

KTH International RAE 2008

REPORT PANEL 8: INDUSTRIAL TECHNOLOGY and MATERIALS SCIENCE

GENERAL ASSESSMENT OF THE RESEARCH FIELD

The **research field** of Industrial Technology and Materials Science comprises the activities of three departments in the School of Industrial Engineering and Management. Each department is a Unit of Assessment. The research fields have evolved out of the merger of Mechanical Engineering and Metallurgy. It is a relatively new assembly. The panel feels that a fairly good collaborative spirit has been established and that synergies are being made use of, although there is still room for improvement in that direction.

The **offices, laboratories and the infrastructure** of the three units of assessment (=departments) are within walking distance on the KTH campus. This helps the internal communication.

The **relations with industry** are very good, providing a strong contextual underpinning for both research and teaching and form a strong basis for future development.

Cooperation activities within KTH are adequate, particularly with certain areas of physics, mechanics and material sciences.

There is a strong tradition of working through and with **conferences** especially for the two UoAs active in Industrial Technology. This makes for a good network amongst students/researchers and other Swedish universities such as Chalmers, Lund, Linköping and Luleå, in addition to enhancing the international profile of staff. The support by the Swedish innovation agency VINNOVA is considered to be good.

The teaching (and in two depts., the research) staff, mainly the professors, are strongly dominated by Swedish nationals. Foreign professors are the exception. This may be due to the fact that, for an outsider, the existing KTH financing system makes it very hard to create early and decent headway in basic and applied research. In the future, more internationalization will be essential: especially as Sweden's already international industries adapt to the next round of globalisation challenges.

The panel was impressed by the integration of high quality education within the research framework and the well functioning co-operation with industry. Commitment to teaching by the staff and the enthusiastic participation by the students at all levels must be commended. For two units of assessment this commitment has affected the basic scientific productivity, which had to be scored at an average.

Overall: The panel had the privilege to assess three good UoAs/departments.

UoA: Industrial Product Development (IPD)

The department has its roots in Mechanical Engineering (machine elements, machine design and internal combustion engineering). The department has picked up new trends over time, such as mechatronics and integrated product development. The “internal combustion engines” area does not seem to have much synergy with the other teams. With nine professors, eight main topics of research and four Centres of Excellence, this department should perhaps be seeking more focus. It offers however, an especially attractive working environment, because of the relevance of the topics to “real life”. With one exception, all professors are of Scandinavian background. The fact that the major competitors are the Universities of Leuven, Delft and Stanford shows that a wider view and an enhancement of internationalization are needed. The standards of teaching and the results thereof are excellent. The visible output of the research activities (rigor, not relevance) is judged to be at European average (two positive exceptions). Plans to improve on that have been initiated.

Performance Against Evaluation Criteria

Scientific Quality (basic research)

The majority of the UoA currently performs at an internationally high standard. IPD has established four divisions with relevant topics from the industrial point of view: System and Component Design (SCD), Mechatronics (Mech), Integrated Product Development (IntPD), and Internal Combustion Engines (ICE). This implies that applied research is dominant over basic research. The low number of qualified publications in top journals is a consequence thereof. However it should be noted that the UoA has a high number of publications in peer-reviewed conference proceedings. The tribology team, however, has a remarkable publication record. Conference papers, a tradition of the department, have little impact on the scientific standing (which relies almost exclusively on publications in basic research). Seven (out of 33) PhD students started an academic career, four of them within KTH. While this proportion (approx. 20%) is good, that only 3 of these PhD students went in to academia outside of KTH means the UoA’s international academic impact is limited.

Scope and quality of academic networks and collaborations

While 75 collaborating institutions are quoted; too little impact is visible in the scientific community, in the opinion of the Panel. With the exception of papers by a newly appointed (external) professor, little international collaborative authorship can be detected in the published works submitted to the Panel.

Strong/weak groups

While all four divisions have a fairly strong record in applied research (see below, Section 2) only one division (IntPD) can show that its basic research is on the rise.

