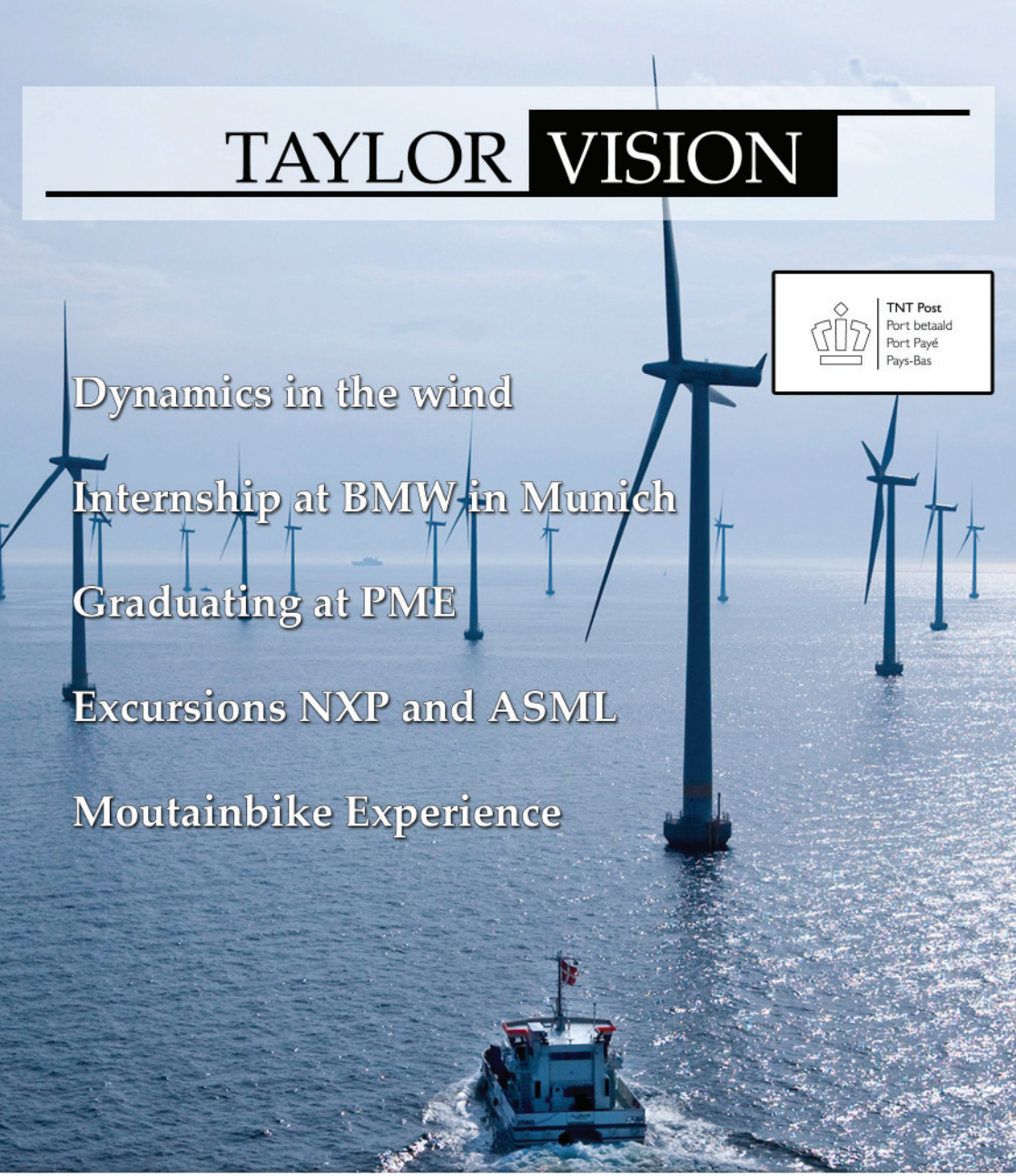
TAYLOR VISION



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Moutainbike Experience

TU Delft
Section Precision and Microsystems Engineering

July 2010

Dispuut Taylor - Mekelweg 2 - 2628 CD Delft

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Preface

Dear PME enthusiast!

