# Research Review
# Mechanical Engineering
# University of Twente

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# Report on the research assessment of Mechanical Engineering at the University of Twente

**Contents**

# Preface

The report summarizes the results of the Research Review Mechanical Engineering of ten research programmes of the Department of Mechanical Engineering belonging to the Faculty of Engineering Technology of the University of Twente. The review covers the research carried out in the period 2007-2012.

The Committee appreciated the thorough self-assessments provided for the Department itself and for each programme, which contained valuable information and formed a very useful basis for an objective evaluation procedure. The Committee acknowledges the openness of the management, Programme Directors and PhD-students during the interviews and the constructive atmosphere of the discussions during the site visit. All representatives shared their opinions and concerns in a very open manner. The Committee hopes that the feedback provided in this report will be used wisely in the quality assurance procedures of the Faculty and University.

As Chair of the Committee I wish to thank the Committee members for their valuable contributions, for the time spent for this assessment and for the fruitful discussions in the Committee. Last but not least, the Committee wishes to thank Annemarie Venemans, the Committee's Secretary, for her assistance, enthusiasm, patience and wise counsel in the preparation of the visits, and in the completion of the final report.

Prof. Bernhard A. Schrefler
Chairman of the Committee

# 1. The review committee and the review procedures

### Scope of the assessment

The Review Committee was asked to perform an assessment of the research in Mechanical Engineering at the University of Twente. This assessment covers the research in the period 2007-2012. In accordance with the Standard Evaluation Protocol 2009-2015 for Research Assessment in the Netherlands (SEP), the Committee's tasks were to assess the quality of the institute and the research programmes on the basis of the information provided by the institute and through interviews with the management and the research leaders, and to advise how this quality might be improved.

### Composition of the Committee

The composition of the Committee was as follows:

- Prof. B.A. (Bernhard) Schrefler (chair) em., Center for Mechanics of Biological Materials, University of Padova, Italy;
- Prof. P. (Paul) Van Houtte, Faculty of Engineering Sciences, KU Leuven, Belgium;
- Prof. A.E. (Erman) Tekkaya, Institut für Umformtechnik und Leichtbau, Technical University Dortmund, Germany;
- Prof. A.M. (Alexander) Taylor, Dept. of Mechanical Engineering, Imperial College London, UK;
- Prof. E. (Erik) Dick, Department of Flow, Heat and Combustion Mechanics, Ghent University, Belgium;
- Prof. F. (Frank) Allgöwer, Institute for Systems Theory and Automatic Control, University of Stuttgart, Germany;
- Prof. W.A. (Wolfgang) Wall, Institute for Computational Mechanics, Technical University München, Germany;

A profile of the Committee members is included in Appendix A.

Dr. Annemarie Venemans was appointed secretary to the Committee by QANU (Quality Assurance Netherlands Universities).

### Independence

All members of the Committee signed a statement of independence to safeguard that they would assess the quality of Mechanical Engineering and its research programme in an unbiased and independent way. Any existing personal or professional relationships between Committee members and the programme under review were reported and discussed in the Committee meeting. The Committee concluded that there were no unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

## Data provided to the Committee

The Committee received the following detailed documentation:

- Self-evaluation report of the unit under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices;
- Copies of key publications of the research programme;
- Bibliometric study (CWTS citation report) of all research groups.

The Committee was asked to evaluate a large number of research programmes with a limited amount of time being available during the site visit. The intensity of the site visit was high, and though all Committee members as well as members of the UTwente staff were highly committed, the Committee is of the opinion that at certain moments more time would have been beneficial to the assessment process. Nevertheless, the Committee considers that it has obtained a good view of the work of all programmes and was able to assess them fairly.

## Procedures followed by the Committee

The Committee proceeded according to the Standard Evaluation Protocol 2009-2015 (SEP). Before the first Committee meeting on 13 May 2014, all Committee members independently formulated a preliminary assessment of the programme. The final assessments were based on the documentation provided by Mechanical Engineering, the key publications and the interviews with the management and with the leaders and researchers of the programmes. The interviews took place on 15 and 16 May 2014 (see the schedule in Appendix 3) in Enschede. In the same week, the majority of the Committee members also evaluated the Mechanical Engineering research programmes at the Eindhoven University of Technology. For this evaluation a separate report was produced.

Prior to the interviews, the Committee was briefed by QANU about research assessment according to SEP, and it discussed the preliminary assessments and decided upon a number of comments and questions. It also agreed upon procedural matters and aspects of the assessment. After the interviews it discussed the scores and comments. The final version was presented to Mechanical Engineering for factual corrections and comments. The comments were discussed by the Committee. The final report was printed after formal acceptance.

The Committee used the rating system of the Standard Evaluation Protocol 2009-2015 (SEP). The meaning of the scores is described in Appendix 2. A note of caution is in order when reading the evaluation: The SEP uses a five-point scale scoring system, which might raise the impression that a ranking is possible between the different programmes based on the scores. The Committee came to the conclusion that such a ranking is not possible because the programmes come from very different disciplines, each having a research and publication culture of its own. Nor can the scores be interpreted as a ranking of the programme with respect to other programmes in the same field; sufficient information about other programmes was not available to the Committee for such a ranking. The Committee decided that the scores should be interpreted according to the description of the meaning of the five numerical scores, which can be found in Appendix B of this report. However, it would like to point out that in using the five-point scale, it took into consideration the difference between the description in Appendix B and the actual impact of each of the points.

Technical disciplines, like Mechanical Engineering, are often societal relevant by nature. The Committee considers the quality of the research very important in order to be societal

relevant and have an impact. Furthermore, it took into consideration the strategy used to increase the impact and societal relevance of the research.

# 2. Research review of Mechanical Engineering

## 2A. Institute level

The Department of Mechanical Engineering is part of the Faculty of Engineering Technology (in Dutch 'Construerende Technische Wetenschappen' or CTW) – together with the Departments of Industrial Design Engineering and Civil Engineering & Management – and is responsible for the corresponding BSc and MSc programmes. The Faculty is also responsible for the 3TU MSc programme in Sustainable Energy Technology. The Faculty of Engineering Technology is one of the six faculties of the University of Twente.

The Faculty is organized through a matrix: the departments conduct the educational programmes cooperatively and participate in interdisciplinary research projects, programmes and the following research institutes: MIRA, CTIT, MESA+, GEI, IBR and IGS.

The Head of the Faculty is the Dean who represents the Faculty in the University Management Team, and is responsible for all strategic, organisational, financial and personnel affairs concerning the Faculty. The Dean also heads the Department of Mechanical Engineering. He chairs the Disciplinary Science Council of this Department, in which the Department's research strategy is discussed. The members of this Council are the full professors and programme leaders of the Department of Mechanical Engineering plus the Departmental Director of Education.

The Department of Mechanical Engineering is divided into the following programmes:

- Applied Mechanics (AM)
- Biomechanical Engineering (BE)
- Design Engineering (DE)
- Engineering Fluid Dynamics (EFD)
- Elastomer Technology & Engineering (ETE)
- Mechanical Automation & Control (MAC)
- Multi-Scale Mechanics (MSM)
- Production Technology (PT)
- Surface Technology & Tribology (SST)
- Thermal Engineering (TE)

The vision of the Department is to be a leading international centre for science-based mechanical engineering. Its mission is to initiate, design and develop technical solutions for the societal problems of today or tomorrow. These technical solutions are found at the crossroads of production, design, materials and energy and these form the four cornerstones of Mechanical Engineering at the University of Twente.

*Assessment/remarks*
The Committee noted with approval the substantial progress made since the previous evaluation period, but finds the programme quite ambitious in its broad range of research themes and approaches. The Department's vision is rather general, and further steps have to be taken to put it into practice.

The Committee is of the opinion that the four cornerstones (production, design, materials and energy) are more teaching-oriented than research-oriented. With regard to research, the structure of the programmes is rather diffuse and should be more focused: for instance, the Production Technology programme is not really concerned with production technology, Mechanical Automation & Control does mainly manufacturing, and Design Engineering has moved away from manufacturing. To fully exploit the positive trend in the renewed interest of the University of Twente in Engineering, a strategic board should be appointed with outsiders, mainly appropriate people from academia but also including industry representatives, to choose new chairs in line with the general aims of the Faculty. This would allow more freedom in the choice of the potential winners.

The Committee is of the opinion that "Design", including "Manufacturing" but with more emphasis on applied research, could form the basis of a characteristic distinguishing the University of Twente with respect to TU/Eindhoven, which is rather strong in fundamental engineering science.

**Quality and academic reputation**

The research staff of the ME Department published about twice as many papers compared with the previous period, as can be seen in the bibliometric study carried out by CWTS. This is in accordance with the developments in the number of projects and temporary researchers. ME scores above average in the MNCS and MNJS top 10% indicators. The Department aims to seek a healthy balance between conference papers and journal publications. ME scores high in areas that are outside the citation index and publishes in journals with a society and engineering focus as well as conference papers. Also, much research is disseminated through conferences, which is a major platform to share knowledge with industry (science-based engineering).

