 days a week. Separated digested solids can be composted, utilized for dairy bedding, directly applied to cropland or converted into other products. Nutrients in the liquid stream are used in agriculture as fertilizer.

However, this is a complicated and complex process including chemical, physical and biological reactions; also mixing and pumping are involved. The experimental investigations are very costly in terms of time and money. They are also limited by safety issues and experimental techniques which can be applied in the real scale reactors. That is why, the computational techniques for modelling of the bioreactors are very desired.

The main task and mission of this PDEng project is to design and optimize biogas output from an anaerobic digester by the means of computational fluid dynamic model which is developed to be a tool for analyzing the interacting phenomena which affect the biogas production. After validation, the model is applied for parametric study of biogas yield. In brief, this model helps to analyze and optimize an industrial anaerobic digester process in order to achieve an improved design of this process which result in more efficient biogas production.

Company: Viride SuSTra BV, Dutch Sustainable Development BV, Dutch DNA Biotech BV
Project: Design and techno-economic evaluation of itaconic acid large-scale manufacturing using alternative feedstocks
PDEng trainee: James Edward Steele Cater, program Delft - Bioprocess Engineering

Bioprocess Engineering

The major objective of this PDEng Individual Design Project (IDP) is to evaluate the technical and economic feasibility of itaconic acid (IA) large-scale manufacturing in the Netherlands (NL) using alternative feedstocks.

The initially evaluated feedstocks were Chemically Defined Medium (an aqueous medium with sugar and ammonium nitrate), Sugar Beet Molasses, Sugar Beet and Green Pellets. The former two are used as a benchmark while the latter two are the alternative feedstocks. Note that the evaluated feedstocks are the carbon source for fermentation, and they constitute the main feedstock of the manufacturing process. The major product is white crystalline Itaconic acid.

The project scope is comprised by three main blocks: a Biorefinery Conceptual Design for each evaluated feedstock, a Techno-Economic Evaluation (TEE), and Downstream Processing (DSP) Experiments. Note that the latter two are based on the Conceptual Designs. The IA manufacturing process is mainly constituted by Upstream Processing (USP), in which the feedstock is pre-treated and the fermentation medium or hydrolysate is prepared. This medium is then aerobically fermented by a genetically modified Aspergillus niger fungal strain. The resulting broth contains water, IA, fungal biomass and feedstock impurities. The produced IA is then purified via DSP.

A Biorefinery Conceptual Design producing 10,000 tonnes/year of IA has been performed for Sugar Beet Molasses, Sugar Beet and Green Pellets. The Conceptual Design for the Chemically Defined Medium was only performed until the project's basis of design (BOD) stage, since preliminary economic results revealed that it was not an economically feasible feedstock for IA large-scale manufacturing.

The main results obtained from the Techno-Economic Evaluation are net present value for a ten- year plant running life and the corresponding scenario and sensitivity analyses. Various conclusions were extracted which can be obtained on request.

Company: Broshuis BV
Project: Improving the steering system of trailers to reduce maintenance costs
PDEng trainee: Hendrik Spoelhof, program Twente - Maintenance