Now that the final exams have passed and the weather is finally comfortably warm the time has come for a new TaylorVision. The coming year a new and improved PME curriculum will be launched for the first year's students and for the first time an introductory week will be organized to let them get acquainted with the department, the teachers and of course the other students. Dispuut Taylor will have a part in organizing the social interstudent activities. Unfortunately next year also means we have to say goodbye to dr. ir. Georg Schitter who is taking over the chair of "Industrial Automation" at TU Vienna. Also dr. ir. Hans Langen has found a position elsewhere and no longer will be part of the PME staff. We wish both of them the best of luck.

In the meantime Taylor has organized a lot of fun and educational activities which are all covered in this issue of Taylorvision. First of all Rui Pan Chen has written a nice report about our visit to NXP ITEC in Nijmegen in March. Taylor treasurer Ferry Bastiaansen made a report on the ASML excursion organized in May with Gezelschap Leeghwater. Rob Dedden shares his opinion on the Taylor Mountainbike Experience. Furthermore our commissioner of activities Maarten van der Kooij is now doing an internship at BMW in Munich and tells about his German adventures. Graduate Paul van der Ploeg lets us know what it's like to graduate. Sven Voormeeren has written a nice article on the dynamics of wind turbines and last but not least Hans van Gurp has maniacally managed to make a new horrible puzzle which will hopefully yield more contributions than the previous one.

Finally on behalf of the Dispuut Taylor I would like to wish everybody a great holiday and we look forward to see you next year!

Kenneth Kamp
Chairman Taylor 2009-2010

Contents

Internship in Munchen

By Maarten van der Kooij

Since the beginning of April I am doing an internship at BMW in Munich. The fun actually already started before arriving in Munich: driving 900 kilometers in a 21 years old BMW E30 on the German Autobahn is always an adventure since you'll never know what's going to happen. Of course the old 6-cylinder is still running smoothly and maybe the feeling of going back to his Heimat made the E30 run even smoother.

The e30 in the Alps

Having an old E30 with the nice yellow license plates is highly appreciated here in Munich. Especially the cops had special interest in this car.. In the first week, when I wasn't too familiar with the public transport, I decided to go drive the car three times. Two times I got pulled over by the police and I got confronted with the prejudices that other countries have about the Dutch liberal ideas. What else then laugh can you do when a policemen says at 08:00hrs in the morning that he is sure you have used some drugs because your pupils look weird.. Obviously the change from a student's live to the working live leaves its traces in the way you look, but to be sure the officer thoroughly checked my car for drugs. At least from that point, without having a fine for anything, I knew that the E30 was doing fine in meeting the

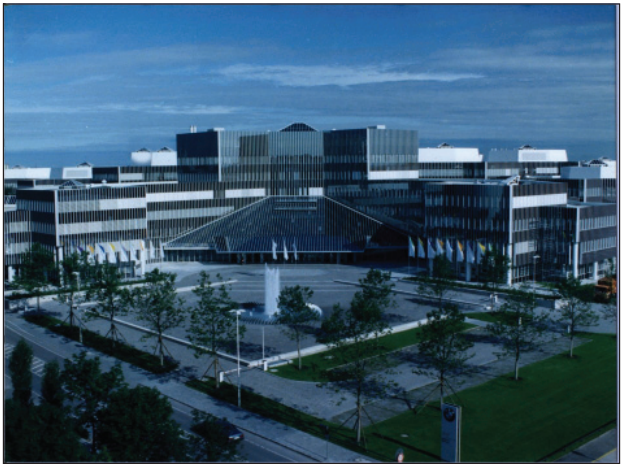
standards that the German police uses for handing out fines. Therefore I had no fears when the police stopped me again some weeks later when I was on the way back from a weekend in the Czech Republic (where they recently changed laws related to drugs). Again the E30 was subject to an inspection by the German's and they actually found 2 euro's somewhere under the floor mats, so I have to thank them for that!

Next to the good relation with the cops the rest of Germany is also really nice! Munich is a city where a mechanical engineer can live well. Where in the Netherlands you will only see 60 year old men driving Porsches it seems here that every girl that turns 21 gets one for her birthday. Next to the nice cars the German culture is easily adoptable: drinking beer and eating wurst at one of the many fests they have here is something I could do every day. I remember the weeks I did that every day here, but as you all know this is more difficult when you grow older..