Applied Research Quality

Part of the UoA currently performs at a world-leading standard with the main part performing at an internationally high standard. According to the mission of the department, this kind of impact is the major aim. The good relations with industry are the positive confirmation:

- The numbers of industrial (=external) PhD students as well as of industrial and governmental research contracts / assignments are impressive.

- The numbers of spin-offs (3 in 12 years) and patent applications (4) are considered adequate but with potential for improvement.
- 20 (out of 33) PhD students went into industry. However, only four of them were employed by international (non-Swedish) companies. This shows the strong impact for the Swedish industry and society, but the relatively moderate effect at the international level.

Long-term plans

The department wants to develop the model-based design capability and intends to enter the medical engineering field rigorously. First steps are encouraging. In addition the department has plans in the areas of innovation processes, sustainable technologies, automation and augmentation, transport and mobility.

Strong / weak groups

Three divisions enjoy already a high recognition by and impact with the Swedish industry. One group (IntPD) has not yet achieved these levels of recognition, in the opinion of the Panel.

Basic versus applied research

Applied research is a strong point of this department. Relevant areas have been identified in collaboration with Swedish industry. A better basis in basic research will be essential, not only for academic reasons. Actions have been initiated.

Scholarship

Part of the UoA currently performs at a world-leading standard with the main part performing at an internationally high standard.

Role and impact on society

Presence in the media (approximately 25 appearances over 5 years) represents a decent level. However, this aspect deserves to be improved considerably (=opportunity), in the opinion of the Panel.

Leading role in science

Major international collaborations, organising conferences, engagements in scientific societies as well as cooperations with industry and government are remarkable. Again, the leadership and impact are visible mainly within Sweden.

Vitality and Potential

Excellent in some parts of the UoA, good in the remainder.

Human Potential

Two recent appointments (1 female, 1 international) show that the renewal process is ongoing. Two professors are about to retire and plans exist for new areas of research (medical technology). There is some uncertainty within the department about whether these renewal plans can be initiated in due time (=now!) and with the necessary push (incl. active support by KTH and the School). The gender balance is improving.

Material resources

There is real concern whether the present financial allocation and charging system at KTH will allow the department to pursue its new objectives and fulfil the requirements for a better

scientific standing (i.e. more rigor while maintaining the good level of relevance). This is not an issue unique to this UoA.

Strategy

Good with real potential to achieve. Ideas for research areas with new potential have been created and the assessment of future success has been made (medical technology, innovation processes, sustainable technologies, automation and augmentation, transport and mobility). One uniqueness is that the department develops a design methodology starting from the mechatronics point of view. However, the international context and diversity (against true benchmarks) and the aspect of more focus (critical mass per topic) do not seem to get the necessary attention yet.

Internal synergies

Synergies within the present department, school and KTH are moderate. One exception is the area of internal combustion engines which seems to be a stand-alone unit within the department but is well linked within KTH. Another is the tribology team with good interaction with materials science and the Ångström lab, Uppsala University.

Actions for Development

- With 9 professors, 8 main topics and 4 centres of excellences this department should perhaps be seeking more focus.
- It offers however an especially attractive working environment for students, and researchers because of the relevance of the topics. This attractiveness should be maintained and enhanced. Even if it does not impact the scientific rating directly, it is one condition for future excellence.
- Another requirement is to build a broader basis in basic research for higher impact in the applied activities. Still open for action.
- With one exception, all professors are of Scandinavian background. The fact that major competitors are international universities in Europe and USA shows that internationalization is needed.
- KTH should address the motivation and effects of its fund/cost allocation system for research activities and researchers.