Maintenance

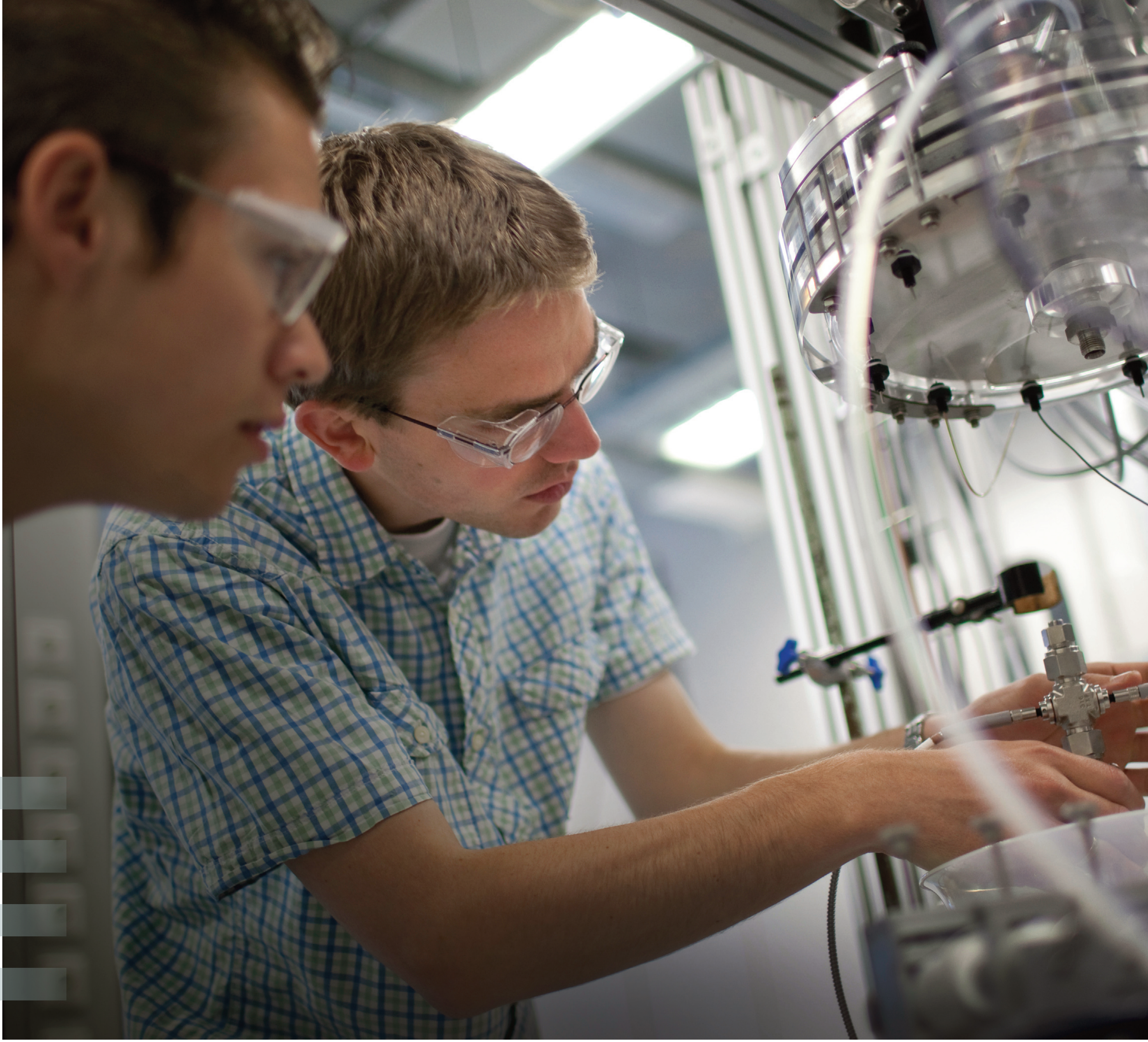
Broshuis BV is a well-respected manufacturer of trailers for heavy and special transport. In this field of transportation the challenge is to use every trailer for moving both heavy and large size goods. Related to the current trend of replacing fossil power plants by for instance wind turbines, one can think of the blades, the tower sections and the top section which is housing the generator. The sector therefore demands trailers that can be used both effectively and efficiently.

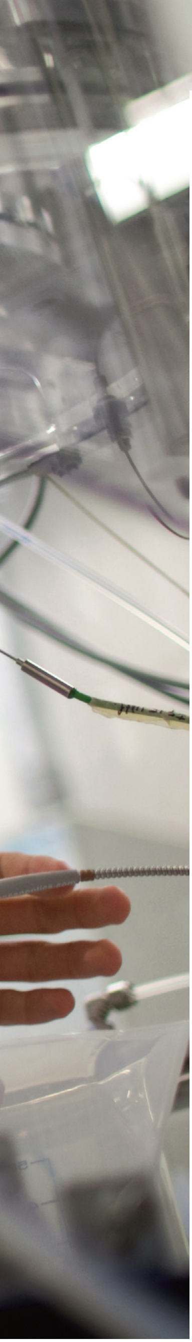
The solution is found in trailers with a low loading floor, multiple axles of which most are steered and an extendable chassis. Due to regulations, the steering of the axles is achieved by a hydraulic-mechanical system. This system does not change when the chassis is extended, both enhancing reliability and preserving ease of operation.