Left: Beer und currywurst at theFruhlingsfest. Right: Me and a friend at the championship celebration of Bayern Munchen at the Marienplatz

So it seems that there would be no time to actually do something at BMW,

but nothing could be further from the truth. I am in the Forschungs- und Innovations Zentrum (FIZ) from BMW at the department Entwicklung Gesamtfahrzeug – Akoustik und Schwingungen. The subject I am working on is related to the power train: sudden changes of the torque (Lastwechsel) result in vibrations of the power train in it's eigenfrequency. These vibrations make the teeth inside the gearbox hit each other due to play that is between these teeth. This is called Klackern and it is the subject of my internship: setting up a standard test cycle to assess gearbox noise. Next to the nice project also the colleagues at BMW are a lot of fun: going to the Beergarten with nice weather and Brotzeit with Weißwurst und Bier at Friday morning are some of the things that make the work even nicer.



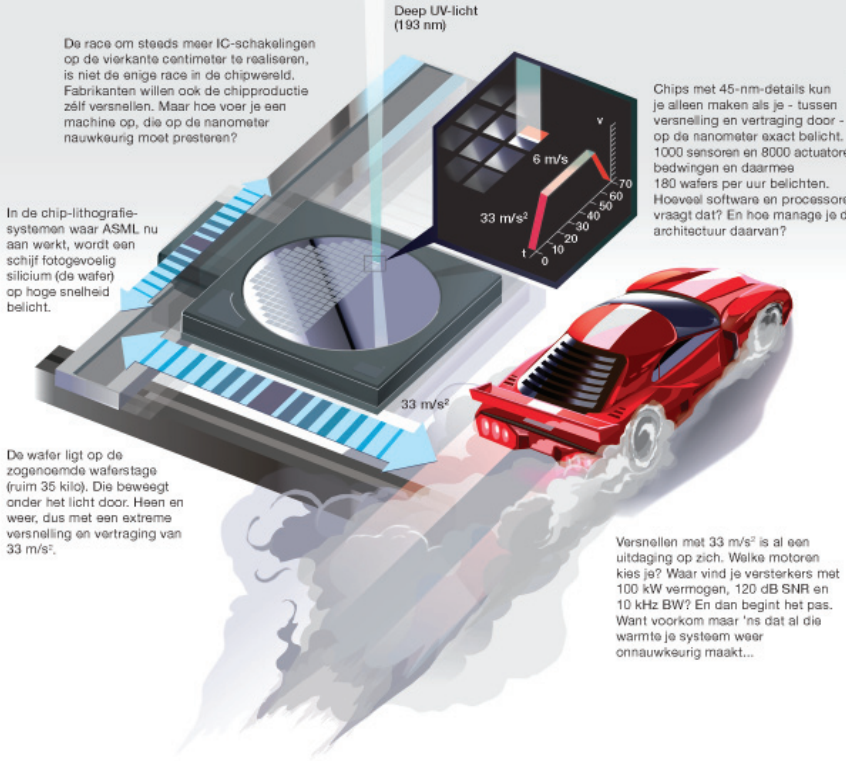
Forschungs- und Innovations Zentrum (FIZ) from BMW

So, this was the short update from Munich! Right now the next big event will be the Weltmeisterschaft Fussball, and of course I have the wooden shoes ready to wear for the Dutch matches. Hope to see you all in August, when I will return to the beautiful Netherlands!

Servus,

Maarten

Morgen kunnen we sneller chips maken. Vandaag mag jij ons vertellen hoe.



Voor engineers die vooruitdenken

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ASML

Mountainbike Experience

By Rob Dedden

On Friday 21st of May a group of PME students set out to Zoetermeer. What was it that they were they up to? Although the Netherlands is a flat country, and the Dutch tend to give names to small hills as if they could compete with the Mont Blanc, there are however possibilities to do some mountain biking. To put it even stronger: Zoetermeer hosts one of the official European Championship mountain bike tracks in Europe! We were eager to see whether we were capable enough to ride the same tracks as world champions like Julien Absalon and Sabine Spitz did.

After the mandatory (and necessary) helmets were fitted to the various heads, we started in a group of eight on the EC track. Soon it turned out that the track was not only a challenge for world champions, but also for PME students! The climbs were steep, resulting in uphill struggle and downhill action. Besides the EC track, there were various small tracks that, according to one of the locals, had a combined length of 150 km! One of us had a spectacular accident, which ended with a collection of "scratches and patches". He decided to quit after this, and thought that drinking beer is perhaps less harmful. The rest of us continued, but without our last man, we soon got

lost in a maze of splitting and crossing paths. After some time, we found our way through these spaghetti of small paths. The weather was perfect, and it was nice to find out who has the best climbing skills.
All the pedalling makes one thirsty, so at about half past four, we decided to join our injured fellow and found out that a nice cold beer tastes even greater when you have the feeling you deserved it.