*Assessment/remarks*
The Committee is of the opinion that a characteristic profile of ME at the University of Twente is lacking. The Faculty is very well known for education, which appears to be its main focus. However, the teaching load in some programmes is much above the average that necessitates cut-downs in research activities. Industrially focussed applied research is considered to be a successful perspective for the Department of Mechanical Engineering. Clearly recognizable fundamental research foci will boost the international visibility of the Department. Based on the citation study, approximately one-half of the research programmes performs better than the world average for Mechanical Engineering. Also, for the entire Department the average value of MNCS is above world average during the period of evaluation, but is steadily descending during the same period. Also the Pptop 10% is declining from the subperiod 2004 - 2007 on. The Committee is of the opinion that there is room for improvement.

The Committee finds that the teaching load is unevenly distributed between programmes. As most researchers did not know how much they teach, the Committee suggests organising a formal allocation system.

**Resources**
Table 1 shows the total number of staff of the ME Department. From 2007 to 2012, the number of fte almost doubled. During this period, there was an increase in the tenured staff fte, non-tenured staff fte and PhD student fte of 62%, 452% and 22%, respectively. The total increase in research staff was 89%.

Table 1 Staff embedded in the ME Department

| | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **fte** | **N** | **fte** | **N** | **fte** | **N** | **fte** | **N** | **fte** | **N** | **fte** |
| Tenured staff | 59 | 17.81 | 73 | 19.72 | 77 | 21.67 | 85 | 23.57 | 88 | 25.17 | 93 | 26.85 |
| Non-tenured staff | 16 | 4.93 | 22 | 7.59 | 42 | 14.17 | 44 | 18.74 | 47 | 19.60 | 63 | 27.19 |
| PhD-students | 93 | 58.01 | 99 | 55.54 | 128 | 68.73 | 136 | 81.49 | 156 | 88.29 | 155 | 98.87 |
| *Total research staff* | *168* | *80.75* | *194* | *82.85* | *247* | *104.57* | *265* | *123.80* | *291* | *133.06* | *311* | *152.91* |
| Supporting staff | 33 | 24.16 | 31 | 23.75 | 37 | 26.72 | 38 | 29.87 | 38 | 31.41 | 39 | 30.45 |
| Visiting fellows | 3 | 0.7 | 4 | 1.97 | 4 | 2.13 | 6 | 2.00 | 9 | 3.59 | 2 | 1.00 |

Table 2 shows an increase in external funding of 162%, from €4,465,000 in 2007 to €11,678,000 in 2012, while maintaining direct funding as well as research grants. This adds up to a total income of €21,674,000 in 2012.

Table 2 Funding of the staff embedded in the ME Department

| | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **k€** | **%** | **k€** | **%** | **k€** | **%** | **k€** | **%** | **k€** | **%** | **k€** | **%** |
| Direct funding (1) | 8918 | 62 | 9790 | 60 | 10,062 | 55 | 9885 | 47 | 9578 | 45 | 9000 | 41 |
| Research grants (2) | 1109 | 8 | 567 | 3 | 893 | 5 | 1118 | 5 | 1694 | 8 | 1355 | 6 |
| Contract research (3) | 4465 | 31 | 5934 | 36 | 7263 | 40 | 9897 | 47 | 9897 | 47 | 11,678 | 53 |
| *Total funding* | *14,493* | *100* | *16,291* | *100* | *18,218* | *100* | *20,813* | *100* | *20,169* | *100* | *21,674* | *100* |

Note 1: Direct funding includes both the research funding, obtained directly from the University, and the financial compensation for educational efforts.
Note 2: Research grants come from the national science foundations (NWO, STW).
Note 3: Contract research includes funding from agencies of Dutch ministries (Agentschap.nl, M2I), EU projects and projects directly sponsored by industrial partners.

*Assessment/remarks*
The Committee is of the opinion that the increase in staff and PhD students in the period under scrutiny is remarkable. There are extremely good links to industry, which is a substantial source of funding. During the interviews, the Committee noted that some programmes did not focus on research grants, the reason being that the programmes lose money on those funds. In the Committee's opinion, it is essential to invest in competing for research grants in order to remain scientifically visible. This problem has to be considered at the University level and solutions must be worked out.

Productivity
The self-evaluation report provides information on the number and type of output of the Department's researchers (Table 3). The number of refereed articles grew steadily from 93 in 2007 to 163 in 2012, which is an increase of 75%. Publications in conference papers show a comparable growth. The number of PhD theses produced in the period was stable at an average of 18 per year. Some research reports are not included in the table because they contained confidential information, particularly in the case of contract research. The total output in academic publications of the Department shows an increase of 62% in the period 2007-2012. Per tenured research fte, the production of the ME Department increased by 16% for refereed journal publications.

Table 3: Main categories of research output in the ME Department

| | | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| Academic publications | Refereed articles | 93 | 139 | 148 | 142 | 144 | 163 |
| | Non-refereed articles | 0 | 5 | 0 | 3 | 7 | 3 |
| | Conference papers | 120 | 138 | 127 | 162 | 173 | 197 |
| | PhD theses | 19 | 18 | 20 | 23 | 12 | 16 |
| | Books | 0 | 1 | 0 | 1 | 2 | 0 |
| | Book chapters | 11 | 13 | 8 | 7 | 6 | 15 |
| *Total academic publications* | | *243* | *314* | *303* | *338* | *344* | *394* |
| Professional publications | | 14 | 35 | 26 | 16 | 13 | 16 |
| Editorships (books) | | 1 | 7 | 4 | 2 | 4 | 1 |
| Editorships (journals) | | 22 | 26 | 33 | 34 | 39 | 47 |
| Patents | | 3 | 2 | 7 | 3 | 4 | 7 |
| Prizes | | 3 | 5 | 8 | 9 | 9 | 9 |

*Assessment*
The Committee approves the growth in refereed articles in the period from 2007 to 2012, but is somewhat concerned with the stable number of PhD theses produced each year, which is at odds with the rising number of PhD students. It is of the opinion that the Department's academic reputation can be improved further by raising the number of graduating PhD candidates and by increasing the number of publications in high-impact journals. In some programmes a healthier balance between conference papers and journal papers should be targeted. While conference presentations and papers are extremely important for the early dissemination of results and visibility, journal papers have archival value and allow a more rigorous evaluation of the scientific level of the research. Conference papers do not exclude the subsequent publication of journal papers, e.g. by clustering some presentations together and deepening some aspects. The Committee believes that appropriate, international, peer-reviewed journals exist for all fields of activity of the Department.

The increasing number of patents (that are the most rigorously reviewed works) over the last 3 years is a strong sign of technological excellence and the Committee encourages this trend.

**Societal relevance**

The contribution to society takes place through the research projects. The best indicator of the societal quality of the research of the ME Department is the large proportion of external funding (53%). The number of spin-offs can also be seen as a measure of the societal impact of the work. During the period 2007-2012, more than 50 spin-off companies were started that are based on research carried out by the Faculty.

*Assessment/remarks*
The Committee is pleased to note that the programmes of the ME Department at the University of Twente place great emphasis on national and international societal relevance. It is of the opinion that the Department gives the impression of specialising in applied research for the industrial problems of today. It is positively impressed by the extremely good links of the Faculty to industry.

However, an area of concern is the apparently weaker focus on fundamental disciplines. The Committee recognizes that the involvement in industrial projects bears merits and contributes to the funding, since public resources have been reduced. To stay at the top, however, the Department should strengthen the fundamental aspects, which underpin their more applied research.

**Strategy for the future**

The ME strategy for the future includes three major points:

- Establishing a national and international centre for science-based engineering;
- Developing specialisations based on the needs of society;
- Further strengthening of internal and external linkages.

*Assessment/remarks*
The Committee is of the opinion that the Department currently does not have a clearly defined image. "Maintenance" appears to be a new focal point. On the other hand, design seems to be the de facto focus. Maintenance or design could be good choices, but appropriate steps in these directions have to be taken. The Department should target appropriate research to obtain a competitive advantage.

A strategic vision is necessary on how to appoint new professors, to be discussed at the Department level. The new appointments should reflect the new focus. The Committee strongly recommends avoiding replacing professors who retire with professors from the same field. It suggests searching for active professors who suit the new focus. It recommends consulting an external advisory board. Industry players should also be involved in this process.

The Committee is of the opinion that clustering of the programmes has to be carried out in line with the focus. A profile within the clusters should be defined, and the programmes should be merged to reach critical mass. There is overlap with other groups (electrical and chemical engineering), which should be taken into account.

The strategy for research groups to become a member of a research institute should be pursued actively, taking into account the positive disposition of the University toward Engineering. It is disappointing that only two groups - Biomechanical Engineering and Multi-Scale Mechanics - are included in one of the new University of Twente Institutes.

The Department should improve its networking with other departments and groups at the University of Twente. Several programmes in this Department struggle, while there are people at the University in closely related fields who have prominent international recognition.

The Department has an excellent perspective concentrating on applied research. However, clear foci have to be set for this. For instance, the emphasis on applied advanced research for the industry of today and tomorrow could be a smart strategy.