In recent years, the industry has adopted independent suspension systems as higher axle load are allowed for trailers with such a suspension system. By upgrading the classical steering system to better suit the independent suspension system, such trailers show improved steering performance. However, due to the higher axle loads, higher lateral forces occur. This causes the mileage of the tires and lifetime of bearings to be similar to traditional trailers.

Maintenance on tires and bearings means downtime of the trailer, so this has to be decreased in order to achieve the desired increase in transport efficiency. The goal of the assignment is to further improve the steering system so that the maintenance costs and maintenance effort can be decreased.

To achieve this goal the behavior of the trailer during transport is investigated. First, the influence of vertical movement of the suspension is analyzed. Second, cornering at various speeds is analyzed and how this is influenced when the chassis of the trailer is extended. Recently trailers with an upgraded steering system addressing the first part have been delivered to the customers. Currently the second part is being addressed using vehicle dynamics and the design improvements are being created.

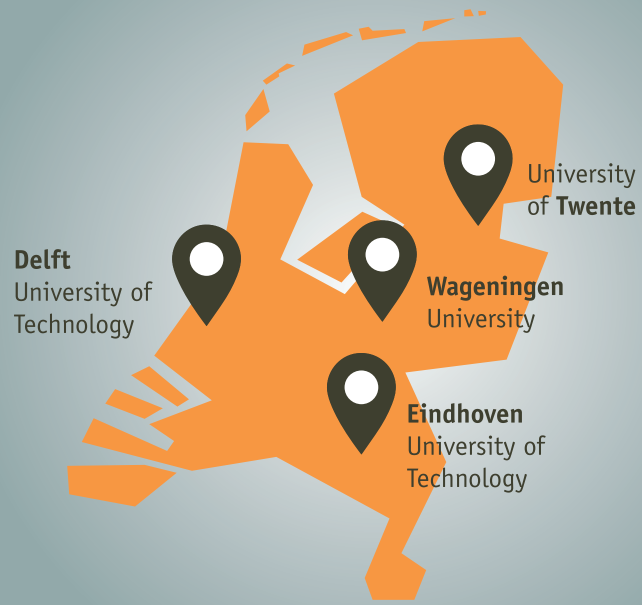




The Professional Doctorate in Engineering (PDEng) programmes in brief

Programme	Founded	Graduates 1988-2018	Location
Industrial Engineering*	1988	361	TU/e
Design of Electrical Engineering Systems (Track Information & Communication Technologie, Track Healthcare Systems Design)	1988	264	TU/e
Process and Product Design	1989	458	TU/e
Software Technology	1990	457	TU/e
Design and Technology of Instrumentation*	1991	173	TU/e
Process and Equipment Design	1991	206	TUD
Bioprocess Engineering	1994	146	TUD
User System Interaction	1998	330	TU/e
Automotive Systems Design	2011	64	TU/e
Smart Buildings & Cities**	2011	35	TU/e
Energy & Process Technology	2011	19	UT
Robotics	2011	11	UT
Civil Engineering	2011	17	UT
Clinical Informatics	2012	65	TU/e
Chemical Product Design	2012	23	TUD
Maintenance	2014	9	UT
Qualified Medical Engineer	2014	17	TU/e
Data Science	2016	9	TU/e

** These programmes are being built down. The current trainees will be supported during their finalisation of the programme in order to receive the PDEng degree. / ** Before Smart Energy Buildings & Cities*



The 4TU.School for Technological Design, Stan Ackermans Institute offers two-year post-master technological designer programmes.

The institute is a joint initiative of the four universities of technology in the Netherlands: Delft University of Technology, Eindhoven University of Technology, University of Twente and Wageningen University.

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