UoA: Production Engineering (PE)

This Unit of Assessment has its roots and its basis in Sweden's strong production industry. Many of the topics are fuelled by the needs of industry. In this department four professors deal with four broad topics which seems to be a well-selected focus. One topic, however (metrology), seems to struggle with industrial and, to a certain extent, also scientific relevance. Corrective actions have been started. Synergies and levels of cooperation between the different activities are visible but not overwhelming. Good industrial relations and high quality teaching have taken its toll on the scientific and academic publishing. This ranks at or below average. The Panel sees one additional obstacle for the future improvement of scientific work: the research relies on capital intensive equipment and infrastructure. The present financial allocation and charging system by KTH does not favour this type of research and thus makes it difficult to remain internationally competitive. This system can also endanger the current leadership role this group plays in Swedish industry.

Performance Against Evaluation Criteria

Scientific Quality (basic research)

Part of the UoA currently performs at an internationally high standard with the main part performing at a nationally high and internationally recognised standard. PE conducts research and education through four divisions: Machine and Process Technology (MP), Industrial Metrology and Optics (IM), Production Systems (PS), and Computer Systems for design and manufacturing (CS). Three (MP, PS, CS) of the divisions derive their direction and have their basis in line with the needs of the Swedish industry. Hence, the majority of the research activities are of applied character, often at the cost of basic research. This is reflected in the low number of scientific publications in top-journals. With eight qualified publications from four professors in five years, the level is below average; however the Panel recognises that this may be related to a tradition of not publishing in journals in this field. On the other hand, one out of the four centres of excellence is positioned in an academic context. Three out of 23 PhD students chose an academic career, two within KTH. While, the overall proportion (approx. 15%) is adequate, the international impact is low.

Scope and quality of academic networks and collaborations

While 54 collaborating institutions are quoted, too little impact is visible in the scientific community. Little international collaborative authorship can be detected. One exception is the group CS with its network of excellence within the EU and with CIRP.

Strong / weak groups

The metrology group is the one with a recognized international standing. Recently one important EU project with basic research character has been assigned.

Applied Research Quality

Part of the UoA currently performs at a world-leading standard with the main part performing at an internationally high standard. According to the mission of the department this kind of impact is a major aim. The good relations with Swedish industry are the positive confirmation: the number of industrial (=external) PhD students is remarkable, as is the amount of financial and project support by the industry. In particular, the increasing support by Vinnova is equally positive. Thanks to high quality applied research the department has been able to offset the strongly declining internal funding furthermore, the involvement in EU projects is a good sign. Three out of four centres of excellence are supported by industry (i.e. a good number of larger Swedish companies but also SMEs); however, the output on patents and the number of spin-offs has been rather moderate.

Long-term plans

While the topics of the four divisions are rather traditional, the content is up-to-date and the will to pick up industrial trends early is clearly visible. The intended goal of enhancing international exchange amongst students and researchers goes in the right direction.

Strong / weak groups

The divisions have successful future oriented relations with the Swedish industry. The metrology group's relations with industry in their state of art micro and nano-metrology research could be further developed in line with their otherwise positive relations with industry.

Basic versus applied research

The applied research is (and has to be) the strong point of this department. Relevant trends have been indentified in collaboration with Swedish industry. The international network of

this department can still be enlarged. Furthermore, the good basis already established in applied research should be utilized to stimulate more fundamental research work in order to form a broader basis which will help shape the future i.e. to help to maintain a strong production-oriented, innovative industry in Sweden.

Scholarship

Part of the UoA currently performs at a world-leading standard with the main part performing at an internationally high standard. Engagement in society at large is probably below average (low presence in media), while engagement in industrial and scientific society is good, thanks to active participation in conferences and membership in councils. These efforts show the corresponding effects. Furthermore, the number of major industry assignments (contract research) is an indication of increasing impact. While impact with Swedish industry is already good, the effects in international industrial and scientific communities are rather low. The metrology group, however, has gained strong international recognition.

Vitality and Potential

Excellent in some parts of the UoA, good in the remainder.