**PhD training and supervision**

In 2012, the staff supervised 155 PhD students. Within the evaluation period, the performance of the PhD students improved; fewer students discontinued PhD projects recently (24% and 33% in 2001 and 2002, respectively, compared with 7% and 6% in the last two years). The number of female PhD students has doubled over the years.

In all research groups, supervision is organised in a similar way. Each PhD student has a tenured staff member as his or her daily supervisor. PhD students have regular meetings with their supervisor and advisor to discuss their progress and planning. PhD research projects are

more formally evaluated after the first year. If the progress or level is not satisfactory, this leads to a no-go decision for continuation on the PhD track. The target for each PhD student is to publish at least three refereed journal papers.

*Assessment/remarks*
The Committee spoke to a very enthusiastic group of PhD students. Their attitude reflects well on the general culture of the institute. They are very satisfied with the guidance they get from the institute and their supervisors. The Committee learned that all PhD candidates are sponsored externally.

In the near future, most ME PhD students will be housed in the Twente Graduate School. The Committee applauds the start of this Graduate School.

The Committee learned that it was difficult to attract international Master students, from which to draw future PhD students. It thinks that the internationalisation of the Master's programme should be improved to strengthen the PhD programme.

## 2.B.1 Programme: Applied Mechanics

Programme leader: Prof. André de Boer
Research staff 2012: 16.93 fte

| | | |
|---|---|---|
| Assessments: | Quality: | 4 |
| | Productivity: | 4 |
| | Relevance: | 4 |
| | Viability: | 4 |

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The mission of the Applied Mechanics programme is to carry out a systematic long-term research programme on selected schemes and to effectively integrate scientific research, education and engineering, by involving scientific staff, junior staff and industry. It conducts both numerical and experimental work in the wide field of solid mechanics. There are three sections: Structural Dynamics & Acoustics, Nonlinear Solid Mechanics, and Dynamics Based Maintenance.

This programme is the result of a restructuring after the last assessment, when the separate programmes of Structural Dynamics and Acoustics and of Mechanics of Forming Technology were merged. The head of the first programme stayed the same, while the head of the Forming Technology programme retired and was replaced by the current programme leader. The programme has also been given the broader mission of Nonlinear Solid Mechanics. It consists of 2.22 fte tenured staff, 3.81 fte non-tenured staff and 10.90 fte PhD students.

### Quality

The quality of the programme is varying between good and excellent. The Forming Technology part is high quality and has a very good international visibility and recognition. This was established by the former head of the programme, an internationally renowned researcher. The new programme leader was able to keep the quality and international visibility. In other sections, both quality and international visibility are clearly lower. This is reflected in the publications – not only in numbers but especially in the quality of the papers (i.e. journal quality and citations). Similar statements were made in the previous assessment report, and it is evident that the programme took the recommendations and criticism seriously and worked on improving the situation. The numbers and quality are much better now, though there is room for further improvement for some sections to achieve excellence.

### Productivity

Since the previous assessment, the number of publications has increased substantially and now is at an overall very good level. Similarly to the remarks concerning quality, the Committee observes differences between the sections of the programme.

The programme has shown to be able to acquire high amounts of funding via contract research and from industry. Research grants, however, are still lacking and, for example, no individual grants (like the Veni, Vidi, Vici or similar) were awarded. The committee is very positive regarding the contract funding the programme obtains, but would like to see a more balanced funding with first and second stream.

**Relevance**

Several topics are of great importance and the programme connects well with industry and from this source provides specific support. It is also important to note that three spin-offs were created within only the last assessment period, which is rather impressive. The Committee hopes for their long-term success, because this is also highly relevant to society.

**Viability**

The programme has good expertise in several fields and good connections to a variety of industrial partners and is embedded in bigger consortia. It obviously has a good inflow of students. These aspects are very positive with respect to viability. On the other hand, both a clear strategy and clear focus areas are missing, which might be problematic in the long run. The programme is advised to formulate a strategy and focus in order to continue its present upward direction.

**Conclusion**

The programme improved in several aspects since the last assessment. Still, the programme suffers from not having clear focus areas, where it has a unique and internationally visible expertise. A first step to achieve this is a clear vision and focus of the programme members. The majority of projects are "work for hire" type projects, which not necessarily promote scientific excellence on the long term.

The Forming Technology part has maintained its high level despite the fact that the former programme leader retired, and it is still considered the strongest subarea of the overall programme. Unfortunately, the transition to the new name of this sector, namely Nonlinear Solid Mechanics, has not yet happened. The planned addition of the sub programme on Biomechanics is still at the beginning, and the ideas presented during the interview were not at all convincing. The programme needs to clearly identify a topic where it has special expertise or a unique selling point and not just add this topic because it is en vogue at the moment.

## 2.B.2 Programme: Biomechanical Engineering

Programme leader: Prof. Bart Koopman
Research staff 2012: 26.32 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 4.5 |
| | Productivity: | 4 |
| | Relevance: | 5 |
| | Viability: | 4 |

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The programme's research focuses on the interaction between the human locomotor system and the various medical devices that support it. On the one hand, humans will adapt to the properties and functioning of the medical device, by (re)learning movements and by structural adaptation to the loading situation (e.g. bone remodelling, cell growth and cell differentiation). On the other hand, with the proper sensory information and control systems, medical devices must to be optimised to the immediate requirements and wishes of the user. Fundamental knowledge gained of the human locomotor system and its interaction with medical devices is used in the development of innovative medical devices. Examples of medical devices that have been developed are rehabilitation robotics for the lower and upper extremities, diagnostic robots for (impaired) motor control, endo- and exo-prostheses, and wearable exoskeletons. The effectiveness of these devices is tested in clinical practice and with industrial partners.

### Quality

The achievements of this programme in the Movement Mechanics area are very good. A series of biomechanical devices have been developed together with bigger consortia: Mindwalker (a mind-controlled wearable exoskeleton); TLEMsafe (an aid to musculoskeletal surgery using a patient-specific navigation system); Lopes (rehabilitation robotics to support and enhance the neuro-rehabilitation of gait for chronic stroke survivors and spinal cord injury patients); Flextension (particular type of an adaptive arm orthosis); Balroom (prognosis and differential diagnoses of balance disorders in the elderly). Another indication of the academic quality is the fact that three of the staff members have obtained Veni grants from NWO. A few years ago, Nico Verdonschot was appointed a part-time professor in the programme; he was recently awarded an Advanced Research Grant by ERC, which certainly is a mark of his quality. Unfortunately, the research line on Tissue Mechanics lags behind quite a bit in terms of quality, although this is a well selected area with a lot of potential.

### Productivity

From 2007 to 2008, there has been a sharp increase of publications in refereed journals, stable at approximately that level since then. With 50 publications per year, the 11 tenured staff members and 23 PhD students (2011 and 2012) produced a very reasonable amount. The quality of the journals is also very good, although the staff members are unhappy that the impact factors of purely medical journals are much higher. The Committee acknowledges that doing research in multiple disciplines with different impact factors makes it difficult to assess the productivity merely on quantitative information.

The obtained research grants awarded are prestigious, but the total amount of earned budget (grants, contract research) could be higher.

**Relevance**

The majority of the projects of the programme are very multidisciplinary, with different medical and industrial partners. Patient organisations and charity funds are willing to co-finance part of the work, and the projects generally draw a lot of attention in the popular media. In addition, several projects resulted in spin-off products or companies. The Committee finds that its relevance to society is the best it can be, because the general public will always be fascinated by the results of this kind of work and the programme is using this in an excellent way.

**Viability**

The future should be bright for this programme. Staff members are relatively young and dynamic; society has a great interest in their work, as well as the students; the programme enjoys good collaboration with clinical partners; the programme has access to a large variety of experimental facilities. There is some concern among the staff about future collaboration with industry, however, because most of the large biomedical companies are established in other countries. The Committee advises the development of a strategy to deal with this issue. It will also be necessary to develop a clear strategy for the Tissue Mechanics research line in order to bring its viability up to a higher level.

**Conclusion**

This programme focuses on a topic of great interest to society and also allows academic work of high quality. The programme is dynamic and has received various types of academic recognition. It should continue to put effort into increasing its international visibility and recognition. Given all this, the number of PhD students could be higher, which would result in even more publications. The programme considers collaboration with industry to be a potential concern and should therefore formulate a strategy to deal with this issue.

**2.B.3 Programme:** **Design Engineering**
Programme leader: Prof. Fred van Houten
Research staff 2012: 20.78 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 4 |
| | Productivity: | 3.5 |
| | Relevance: | 5 |
| | Viability: | 4 |

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The Design Engineering programme aims to develop efficient methods and tools by studying design theory and practice to improve the design process, create better products and avoid unintended side effects. Its main contribution consists of new methods and tools for design synthesis, process planning and tool design, plus product life-cycle management, production and control. It focuses on the horizontal synthesis-based approach in design engineering rather than the vertical integration approach. Along with the mechanical engineering educational programme, it is also involved in the development and implementation of the Industrial Design Engineering programme, as well as several others. This extended educational portfolio necessitated adding various new research fields.