Dynamics in the Wind

By Sven Voormeeren

With wind turbines getting ever bigger and installed in larger numbers, wind energy is becoming more and more important for our sustainable future energy supply. How do we accurately predict the dynamic loads and vibrations such that we can design these machines to reliably do their job?

Introduction

At present there are few topics as heavily debated as "sustainability". On a daily basis the media are covering items on climate change, oil prices, CO2 reductions, rising energy consumptions and so on. Regardless of one's opinion on the subject, a fact of the matter is that more sustainable ways of power generation need to be found simply because the currently used resources will some day be exhausted.

One of the more promising ways of generating "green" electricity on a large scale is provided by wind energy. As a result, the wind turbine industry has undergone a huge transition: from a small group of (mainly Danish) enthusiasts in the early 1980's, today's wind power industry has grown to a global multi billion euro business and has seen consistent annual growth of more than 25% since 2002. The same exponential growth was seen in wind tur-

bine size. Whereas in the mid '80's the first commercial wind turbines had a rated power of 50 kW with a rotor diameter of 15 meters, their modern successors come as large as 7 MW and rotor diameters up to 126 meters. With hub heights (the hub is the centre of the rotor) up to 135 meters, this gives a total height of the turbine of almost 200 meters. For the sake of comparison, the rotor swept area is almost as much as two soccer pitches, while the rotor diameter is more than 1.5 times the wing span of the Airbus A380 jumbo jet (80m). Indeed, a modern wind turbine is a truly huge and fascinating machine and presents many challenges to the mechanical engineer. One of those challenges concerns the correct modelling and analysis of the structural dynamic behaviour of the wind turbine.

Structural Dynamics

Naturally a wind turbine, with its large and slender structure and the complex ambient excitations, exhibits all kinds of structural dynamic behaviour. The dynamic loading and structural vibrations sometimes have caused problems, from cracking blades, breaking gearboxes to "singing" towers. These problems have not been limited to a single manufacturer, but simply seem inherent to the structure of a modern wind turbine.

To cope with these dynamic effects, wind turbine manufacturers, research institutes and universities have developed many different simulation tools, called aero-elastic codes. These codes are developed to analyze the global dynamic behaviour of a wind turbine, taking into account aerodynamic loads, possibly wave loads for offshore turbines, and the turbine controller dynamics. To get wind turbines certified and insured, many load cases need to be evaluated. Hence, the actual models used are pretty coarse and geometries and components are very much simplified in order to keep the computation times at an acceptable level.

Driven by today's highly competitive wind turbine market, manufacturers are searching for ways to optimize their turbine designs and thereby save costs. An important way of achieving this is by reducing the total weight of the turbine. This initiates a chain of benefits as less material is used, transport and installation is made easier, smaller foundations can be used and

so on. On the downside, these optimized turbine designs generally tend to make the structure more flexible. As a result, components can start to exhibit local dynamic behaviour, which can lead to increased component loading up to a level that can result in failure. Thorough understanding of these dynamics is therefore important to guarantee the overall reliability of a wind turbine. However, due to their relatively few degrees of freedom and geometric simplifications, the aero-elastic models commonly used are often not capable of predicting these local dynamic effects.

Therefore, a need exists for more detailed structural dynamic analysis tools, without losing generality and versatility. This PhD project, carried out within the section Engineering Dynamics of department PME, was set up in close collaboration with Siemens Wind Power in order to fill this need; to do so we use the paradigm of dynamic substructuring (DS).

Dynamic Substructuring

The theory of dynamic substructuring is about performing a structural dynamic analysis of a complex system by dividing it into a number of smaller, less complex ones. These parts of the system are called substructures, subsystems or components, and their dynamic behaviour is in general easier to determine than that of the complete system. When the dynamic properties of all the subsystems are known, DS techniques allow constructing a model for the dynamic behaviour of the complete system by coupling the subsystem models. Performing the dynamic analysis of a system in such component-wise fashion has some important advantages over analyzing the complete structure at once:

- By analyzing the subsystems, local dynamic problems (e.g. resonating components) can be recognized more easily.
- Dynamic substructuring gives the possibility to combine modelled parts and measured components.
- It allows sharing and combining substructure models from different project groups.