Human potential

Out of three recent retirements of professors, only one position has been filled. While the panel is not of the opinion that professorships should be replaced “one on one”, we think that too little action has been initiated to pick up new trends and to enable the department to follow them with solid academic research and future-oriented teaching. A further indication in this direction is the fact that no external or international recruitments have occurred within this department for a considerable period. Out of the fourteen internal recruitments made, only one female candidate was selected. On the other hand, there is a good network of interpersonal relationship within and outside the department. International exchanges of students are encouraged and take place.

Material resources

The production engineering department and its research depend heavily on good and sophisticated laboratory equipment. There is a real concern whether the present financing and charging system of KTH will allow the department to pursue future plans and fulfil a future requirement for more basic research. The replacement of old equipment with new up-to-date instruments and tools is not progressing as it should and absorbs too much attention and capacity of research workers.

Strategy

Good with real potential to achieve. The department is actively monitoring and supporting chances/opportunities in industry, particularly in the traditional production activities (where trends are strong to move these activities to non-European low-cost countries). Creative ideas have been formulated. The potential benefits of new technologies (e.g. nano-technologies) and new processes are being looked at. While planning seems to progress adequately, the realization seems to lag behind.

Synergies

Possible synergies between groups and departments are actively pursued. The panel is of the opinion that more efforts have to be put in to international collaborations. The chances of success here are good, given the recently increased number of successful EU project applications.

Strong / weak groups

While the metrology group has a good standing in international basic research (and hence, needs more recognition on the applied side), the other three groups show signs that their strong applied research will be enhanced to serve as a basis for more fundamental work. Chances for success are good.

Actions for Development

This unit of assessment has its roots and its basis in Sweden's strong industrial base. This position should be used:

- To pick up new trends and possibilities at an early stage and concentrate on real trendsetting applied research.
- At the same time, to work on a broader foundation in terms of basic research. This will form a better basis to come up with truly innovative, applied research.
- To aim for much more international diversity, not only in the student body but also among the researchers, particularly the professors.
- To redefine and improve substantially the financing/charging system for long-term projects and the more fundamental research (incl. up-to-date equipment), particularly by incoming new (non-Swedish) professors. Actions to be taken by KTH.

UoA: Material Science and Engineering

The present constellation combines the disciplines of material properties, material structure and material processing. It forms an ideal entity with solid scientific fundamentals and strong practical applications in material products and production technologies. TKK Helsinki is the nearest university in profile with materials and processes at approximately the same level. Other competing organizations are in Japan, the USA and in several European countries. This department already has collaboration agreements with several of these strong groups.

Ten professors cover five main topics. This gives the clearest focus within the three Units assessed by this Panel. This department not only has an excellent reputation in the scientific field but also provides an equally good level in teaching.

The threat for the future lies in the fact that five (out of ten) of the professors are at, or approaching, retirement age. The search for adequate successors does not seem to have started yet. The start of this process is of considerable importance and crucial for maintaining the high scientific and teaching standard of this department.

Performance Against Evaluation Criteria

Scientific Quality (basic research)

This UoA is made up of three areas: Materials Function, Design and Process Design. The majority of the UoA currently performs at a world-leading standard. It has a strong competence regarding modelling based on thermodynamics, kinetics and ab-initio calculations in combination with an experimental expertise regarding determination of thermo physical and thermodynamic properties as well as a range of advanced microscopy techniques. The quality of research in this department is of the highest international level,

concerning both experimental research and modelling on the extended range from atomic level to micro- and macro systems. More than 330 publications, two-thirds of them in top-refereed international journals, are clear evidence of this. Twenty-five per cent (23 of 93) of the PhD students started an academic career, more than half of them with universities outside Scandinavia. Strong international collaborations in the form of projects, student exchange, visiting professors and scientists are extraordinary. This department has managed to combine scientific rigor with relevance in a very powerful way, i.e. basic and applied research are well integrated. Processes and structure are clear highlights of this department. Among the very good research activities undertaken, the panel wishes to highlight the ab-initio calculations, the thermodynamic and kinetic modelling of different phases as well as the nano-characterization laboratory.