**Quality**

Some of the publications appear in the prestigious CIRP Annals (with the second highest impact factor in the Manufacturing and Design field in 2013) and some in other journals with lower impact factors. Due to the nature of the research field, the basic publication medium is conferences. Evaluation of the quality of these publications is explicitly performed at conferences by peers. Although the technological impact is very good to excellent, the scientific impact to the research field is not obvious in several cases. Despite the close link of the research field to industrial application, the Committee strongly believes that scientific impact can and should be increased.

The international reputation of the chair is outstanding in the manufacturing and design community. He led the International Academy of Production Engineering (CIRP) as its president, he is a member of the German Academy of Engineering Technology (acatech), and he holds the Gold Medal of the American Society of Manufacturing Engineers (SME). Other staff members also have a high international reputation. NWO Veni-Vidi-Vici grants or ERC grants would increase the quality of research. Sabbatical leaves of young staff for one-year-periods to research places in the States, Denmark, Japan or Switzerland might increase the scientific impact.

**Productivity**

Though the number of conference papers is the highest in the Mechanical Engineering Department at Twente University, the number of publications in internationally respected journals per fte is below expectations. The programme should look – with all respect to the success of the industrial impact – for a balance between the conference papers which are an important output category on the one hand and publications in international peer reviewed journals. The low number of international peer reviewed publications is partly attributed to the extremely high educational load. The number of completed PhD theses could also be improved. As a research field closely related to industry, the number of patents should be higher.

**Relevance**

The Design Engineering programme has the largest overall funding among all the programmes. In 2012 contract funding was 50% of total funding and comes basically from ministries, industry and the EU. This gives the research work of the programme a strong social and industrial relevance. Furthermore, the fact that this field is only served by this Design Engineering programme in the Netherlands makes its impact vital. Even in Europe, only a few research programmes cover some individual subjects of this programme. Hence, its unique status can have an impact on the other programmes at the University of Twente, opening them to interesting research opportunities.

**Viability**

The Design Engineering programme evolved from a hard-core manufacturing programme to a design programme containing innovative production units, such as additive manufacturing. The size of the programme has been driven up by teaching responsibilities rather than research, however. This has led to a strong diversification of subjects (11 formal sub-programmes with no critical mass). A consolidation of these sub-programmes would be a helpful basis for the strategic development decision framing the appointment of the successor of the very successful current chair in less than three years. This seems to be a unique opportunity also for the entire Mechanical Engineering Department, for which design and manufacturing could build an integrating thread.

**Conclusion**

The Design Engineering programme, with its strong lab facilities and excellent industrial contacts, could provide the nucleus for a distinguished profile for the University of Twente that could place the Department in a unique position. European industry needs strong manufacturing and design abilities more than ever, but especially the close interaction of both. The new visionary approach of manufacturing-based product design supported by life-cycle perspectives can open up new opportunities for the high-wage industry of Europe. This is currently not provided in an integral manner at European research sites and would allow the Mechanical Engineering Department at the University of Twente to achieve an outstanding unique position in research with a high social impact.

## 2.B.4 Programme: Engineering Fluid Dynamics

Programme leader: Prof. Harry Hoeijmakers
Research staff 2012: 9.81 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 4 |
| | Productivity: | 3.5 |
| | Relevance: | 3.5 |
| | Viability: | 3.5 |

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The mission of the Engineering Fluid Dynamics programme is to carry out scientific research in theoretical, numerical and experimental fluid dynamics, driven by applications in fields such as mechanical engineering, maritime engineering, aerospace engineering and process technology. In the assessment period (2007-2012), the average number of tenured staff members in the Engineering Fluid Dynamics programme was 2.02 fte, equivalent to 5.05 persons. There was 1 full-time full professor, two part-time full professors and 7 to 9 assistant/associate professors (not all full-time or not all present for the entire period). In addition to the tenured staff, there was on average 1.06 fte non-tenured staff (about 1.33 persons) and 5.47 fte PhD students (about 6.85 persons). The number of PhD students was almost constant during the review period.

### Quality

With respect to quality, the ratio of journal articles to the rest is very good with a Mean Normalised Citation Score (MNCS) of 1.04. About 36% of the journal publications are in top 25% journals. The choice of journals seems justified to the Committee. It includes some highly esteemed journals, producing an average journal score (MNJS) of 1.06. In principle, the citation score of the research programme is very good, but not excellent. The staff members are internationally visible due to editorships of international journals, invited presentations on conferences and participation to organisation of conferences. The leadership of the staff members on the national level is clearer, with some proven impact on the local industry.

### Productivity

The Engineering Fluid Dynamics programme has published 72 refereed journal articles in the review period of 6 years and 59 conference papers. There was also involvement in book chapters. The productivity in terms of numbers of refereed journal articles is acceptable, but also not high. It is about 2.37 per year and per tenured track person (72 publications in 6 years for 5.05 persons). One obvious reason is the rather low number of completed PhD theses, i.e. 14 for the review period of 6 years. This means about 0.46 per year and per person of tenured staff. A more typical number in a research programme is three PhD students per staff member, which means, theoretically, about 0.75 defended PhD theses per year and per staff member.

The Committee judges that not enough effort has been done to acquire sufficient funding with the objective to increase the number of PhD students. The research funding of the programme comes mainly from contract research, with a complete absence of research grants. Therefore, the Committee recommends that the programme make a greater effort to

acquire research grants. The educational load of the staff members is quite high, but not extreme (does not exceed 40% on average).

**Relevance**

The research topics covered by the programme are 1) fluid mechanics of turbomachinery (wind turbine aerodynamics, pump design, fan design, ice accretion and ice ingestion in aero-engines; 2) multi-phase flows with phase transition (cavitation and condensation); 3) flows in thin films (lubricant films in bearings); 4) computational fluid dynamics for analysis and design. The choice of the research topics is justified on the global scale and on the local scale of the Netherlands. A substantial part of the research is related to sustainability, which is of societal relevance. However, the Committee judges that the number of research topics is quite large relative to the size of the programme and that much greater relevance could be obtained with a better focus on certain research topics.

**Viability**

There is no clear strategic planning of the programme. Currently, it involves to an enumeration of the current research topics and the statement that they will be continued. During the review period, the part-time full professor on two-phase flows retired, but no new person was employed for that particular research field. The part-time full professor on aero-acoustics will retire in 2014. The self-evaluation report does not give details about his succession and just says that "his succession is to be considered". The programme leader will soon retire and, from the interview with him, the Committee understood that the procedure for recruiting of a new chair of the Engineering Fluid Dynamics programme had started, but no precise information was given. After the site visit and prior to finalisation of the report, information was given to the committee that a new chair is appointed, however, without any further clarification.

The Committee is convinced that, principally, the research field of Engineering Fluid Dynamics is viable, but that much more focus should be put on the research topics and more attention to continuity of research lines. It also stresses that some of the research activities are experimental, that the programme has quite unique facilities, but that maintaining the facilities requires a coherent plan of acquiring funding.

**Conclusion**

The Committee judges that with respect to productivity, the programme on Engineering Fluid Dynamics programme has worked in a suboptimal way during the review period. It recommends spending more effort on obtaining research funds and PhD students. It feels that the relevance of its research may be largely improved by a better focus of the research topics. These recommendations are basically the same as those formulated by the previous Committee (2008).

The previous Committee came to the conclusion that the Engineering Fluid Mechanics programme consisted of three main areas (rotating flow machinery, multiphase flows and aero-acoustics) with no interaction between them. Further, the Committee judged that the potential of the three sub-programmes was not fully exploited by lack of critical mass in the numerous research topics. A similar observation is done by the present Committee; there are no clear signs that show attention to the focus of the programme. The Committee emphasises the focus that is required for the future of the programme.

## 2.B.5 Programme: Elastomer Technology & Engineering

Programme leader: Prof. Jacques Noordermeer
Research staff 2012: 6.98 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 3.5 |
| | Productivity: | 4 |
| | Relevance: | 3.5 |
| | Viability: | 3.5 |

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Elastomer Technology and Engineering is a specialised niche within the very wide and diverse world of Polymer Science and Technology, of which the 'Science' is largely chemically focused and the 'Technology' is oriented more towards mechanics and application technology. This programme wants to position itself within the wider context of the Mechanical Engineering Department in the latter field. It therefore has the following sub-programmes:

- Mechanisms of Elastomer Reinforcement: particulate fillers, as well as continuous cords and short-cut fibres;
- Rubber Recycling and Reuse;
- Crosslinking Mechanisms.

**Quality**

It has to be noted that it seems that the programme leader has apparently retired: he seems not to have been be the Chair holder for the past one or two years, and his position has been reduced to 0.4 fte. This may partly explain the sharp reduction in the output of refereed articles from 2011 to 2012.