Although the concept of dynamic substructuring has been around already for some decades, it has not yet become a standard tool for the structural dynamic engineer. The aim of this project is therefore twofold. Firstly, we try to further develop the DS methodology through theoretical extensions. Thereby we aim to generalize the methodology and create a platform in which all sorts of modelling techniques (e.g. finite element (FE) models, measured models, simplified models, etc.), can be combined. Secondly, the goal is to implement the methodology in the wind turbine engineering practice and illustrate its potential through an in-depth case study. Here we will not go into the theoretical details, but focus on the application instead.

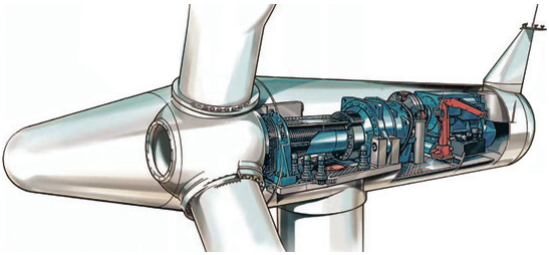


Figure 1: The nacelle of the 2.3 MW Siemens wind turbine

Application

During the first half of the project, the focus of the case study has been on the yaw system of Siemens' most popular wind turbine, the SWT-2.3-93. As the name suggests, this is a 2.3 MW wind turbine with a rotor diameter of 93m. The yaw system is situated at the tower top of the wind turbine and enables the rotation of the nacelle (the "box" on top of the tower housing the drive train) and the rotor about the vertical tower axis. See figure 1. By yawing the wind turbine, the rotor can be positioned such that the rotor plane remains orthogonal to the wind direction. This maximizes energy capture from the wind and avoids asymmetric loading of the rotor. This actively controlled system is an important part of every modern wind turbine and provides an interesting test case for the DS methodology, since it comprises many components and complex interfaces.

The first step in modelling the yaw system with DS is to subdivide the system in components. Secondly, all components must be modelled. We decided to model most components using the finite element (FE) method (see figure 2). This method is straightforward since 3D CAD models of most components already exist. However, for the more complex yaw gearbox a tailor made model was created in Matlab. Some of the models were validated by real life vibration measurements of the components to make sure the models predict the right dynamics.

After having created the component models, the next step is to assemble these and obtain the complete yaw system model. This however resulted in a very large model which takes too much computation time to be useful in a design process. Therefore, so called model reduction techniques were applied, which allow to simplify the component models without losing their detail and accuracy. The driving idea behind these techniques is the modal superposition principle that states that the behavior of any component can be expressed as a combination of its fundamental vibration shapes.

This finally resulted in a model of the yaw system that was both accurate and compact, and can for instance be used to study the effect of changing the stiffness of a certain component.

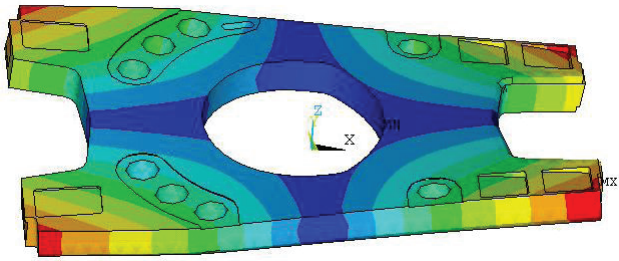


Figure 2: One of the component models used in the yaw system analysis

Outlook

Currently, we are extending the yaw system model to a full wind turbine model. With this model studies can be performed on the effect of the yaw system components on the total turbine's dynamic properties. In the future the methodology will be extended to incorporate non-linear effects, arising for example from friction, and efforts will be made to validate the total model with measurements on a real wind turbine.

Together with MSc students and the support from Siemens Wind Power engineers we thus work towards making dynamic substructuring a valuable tool in wind turbine engineering. Hopefully, our efforts will one day help to get more efficient predictions of the dynamic loads on wind turbines, enabling more optimized designs. This eventually reduces the costs of wind turbines and in the end contributes to affordable sustainable energy. So, as long as the wind remains dynamic, structural dynamic engineers can help to make a difference.