Applied Research Quality

The majority of the UoA currently performs at a world-leading standard. Although the research aims at the highest scientific level, the department has focused on topics with practical industrial applications, primarily for the material producing industries. The department has succeeded in attracting about 65% of financing from external funds, both for research work and for modern equipment. 63% (60 of 93) of the PhD Students went into industry, a third to international companies outside Scandinavia. Several computer programs and codes with worldwide applications have been developed. Two spin-offs and four patents show some additional innovative power of the department (= clear chance to improve). Five centres of excellence (one now closed), each with a high number of PhD students, many of whom have an international background, are a convincing sign of good collaboration with Swedish industry.

Long-term plans

The department has traditionally focused on processes and products related to the steel industry and other materials producing industries. It plays a strategic role in these collaborations. The department wants to continue and develop this relationship with both theoretical and experimental work. The department is also considering new materials which are expected to become important in the future, such as biomaterials, bulk metallic glasses and nano-prototyping. The planned Materials Forum at KTH - which is thought to be an organization for all materials science groups at KTH - could play a very important role in developing work on new materials.

Strong / weak groups

The whole department, with its total of eleven groups, is a model case in the European university landscape. The applied process metallurgy group is recognized globally.

Basic versus applied research

This department shows that both aspects, basic research and applied research, can be mastered at the same time.

Scholarship

Outstanding across the majority of the UoA. The department is neither particularly visible in public media nor as advisor to international organizations. On the other hand, the department is well recognized in the international scientific community, as is demonstrated by the large number of assignments and awards. Members of the department are also called upon as advisors to Swedish government agencies. The department is a well respected partner of Swedish industry and, to a lesser degree, international industry. It attracts many foreign post-

docs, guest professors and PhD students. Overall, the department has shown a very high level of scholarship.

Vitality and Potential

Excellent in some parts of the UoA, good in the remainder.

Human potential

The fact that none of the five professors who are in the process of retiring has really been replaced yet is disturbing. Fast action is essential. The reputation of the department, its international network and support from Swedish industry should make it easy to act swiftly.

Material resources

In the past, the requirements for research equipment and infrastructure have been satisfied to a substantial degree by contributions from Swedish industry and the research funding agencies. However, the more fundamental work needs long-term financing which should ideally be provided by KTH. It would be detrimental to this leading department should such a sustainable long-term financing for basic research not be established.

Strong/ weak groups

With above mentioned measures, the department should be in a position to maintain its international reputation.

Strategy

Excellent but challenging to achieve. The department has built a unique position regarding the modelling of materials and processes based on thermodynamics, kinetics and ab-initio calculations. It is of strategic importance for the Swedish materials producing industry that this strength is maintained and developed. This is also clearly stated in the strategy document.

It is wise, as proposed, to take up studies on other materials such as biomaterials and materials for energy applications in collaboration with other materials science groups at KTH within the new unit Materials Forum at KTH.

There are good synergies between most of the research groups in the department. A little outside the main stream is the Energy and Furnace Technology group.

The fact that five professors will have retired within three years makes it difficult to define a binding long term strategy. It is very important that the research programmes for these chairs are defined soon.

International synergies

There is a strong international collaboration/network in most fields of the department. This is to continue e.g. with EU research programmes.

Actions for Development

The panel recommends enhancing the present strengths by:

- Exploring new fields without losing focus. In particular this means balancing the need for basic, exploratory research with relevant topics from the point of view of the industry.
- Allocating some financial resources and infrastructure not only to attract talents on a global basis but also to allow for a sustainable financing, in particular for a sufficiently funded starting-periods for the five new professors.

- Staying in the lead in the focus areas by starting the succession process immediately and globally including the above mentioned starting support for external professors/scientists.
- Going for more recognition, prizes and awards. This will need some kind of additional but different publishing and marketing efforts from both the department and KTH.

With such measures this department can remain one of the true leaders within KTH, with a strong international reputation as well as extended industrial support.