The Rubber or Elastomer Science and Technology programme is only a niche within the wider world of polymers. The research has focused on a few (nevertheless important) topics for a number of years: reducing rolling resistance of rubber tyres and development of recycling routes for rubber products (the number of worn tyres which are wasted each year in the world is absolutely staggering). This research programme is the first in having published on the reinforcement of natural rubber with silica for tyres. Industry in the Far East is highly interested in these achievements.

The scientific performance indices of the Web of Science are high for the programme leader when compared to those of materials scientists or scientists active in Mechanical Engineering; it would not be fair to compare these indices to those of scientists active in 'pure' chemistry, as chemical journals have a much higher impact factor than engineering journals.

So far, the programme has not developed formal collaborative projects with other chemistry groups at Dutch universities; however, there are occasional contacts each time there is a need for expertise available at other universities.

**Productivity**

There has been a reduction in the output of the number of refereed articles from 2011 to 2012: from 13 to 6, for three tenured staff members in both years, which represented 0.90 fte

in 2011 and 0.74 in 2012. Before 2012 the productivity numbers were very good, both in number of refereed articles and in number of conference papers and the committee noted that the number of published papers has increased again after the period of assessment.

At first sight, it seems that the research of the programme is mainly application-oriented; however, three of the key papers report on rather fundamental research that has been done on elastomers.

The programme raised a reasonable amount of contract research funding from industry (€519,000), which is approximately 50% of the programmes funding. Again, one has to bear in mind that it seems that the programme leader has apparently retired, which explains the current drop in productivity, however a successor has been appointed after the period of assessment.

**Relevance**

Tyres, their impact on energy consumption, and the difficulties related to their recycling are important problems and have been for many years. This is very relevant for society, as the total yearly amount of tyres made from non-recyclable rubber is dramatically high. This yearly pile spoils the environment world-wide. Most research is done in the laboratories of large, international companies. However, there are also some less 'bulky' and more modern applications of elastomers. A few examples are: membrane separation systems, conducting polymers, controlled drug release systems. The present programme has the potential to contribute to the scientific research in these fields. Besides, it is indeed able to acquire funding from industry. So it has a good position to find its niche in societal relevance with its work.

**Viability**

The programme does interesting work, in which the international tyre companies are interested. It attracts the interest of these companies as well as financial support from them. However, national industry and the public in the Netherlands are less interested. As a result of this, most PhD students are foreign and the building of a high quality programme in the Netherlands is therefore more difficult. The Committee recommends that the programme also looks for other modern topics to which to apply its scientific know-how, and which might interest Dutch society more. During the site visit some information was given about other research topics which – for unknown reasons - were not mentioned in the self-evaluation report.

**Conclusion**

This programme performs good research but is not very active in finding new research topics that would serve the new needs of modern society. Even for the research that they are doing, it is advisable that they should establish good scientific collaborations with some other Dutch research programmes specialised in polymer chemistry.

## 2.B.6 Programme: Mechanical Automation & Control

Programme leader: Dr. Ronald Aarts
Research staff 2012: 15.31 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 3 |
| | Productivity: | 3.5 |
| | Relevance: | 4 |
| | Viability: | 3 |

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The research in Mechanical Automation and Control (MAC) concerns the design and modelling of controlled mechanical systems and the development of laser material-processing techniques. MAC fosters the future of miniaturised and precise manufacturing techniques by means of a highly innovative combination of precision engineering, control and modelling in high-tech systems and materials. More specifically, for controlled mechanical systems, i.e. mechatronic systems, the focus is on high-performance systems that combine precision and speed, e.g. for production and analytical equipment. The main research on laser technology is on laser micro- and nano-material processing using ultra-short pulsed laser sources with pulse durations in the femto- and picosecond regime. The mission of the MAC programme is to advance the fundamental understanding of these systems and processes, to make modelling techniques (numerical) suitable for design optimisation and, in this way, enable innovations linked to industrial challenges and new applications.

In connection with the retirement of Ben Joncker in 2011, Claudio de Persis was appointed in 2009 with the idea to allow an early replacement and a smooth transition. However, de Persis left the University of Twente in 2011, and since then no successful appointment of a full professor has been possible for various reasons, all within the responsibility of the University and the Department. Dr. Ronald Aarts has been tasked with leading the programme in the interim. Considering the difficult situation and suboptimal setup, he must be complimented for having successfully taken over the lead of the programme and for having taken care of the substantial teaching responsibilities. But clearly, in such a difficult position, it is not possible to build up a strong, future-oriented research programme that is competitive on an international or even a national level. Again, considering the situation, Dr. Aarts has made the most of this.

### Quality

The programme has been undergoing a difficult period with a change in leadership in 2009 and no full professor in office since 2011. It is not surprising that the quality of the research is only competitive at the national level, as indicated by the number and impact of publications and by the academic reputation, as measured by the number and quality of awards, speaker invitations, editorships, etc. Also, the international connections of the programme are comparatively small when compared to other programmes led by one or more full professors. The breadth of the research activities is also limited, with a strong but successful focus on laser technology.

**Productivity**

Due to the full professor vacancy, the permanent staff of the programme is heavily burdened by a large teaching load. This immediately explains the comparatively reduced research output.

The amount of external funding is surprisingly high (€1,240,000 in 2012), but is mostly due to larger grants that will end at the latest by 2015. The industry funding is substantial, but competitive public grants are almost down to zero. It has to be noted, however, that under the current circumstances, Dr. Aarts's personal performance and productivity are substantial for an associate professor.

**Relevance**

With a strong industrial orientation and a focus on a few interesting research fields, the programme is well positioned with respect to relevance. At the moment, the connections within the Department and with other modelling, dynamics and control programmes at the University of Twente, and in the Netherlands, are under pressure.

**Viability**

For the time being this programme is in a difficult position that makes research contributions on an international level essentially impossible. The CWTS study clearly shows that the programme is below world average. Editorships are good, but in itself not sufficient to boost viability of the programme. The current permanent staff is doing a very good job and has to be complimented on dealing with this situation in a relatively good way. Limited human and physical resources, and especially the undecided future concerning the vacant full-professor position, do limit the prospects of the programme for the future.

**Conclusion**

For the programme, no future-directed planning is possible as long as the Department and University cannot decide on and implement plans for the future of the programme and the field of automation and control at the University of Twente. Control and automation could be important fields for a new strategic orientation of the Department. However, this strategy needs to be first developed and only then will it be possible to assess the benefits of this research domain for the Department. Depending on the chosen strategic orientation, consideration could be given to re-orienting the focus of this programme away from control and automation. The necessary teaching in dynamics, control and automation needs to be ensured, however, because it is an important part of any engineering study programme. It should be investigated whether the teaching demands can be realized, for example, by a tighter connection to the teaching activities in electrical engineering at the University of Twente.

## 2.B.7 Programme: Multi-scale Mechanics

Programme leader: Prof. Stefan Luding
Research staff 2012: 13.47 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 5 |
| | Productivity: | 4 |
| | Relevance: | 4.5 |
| | Viability: | 5 |

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The vision of the Multi-Scale Mechanics programme is to establish itself as a source of knowledge in the fields of fluids and solids, particles and their contacts, granular materials and powders, self-assembling and self-healing materials, micro- and nano-fluidics and biological systems. The common denominator is looking at processes where distinct characteristic scales are equally important and interact. In order to follow this vision, the programme is developing new methods and algorithms in the areas of statistical, continuum and micro/macro theories, applying them to interesting problems using high-performance computing expertise and enriching this with some experimental work. The programme was established in 2007, i.e. right at the beginning of the assessment period.

### Quality

The quality of the programme is excellent. The programme has very good publications in top level international journals in the field. The programme leader is very well recognized at an international level. This is confirmed by his h-factor, his board memberships and editorships, keynote lecture invitations as well as his involvement in international consortia. He was also able to obtain a Vici grant, which proves that he has a good reputation on the national level.

### Productivity

The productivity of the programme is very good, especially taking into account that this is a newly established programme. The publication numbers are solid over the years, showing an overall increase (from 3 refereed journals in 2007 to 21 in 2012), and research funding is also steadily increasing, with a significant part of funding coming from research grants. The number of PhD students shows a steady rise. It will be important now to target a consolidation of all these aspects: funding, high-quality publications and staff.

### Relevance

The programme is relevant in a number of aspects. Its specific and broad expertise allows it to tackle a number of quite different and relevant problems, such as particles suspended in fluids, molecular flow through nano-porous media, micro-structured materials and granular systems displaying both solid-like and fluid-like behaviour. The work is very important for a number of industries and it also connects well with other research programmes, contributing specific expertise. The programme works hard on some open source projects and directly supports the industrial as well as the scientific sector.

**Viability**

The viability of the programme is excellent. The programme has established itself in an impressive way already within the first few years of its existence. They have developed a good strategy for the programme and taken into account the local peculiarities. They have already established a number of collaborations, not only on the international level but also within the University of Twente, and are working to expand this. They have identified potential problems, like their limited involvement in undergraduate teaching and hence their lower visibility among students, and are taking steps to change this. When looking at how they managed challenges in the past, the Committee is optimistic that they will also solve these future challenges.