Graduating at PME

By Paul van der Ploeg

My dear PME friends, I am honored by the chance of writing a few words which may by distributed by means of our periodical. At the time of writing my thoughts go out to the final presentation of my thesis work, which will probably be held before this publication. However that will be, in the sentences below I shall try to relate in a coherent way the experience of graduation. As my mindreading skills are still underdeveloped in reference to our own PME legend Arvind Jayashankar, I am limited in this story to relate only my own experiences . In October 2009 I started my thesis work by knocking on the door of Marcel Tichem. He asked me straight away what kind of assignment I wanted. As I liked experimental work and design, and was less enthusiastic about hardcore physics or any analytical mathematical assignment, I was put in touch with Friedjof Heuck, a Phd student of Urs Staufer. As he was investigating different kinds of microfluidic pumps, so I could choose an assignment on which I could design and experiment to full extend. The months that followed were crowded by labwork, partly performed at Dimes. I remember a day in January, where I bicycled past the faculty and saw how the rain created circles in the water before the faculty. The water was as green as the SU8 I had spun that day, and the circles in the water reminded me of the unexplained island formation in the photoresist layer, which thoroughly undermined my work. At that moment the graduation project really drove me to despair. But then, the following days you book success, in my case I made my fluidic chips. Back again in the faculty, you carry the box of wafers closely grasped in your hands before you. A friend stops you, inquires what you carry… then of course, you are proud! In my case I was happy that the fluidic chips were made, but for success I had to carry out a extra process step: the fabrication of silver electrodes. This succeeded only after weeks of continuous effort. But then i had fabricated a working pump! In the first whirl of excitement I quickly recorded its functioning under the microscope and played with it for some minutes to persuade myself it actually worked. Then I left for lunch with my colleagues. When I came back, I looked hopefully in my microscope….my eyes grew large in astonishment …the microfluidic structure had debonded, the pump was no more… Luckily the recorded movie proved that the pump had re-

ally existed, and this movie served as the basis on which my thesis defense is based. May this story encourage us experimentalists to frequently record our experiments!

In hindsight I am happy with my supervisor, and I think it is important to have someone with which you can communicate. This sound trivial, but a professor that can only be spoken on a appointment, scheduled 2 weeks in advance, is not the most ideal person as direct supervisor. In my case I was happy with Urs as he kept the overview and sharpened me about the physical phenomena I encountered. Of course a Phd student will try to exploit you as much as possible (@Friedi, your words!), but it keeps the work going and when your work is recognized, you are probably willing to do a lot.

And then… you are, if you delivered appropriate work, graduated! Hurray! First a good 'borrel', some period of well earned diversion… and then? Dear reader, probably it is recognizable when I relate of fantasies, concerning the rosebud fragrance of possible occupations after study. Those wonderings are frequently accompanied by the bright halo's of ideas as 'development', 'responsibility' and the more prosaic idea that a positive instead of negative slope of your bank account would finally grant you a certain freedom of living. It is remarkable that these reveries diminish and eventually change character when the end of the study comes in sight. But I also read somewhere that being without a job for a long time can be traumatic for engineers. Several friends found jobs at Demcon, ASML, TNO. Whatever the future will bring, it will be different then Delft... But still, I look forward to it!

Solong PME'ers,
Thanks for all the fish!

Paul van der Ploeg

NXP excursion

By Rui Pan Chen

Hi, everybody! My name is Rui Pan Chen, an international student of the PME department. Now I am studying in the specialization of Mechatronics System Design. The 26th of March, Taylor organized an amazing excursion to NXP, which is a so-called semiconductor manufacturer company. It was such an attractive excursion to me since it is a mechatronic relevant company. I feel so honored that I have the opportunity to attend the excursion and also have a chance to write down something about that impressive experience.

We traveled to the main production factory of NXP which is located in Nijmegen. As we know, high speed and high accuracy are two critical issues in the domain of semiconductor industry. Higher speed indicates a higher output which obviously can bring more profits for company. High accuracy corresponds to high-performance of the machine. After a short introduction about the basic function of the machines which we were going to see, technicians from NXP took us to the workshop. In the workshop we saw several kinds of superfast assembly machines which are used in the process of the manufacturing in semiconductor products. These machines can operate at high speeds, while still assuring the allowable error. The whole process is observed to get feedback information when something goes wrong. People from NXP were so kind and patient to answer each question that we asked. We were told what kind of actuator and sensor they used and why, which really improved my understanding about mechatronic systems.