**Conclusion**

This is a very good programme that enjoys a high international visibility. It also works across disciplines and departments – something that is missing in many other programmes in the Department, and that is quite astonishing, seeing the huge potential that is available at the University of Twente. The Department should be congratulated for having added this programme and for hiring its programme leader. This success should also be seen as a motivation for the Department: developing a clear strategy, identifying the right topic and hiring the right person can lead to impressive success even within a few years. This programme impressively raised the overall quality of the Department.

## 2.B.8 Programme: Production Technology

Programme leader: Prof. Remko Akkerman
Research staff 2012: 13.21 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 3.5 |
| | Productivity: | 4 |
| | Relevance: | 4 |
| | Viability: | 4 |

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The topic of this programme is the study of 'Processing' and 'Product performance' of lightweight materials for structural applications. 'Lightweight materials' are defined as fibre-reinforced composite materials with a polymer matrix (thermoset or thermoplastic). In this programme, the focus is clearly on composites with thermoplastic matrices, because they can be recycled, and there may be some advantages with respect to processing. Research is certainly necessary, because without special efforts, these materials also present certain drawbacks compared to the more conventional thermoset-based composites. Analysis and modelling as well as an experimental approach are used to study processing and performance.

### Quality

As a whole, the number of citations of refereed journal publications (measured through Hirsch factors) is very good, but somewhat less than that of the world's top research groups on composites. The Committee also got the impression that the field of composites materials is only partially covered, not to mention other lightweight materials. A remark that can be made is that the name 'Production Technology' of a research programme within a Department on Mechanical Engineering would normally raise wider expectations than research mainly focused on composite materials. It is noteworthy that in June 2009, together with the companies Boeing, Ten Cate Advanced Composites and Fokker Aerostructures, the present research group founded the ThermoPlastic composite Research Centre (TPRC) at the University of Twente. The research facilities of the programme are of high quality, which is demonstrated by the fact that they are also used by researchers from other groups or from industry.

### Productivity

The number of refereed publications per tenured staff member is good. There are 15 PhD students for four tenured staff members (2 fte). Together they produced 12 articles in refereed journals in 2012 (after a dip to 5 in 2011), which is acceptable. The year 2012 was a good year for funding: €118,000 in research grants and €1,324,000 from contract research, plus €584,000 in research grants and €462,000 from industry funding for TPRC.

### Relevance

Industry collaborates well with the Production Technology programme. From a more general point of view, it must be stated that the replacement (as far as possible) of the currently popular thermoset-matrix composite materials by thermoplastic ones is of major importance, because the latter can be recycled (in contrast to the former). And this is precisely the long-term goal of this programme.

**Viability**

The research on the development of production processes to get fibre-reinforce thermoplastic composites with desirable properties is certainly important (because strategic in the worldwide effort to switch to recyclable composites), and also benefits from a certain effort of generic fundamental research on composites.

It is however felt that the programme focuses too much on a single industrial application (even though it is a very important one). Although this single focus is executed very well, it would be wise to add some other important industrial applications to the research portfolio.

**Conclusion**

This programme has managed to attract an important industrial research centre (TPRC) to Twente. This is a result of its research efforts on fibre-reinforced composites with a polymer matrix of the thermoplastic type. The academic quality (publication output in refereed journals, awards, etc.) is good. This group has positioned itself at the top of those doing research on thermoplastic composite materials..

## 2.B.9 Programme: Surface Technology & Tribology

Programme leader: Prof. Dik Schipper
Research staff 2012: 14.09 fte

| Assessments: | | |
|---|---|---|
| | Quality: | 3.5 |
| | Productivity: | 3.5 |
| | Relevance: | 4.5 |
| | Viability: | 3.5 |

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The Surface Technology & Tribology programme is concerned with the interaction of surfaces in contact in mechanical systems. Basically, two research areas are covered: Contact Mechanics and Surface/Interface Layers. The programme is primarily concerned with optimising friction, lubrication and wear. It particularly focuses on visco-elastic material behaviour. Elastic-plastic material behaviour is also considered, for instance for contact in metal forming. The three basic research themes are High Tech Systems & Energy, Health, and Reliability & Durability. The programme consists of 2.16 fte tenured staff, 1.11 fte non-tenured staff and 10.82 fte PhD students.

### Quality

The publications are mostly in recognized journals, except for a few journals such as "Key Engineering Materials" that are not on the SCI list and hence not reviewed at a high standard. The citations are above average for this field, but below the top groups. Research grants are virtually absent and this limits research on fundamental, self-selected, new subjects. Fundamental new research findings should be an area of attention. The best possibility to become be internationally prominent seems to lie in the research area on the tribology of human tissues. NWO Veni-Vidi-Vici grants or ERC grants could give a further stimulus to the programme. International recognition is demonstrated by the various editorial responsibilities of the leading researcher.

### Productivity

The number of publications per fte is average and could be improved. In the first three years of the evaluation period, not one PhD student graduated. The number of PhD students should be increased and their topics kept more uniform. The contract-based research is successful. The collaboration with other programmes is excellent. The successful method of completing a PhD based on publications should be accessed internally not only from the productivity point of view but also from the quality point of view.

### Relevance

The topic in general has a clear societal relevance. Friction and wear are two critical performance issues in almost all industrial applications. Therefore, this has to be a strong programme in the Mechanical Engineering Department. In this sense, the output of the research of the Surface Technology & Tribology Programme is almost excellent. The self-evaluation report covers some impressive examples of the impact of the research of this programme in for the Dutch railway system and the automobile industry. The recruitment of MSc students as pre-research staff is important for a solid basis of PhD candidates and must be the prime interest of the programme.

**Viability**

The programme has a clear subject field with well-defined sub-themes. Four strong researchers have joined the programme, and a boost in the research can be expected in the next period. Publicly funded research projects will still be necessary to allow the freedom to conduct novel, world-quality, fundamental research. This should also permit to raise the scientific output in these fields. Its internal visibility must be increased significantly to acquire more high-quality students. A research and funding strategy for the next years must be worked out.

**Conclusion**

The Surface Technology & Tribology programme has a high potential for cutting-edge research. Despite the moderate number of publications, most of them are in renowned journals. Utilizing more competitive public funding will increase its scientific output. Contract research with industry is important for its societal relevance and is a typical strength of the University of Twente. The collaboration with other programmes is exemplary and must be continued. Internal as well as external visibility should be improved.

## 2.B.10 Programme: Thermal Engineering

| | | |
|---|---|---|
| Programme leader: | Prof. T. Van der Meer (2007 – 2012), Prof. Gerrit Brem (2013 - …) | |
| Research staff 2012: | 16.04 fte | |
| Assessments: | Quality: | 4 |
| | Productivity: | 3.5 |
| | Relevance: | 4.5 |
| | Viability: | 4 |

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The Thermal Engineering programme works on the "Trias Energetica" (reduction of energy consumption, use of sustainable energy and using fossil fuel in a clean and efficient way). Within this context, the research has three primary themes, namely (i) thermo-chemical conversion of biomass into heat, power and fuels; (ii) unsteady and turbulent heat transfer in thermal processes and equipment; and (iii) unsteady combustion and thermo-acoustics. The research into these themes is both fundamental and applied and is pursued using mathematical modelling and as experiments. The programme contains secondary themes related to the water footprint of biomass, the production of solar fuels, and the Dutch gas infrastructure.

Within the primary themes, the programme pursues a multitude of "applied" projects, including liquid, gas and syngas combustion, turbulence; new materials for enhanced heat transfer; heat engines; bio-mass co-firing; superficial gasification; pyrolysis of biomass and use of biofuels. The lab facilities are well above average, and some are world-class or close to it. The team consists of two full professors, one associate professor and a further five tenured staff. It is to be noted and welcomed that there are two female members of staff.

**Quality**

The programme publishes in above average quality journals with a commendably large impact factor and has chosen to highlight its activity in the areas of (i) flash pyrolysis of biomass; (ii) combustion of biomass and waste; (iii) pulsed compression technology; (iv) thermo-acoustics; and (v) water footprint of biomass. Item (i) has produced three patents, resulted in an STW demonstrator project and the building of a pilot plant which has generated interest from industry; item (ii) allowed the programme to develop a new combustion concept which has resulted in a follow-up project fully financed by the Dutch Waste Association; (iii) is a new reactor concept which permits the production of syngas from methane; (iv) continues the traditional strength of this programme in this field; (v) has produced publications with a very high impact factor indeed.

It is gratifying, in the context of 'quality', to note that the reputation of the programme's output and of its members is reasonably strong. There have been major awards (TNO award; Dutch Gas industry prize; two awards for best MSc thesis), there have been invitations to speak at major conferences, and the TE programme's staff has been active in conference organisation, editorship and widespread membership of academies. Nevertheless, as noted below, the programme would do well to focus on, and increase, winning more competitive public funding to bolster and preferably increase the scientific underpinning. This is perhaps easier said than done: thermal engineering is – incorrectly – seen as a 'sunset' area by some and in particular National Funding bodies.

**Productivity**

The output in terms of the annual number of refereed articles has increased by 50 % over the period of the review: the average is about 7.67 per year for 8 tenured staff members, representing on average 2.06 fte, which is the equivalent of 5.43 physical persons. The number of conference papers is about a factor of 150 % higher. On average, there are about 1.41 refereed articles per physical tenured staff person. In 2012 this productivity had increased to about 1.75. This is still not a very high number, even taking into account the larger number of publication in conference proceedings. It should to be noted that the number of PhD students has sharply increased recently, as has the number of post-docs, and the target is to have a continuous population of 16 PhD students, producing, on average, about 12 refereed publications per year. So, the productivity has been suboptimal in the period of the review, but it probably will be much better in the near future.

In 2012, the programme raised €1.28 million in contract research funding from industry, representing 58% of the total funding. This is part of a desirable trend to increase the funds from valorisation and projects fully funded by industry. The programme almost doubled its total funding over the reporting period: that is a remarkable and welcome achievement. Taking 2012 into consideration, the programme did very well while the earlier years were less impressive.

**Relevance**

The subject matter of the TE programme, neatly summarised under the label of the "Trias Energetica", will be relevant in principle for a long time to come – especially given the ambitious, politically defined goals for renewable and biomass fuels. In practice, and as noted in the self-evaluation report, the TE programme has a 'long tradition of close cooperation with industry' – including the financial support for a part-time chair on the Thermal Conversion of Biomass and support from electricity and waste companies - and this is a direct, tangible expression of the relevance of its output. There is the possibility of a spin-off company in the field of biomass and there is support from the "Kennispark Twente". The collaboration with a wide range of burner and gas turbine industries is particularly close and notable in terms of the relevance of the TE programme. The interdisciplinary approach between the TE labs and the Department of Water Engineering and Management is to be encouraged particularly in the thermodynamic analysis of energy generation from biomass, which has a high 'water footprint' and which deserves further study.

An aspect of increasing importance is the need to engage with 'society' (e.g. local government, presentations on local television and radio, and so on). It is clear that the TE programme has made significant efforts in this direction, thereby demonstrating its relevance through an alternative channel, and this is all to the good.

**Viability**

The subject matter of the programme, namely Thermal Engineering, is likely to remain one of interest for the foreseeable future within the "Green Energy Initiative" of the University of Twente and the 'Top Sector' policy of the Dutch government, and overall funding for basic and applied research should remain adequate. However, the threat posed by the national government's reduction in funding for fundamental research in the field of energy is clear and is unlikely to dissipate in the next funding period, so steps must somehow be taken to continue an adequate level of basic research. The expansion since the previous evaluation in

2007 in terms of staff and number of PhD students and post-docs is evidence of the viability of the programme. The plans for the future – a new Biofuel test lab, a new PDEng programme in Energy and Process Technology – further bolster the impression of an energetic and expansionist frame of mind in the programme. Less expected aspects are the reported effects on the 'internal income flows' of the 'financial model' operated by the University of Twente, the decreasing contribution from the IMPACT research institute, and the important consequences due to the programme not being part of any of the research institutes of the University of Twente and thus totally dependent on external grants for PhD research. It is to be hoped that the success in covering the shortfall from the internal flows will continue to be compensated by extra income from contract research. The TE programme is aware of the high rental and maintenance costs of its well-equipped laboratory, and it is vital that the programme plan and set aside budget for the depreciation of this capital asset.

Although the increase in the number of students is evidence of its success and viability, there is a risk that the concomitant increase in the teaching load may restrict the time available for research or supervision of PhD students. In the context of the latter observation, the self-assessment notes that 'progress in some PhD projects is slow' and that, in common with many others, the TE programme finds that it is difficult to fill vacancies for PhD students with smart young researchers from the Netherlands and Europe. Although PhD completion rates are not yet an important metric and perhaps to some extent not completely controllable, the increasing demands on staff time from teaching and the possibility of recruiting future students of variable quality are constraints that the TE programme must consider carefully in the coming period. In common with other programmes in the Netherlands, the TE programme must re-double its efforts to make PhD positions attractive to its own undergraduate population.

**Conclusion**

The main action as a consequence of the previous review assessment was that "…the Committee suggests that an increase of basic research will be essential, as will be an increase of scientific output and academic reputation…". It seems that this was achieved, to the extent possible within the boundary conditions imposed by changes in the availability of funding for basic research.

This programme performs research in Thermal Engineering which is of internationally competitive quality; it is increasing its productivity to the levels expected nowadays and has already made an impact within its chosen research areas, which are likely to remain viable long-term topics that serve the needs of society. The tenured staff seems well-adapted to these research areas, with strong links to industry internationally and a good infrastructure, so that two of the major identifiable challenges that the TE programme faces are the familiar ones of declining budgets for fundamental research and the difficulty of recruiting smart PhD students – in slight contrast to its success in increasing the number of Master students. The third, and somewhat surprising, challenge that the TE programme faces is that associated with the 'internal' financial arrangements of the University of Twente. Fortunately, the strengths and the opportunities of the TE programme seem adequate to withstand the weaknesses and threats that it faces – but this will require the tenured staff to work harder just 'to stand still' in terms of quality, productivity, relevance and viability.

# Appendices

# Appendix 1: Curricula vitae of the committee members

**Frank Allgöwer** is Director of the Institute for Systems Theory and Automatic Control and full professor in Mechanical Engineering at the University of Stuttgart in Germany. His main interests in research and teaching are in the area of systems and control, with an emphasis on the development of new methods for the analysis and control of nonlinear systems, networks of systems and systems biology. He has received several recognitions for his work including an appointment as IFAC Fellow and IEEE CSS Distinguished Lecturer, the IFAC Outstanding Service Award, the state teaching award of the state of Baden-Württemberg, and the Leibniz Prize of the Deutsche Forschungsgemeinschaft. At present, he is serving as IEEE CSS Vice-President for Technical Activities and is President-elect of the International Federation of Automatic Control. He is editor of the journal *Automatica* and for the Springer Lecture Notes in Control and Information Science book series and serves as associate editor or on the editorial board of several more journals. He has been the organizer or co-organizer of more than a dozen international conferences and has published over 200 scientific articles. Since 2012 he has serves as a Vice-President of the German Research Foundation (DFG).

**Erik Dick** was born on December 10, 1950 in Torhout, Belgium. He obtained an MSc in Mechanical Engineering from Ghent University (Belgium) in 1973 and a PhD in Computational Fluid Dynamics from the same university in 1980. From 1973 to 1991, he worked at Ghent University as researcher, senior researcher and research leader in the turbomachinery division of the Department of Mechanical Engineering. He became Associate Professor of Thermal Turbomachines and Propulsion at the University of Liège (Belgium) in July 1991. He returned to Ghent University in September 1992 as associate professor and became full professor in 1995, where he teaches turbomachines and computational fluid dynamics. His area of research is computational methods, turbulence, and transition models for flow problems in mechanical engineering. He is author or co-author of 120 papers in international scientific journals and about 220 papers at international scientific conferences. He is the recipient of the 1990 Iwan Akerman award for fluid machinery of the Belgian National Science Foundation and of the 2002 Belgian Francqui Chair with a lecture series on simulation and modelling of complex flows at the University of Liège.

**Paul Van Houtte** (Antwerp, 1948) graduated in 1970 with a MSc in Mechanical Engineering from the Katholieke Universiteit Leuven (KULeuven), where he also obtained a PhD in Metallurgy (1975). Since 1972, he has worked as a scientist at the Department of Metallurgy and Materials Engineering of the KULeuven. He became full professor in 1995. From 1996 until 2004, he was Chairman of the Department. Since 2008, he has been the Chairman of the Commission on Scientific Integrity of the KULeuven. He became Emeritus Professor on 1 January 2013. He is well known for his work in the fields of crystallographic textures of materials, residual stresses and plasticity theory. He is author or co-author of about 200 papers in scientific peer-reviewed journals and of about the same number of papers in the proceedings of international scientific conferences. In 2004 he was elected a Fellow of the Institute of Physics in London. In 2013, the Société Française de Métaux et Matériaux awarded him the Sainte Claire-Deville Medal. In 2014, he received the "Khan International Medal" at "Plasticity 2014" in Freeport, Bahamas. He also holds some positions outside the KULeuven: in 2008, he was elected Chairman of the International Committee of ICOTOM (the main series of international conferences on Textures of Materials), and recently, he was elected as the Governor of the Class of Natural Sciences of the Royal Flemish Academy of Sciences and Arts of Belgium (2014-).

**Bernhard A. Schrefler** (chair) holds a ME degree in Structural Engineering from the University of Padua (summa cum laude), a PhD and DSc from Swansea University, Wales. He is Secretary General of the International Center for Mechanical Sciences (CISM) in Udine, Professor Emeritus of Structural Mechanics at the University of Padua, and Senior Affiliate Member of the Department of Nanomedicine of the Houston Methodist Research Institute, TX. For his research work Dr. Schrefler has been awarded the Maurice A. Biot Medal from ASCE, the Euler Medal from ECOMAS, the Olgierd C. Zienkiewicz Medal from PACM, the Computational Mechanics Award from IACM, the IACM Award and the Palmes Académiques in France. He has received honorary doctorates from the St. Petersburg State Technical University, the University of Technology of Lodz, the Leibniz University of Hannover, the Russian Academy of Sciences and the Ecole Normale Supérieure at Cachan, an honorary fellowship from the University of Wales Swansea and an honorary professorship from the Dalian University of Technology. Dr. Schrefler is a member of the National (Italian) Academy of Sciences ("dei XL"), of the Accademia Galileiana di Scienze, Lettere ed Arti, of the Istituto Veneto di Scienze, Lettere ed Arti.

**A. Erman Tekkaya** is a professor at the Technische Universität Dortmund, Germany, and has led the Institute of Forming Technology and Lightweight Construction (IUL) since 2007. He started as an assistant professor in 1986 at the Mechanical Engineering Department of the Middle East Technical University in Turkey and was promoted in 1993 to a full professor. Tekkaya was the founding chairman of the Manufacturing Engineering Department at the Atilim University (Turkey) and founding director of the Metal Forming Center of Excellence. Since 2013 he has been the vice dean of the Faculty of Mechanical Engineering at the Technische Universität Dortmund. He has been editor-in-chief of the *Journal of Materials Processing Technology* (Elsevier) since 2007. Tekkaya is a fellow of the International Academy for Production Engineering (CIRP) and a member of the German National Academy of Science and Engineering (acatech), the Japan Society for Technology of Plasticity (JSTP), the International Impulse Forming Group (I²FG) and the International Cold Forging Group (ICFG). He is a member of the review board for manufacturing technology of Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) and the Allianz Industrie Forschung (AiF). His research interests are metal forming technology, modeling of manufacturing processes and material characterization. Engineering education is also a prime interest of his.

**Wolfgang A. Wall** has been a full professor and founding director of the Institute for Computational Mechanics at the Technische Universität München in Germany since 2003. He received his diploma in Civil Engineering from the University of Innsbruck (Austria) and his PhD from the University of Stuttgart (Germany) in 1999. He acted as founding director of the Munich School of Engineering and is co-founder of the company AdCo Engineering$^{GW}$. He serves on several editorial boards of leading international journals and currently is president of the German Association of Computational Mechanics, Chairman of the ECCOMAS CFD committee, and member of the executive council of IACM. He has received several awards, including the IACM Fellow award in 2008, the Computational Mechanics award in 2012, the Heinz Maier-Leibnitz Medal in 2013 and several Golden Teaching awards. His research interests can be described as "application-motivated fundamental research" in a broad range of areas in computational mechanics, including both computational solid and fluid mechanics. His current focus is on multifield and multiscale problems in all fields of engineering and the applied sciences as well as on computational biomedical engineering. In all these areas his programme covers the full cycle from advanced modeling to the development of novel methods to advanced software development to application-oriented simulations on High Performance Computers, while also including

optimization, inverse analysis, uncertainty quantification aspects and his own experimental work.

# Appendix 2: Explanation of the SEP scores

| | |
|---|---|
| Excellent (5) | Research is world leading.<br>Researchers are working at the forefront of their field internationally and their research has an important and substantial impact in the field. |
| Very Good (4) | Research is nationally leading.<br>Research is internationally competitive and makes a significant contribution to the field. |
| Good (3) | Research is internationally visible.<br>Work is competitive at the national level and makes a valuable contribution in the international field. |
| Satisfactory (2) | Research is nationally visible.<br>Work adds to our understanding and is solid, but not exciting. |
| Unsatisfactory (1) | Work is neither solid nor exciting, flawed in the scientific and/or technical approach, repetitions of other work, etc. |

*Quality* is to be seen as a measure of excellence and excitement. It refers to the eminence of a group's research activities, its abilities to perform at the highest level and its achievements in the international scientific community. It rests on the proficiency and rigour of research concepts and conduct; it shows in the success of the group at the forefront of scientific development.

*Productivity* refers to the total output of the group; that is, the variegated ways in which results of research and knowledge development are publicised. The output needs to be reviewed in relation to the input in terms of human resources.

*Societal relevance* covers the social, economic and cultural relevance of the research. Aspects are:

- societal quality of the work. Efforts to interact in a productive way with stakeholders in society who are interested in input from scientific research, and contributions to important issues and debates in society.
- societal impact of the work. Research affects specific stakeholders or procedures in society.
- valorisation of the work. Activities aimed at making research results available and suitable for application in products, processes and services. This includes interaction with public and private organisations, as well as commercial or non-profit use of research results and expertise.

*Vitality and feasibility*. This dual criterion regards the institute's ability to react adequately to important changes in the environment. It refers to both internal (personnel, research themes) and external (developments in the field, in society) dynamics of the group. On the one hand, this criterion measures the flexibility of a group, which appears in its ability to close research lines that have no future and to initiate new venture projects. On the other hand, it measures the capacity of the management to run projects in a professional way. Policy decisions and project management are assessed, including cost-benefit analysis.

# Appendix 3: Programme of the site visit

**Thursday May 15th Enschede**
**Room Z-203**

| Time | Activity | Present |
|---|---|---|
| 13.15 uur | Arrival in Enschede | Welcome |
| 13.15 – 14.00 | Lunch | |
| 14.00 – 15.00 | Preparation of interviews | |
| 15.00 – 15.40 | Meeting with the Dean + Departmentlevel | Prof.dr. G.P.M.R (Geert) Dewulf (Dean)<br>Prof.dr.ir. Th. (Theo) van der Meer (Preparation Committee) |
| 15.40 – 16.05 | Applied Mechanics (AM) | Prof.dr.ir. A. (André) de Boer<br>Prof.dr.ir. A.H. (Ton) van den Boogaard |
| 16.05 – 16.30 | Biomechanical Engineering (BE) | Prof.dr.ir. H.J.F.M. (Bart) Koopman<br>prof.dr.ir. H. (Herman) van der Kooij |
| 16.30 – 17.00 | Break | |
| 17.00 – 17.25 | Design Engineering (DE) | Prof.dr.ir. F.J.A.M. (Fred) van Houten<br>Dr.ir. G.M. (Maarten) Bonnema |
| 17.25 – 17.50 | Elastomer Technology Engineering (ETE) | Prof.dr.ir.J. W.M. (Jacques) Noordermeer<br>Prof.ing. A. (Anke) Blume<br>Dr. dipl.-ing. W.K. (Wilma) Dierkes |
| 17.50 – 18.10 | Lab visit in two groups | Prof.dr.ir. Th. (Theo) van der Meer<br>Prof.dr. G.P.M.R. (Geert) Dewulf |
| 18.30 – 20.30 | Dinner | |

**Friday May 16th Enschede**
**Room Z-203**

| Time | Activity | Present |
|---|---|---|
| 09.00 – 09.25 | Engineering Fluid Dynamics (EFD) | Prof.dr.ir. H.W.M. (Harry) Hoeijmakers<br>Dr.ir. C.H. (Kees) Venner |
| 09.25 – 09.50 | Mechanical Automation & Control (MAC) | Dr.ir. R.G.K.M. (Ronald) Aarts<br>dr.ir. G.R.B.E. (Gert-Willem) Römer |
| 09.50 – 10.15 | Multi-scale Mechanics (MSM) | Prof.dr. rer.-nat. S. (Stefan) Luding<br>Dr.ir. W.K. (Wouter) den Otter |
| 10.15 – 10:45 | Break | |
| 10:45 – 11:10 | Production Technology (PT) | Prof.dr.ir. R. (Remko) Akkerman<br>Dr.ir. T.C. (Ton) Bor |
| 11.10 – 11.35 | Surface technology & Tribology (STT) | Prof.dr.ir. D.J. (Dik) Schipper<br>Dr.ir. M.B. (Matthijn) de Rooij |
| 11.35 – 12.00 | Thermal Engineering (TE) | Prof.dr.ir. G. (Gerrit) Brem<br>Prof.dr.ir. Th. (Theo) van der Meer |
| 12.00 – 13.00 | Lunch with PhD's | A. (Andrea) Sanchez Ramirez ,MSc. (AM)<br>Ir. M. (Mark) Mark Vlutters (BE)<br>Ir. M.S. (Maarten) Essers (DE)<br>Ir. E. (Ellen) Norde (EFD)<br>E.M. (Ernest) Cichomski, MSc. (ETE)<br>Dr. ir. V. (Volkert) van der Wijk (MAC)<br>Ir. D. (Dinant) Krijgsman (MSM)<br>Ir. J.H. (Johan) van Ravenhorst (PT)<br>M. (Milad) Mokhtari, MSc. (STT)<br>Ir. A.A. (Anton) Verbeek (TE) |
| 13.00 – 15.00 | Committee meeting – discussion UT programmes | |
| 15.00 – 15.30 | Final meeting | Prof.dr. G.P.M.R (Geert) Dewulf (Dean)<br>Prof.dr.ir. Th. (Theo) van der Meer (Preparation Committee) |