After the workshop visit we went for lunch in the main building. Satisfied with this excellent lunch provided by NXP we continued with technical presentations which covered some of the most important topics in the domain of mechatronic design such as loop shaping and feed forward control. They challenged us to come up with hard and much more detailed questions on which they would not know the answer, but as expected it is very hard to beat an expert in his own field of knowledge! To conclude the day in a more informal way we and the NXP crew went for (free!) drinks in a sports bar nearby.

Hans Horrible Puzzling Experience

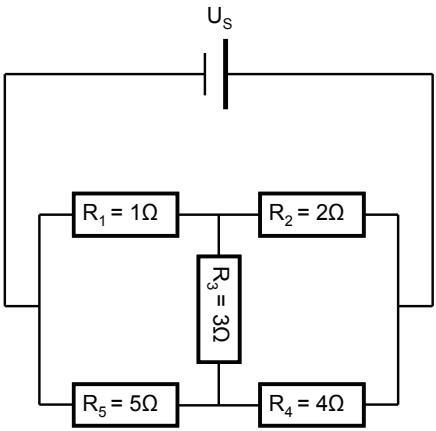
The previous problem appeared to be a too though challenge for the Taylor Vision readers, except of course for Paul van Woerkom. Therefore, the next problem is a bit easier, but still requires you to make a small step beyond the general knowledge of a mechanical engineer. Please charge yourself for the joy of a spark(l)ing electrics problem. And, whenever you're stuck, remember: "de mooiste tijd is elektriciteit".

A voltage Us of 12 V is applied to the circuit below.

a. Compute the equivalent resistance of the circuit.

b. Compute the potential difference over R3.

In order to win a faboulous price; please send your answer to: dispuuttaylor@3me.tudelft.nl. The first two correct submissions will be awarded.



ASML excursion

By Ferry Bastiaansen

Hello everyone! My name is Ferry Bastiaansen, PME student and of course member of the Taylor board. I have written a bit on my experience on our exciting and interesting company excursion to ASML.

Let's start from the beginning: the organization of the excursion. We had a conversation with our ASML contact and were discussing could be organized, and who should be able to attend. Not only master dispute Taylor wanted to go to ASML, but the bachelor study association Leeghwater as well. Therefore it was decided to organize this excursion together. So both specialized PME students and 3th year bachelor students could come. All together about 15-20 students joined this fabulous excursion and Leeghwater arranged a nice bus to bring our group to Veldhoven. The office in Veldhoven is in fact the main production facility. ASML is dominating the market for complex lithography systems all over the world, and is of Dutch origin. This is of course something we are very proud of!

Upon arrival we has a nice cup of coffee in the lobby. Since ASML organized this open day for TU Delft, TU Eindhoven and Twente about 70 students were present. It should be noted here that the TU Delft presented itself much more professional since we were the only delegation that had suited up for this occasion.

First the ASML employees that would be our guides and experts were introduced to us, and an introduction presentation on the company was given. Some interesting fact that I wasn't aware of: the chip production process has many steps, and ASML is only doing the most complex and costly process, namely the lithography step. All other steps are outsourced to other companies. It turns out this single lithography step is big business! Since ASML want to stay ahead on their competitors they invest up to 500 million in R&D each year! Some more technical and detailed presentations, mainly on recent (non-secret) research and plans for the future were given.

After these presentations it was time for the tour. This tour started in the lobby, where developments from the past were displayed. Our guide explained a lot about these machines, what they were capable of, advantages and disadvantages etc. The old machines and the models were opened up so the parts and inner systems became viable. It was quite impressive to see all these thick lenses and clever mechanisms packed together in such s small space. The tour then took us to the production halls and the clean rooms, which unfortunately we were not allowed to enter. I guess 70 visitors entering and leaving your clean room is not that practical. However, we did manage to see the machines and personnel working on the machines behind the glass. Our guide showed us an installation hall. This was a hall where the entire machine frame (of one subpart of the machine) would fit in. It could be rotated and lifted up and down to allow different installation methods: some parts had to be installed with the frame upside down, or 90 degrees tilted. This is what it takes to build these complex machines. The people doing the assembling were highly trained engineers.

We happened to cross the street to another building and passed by a number of containers on trailers. That's where the picture below was made. Nowadays an ASML machine is composed of up to 4 containers. These are transported to the location of the customer and put together. In the future even bigger machines are used, and the machine ASML is working on now would have up to 7 containers.

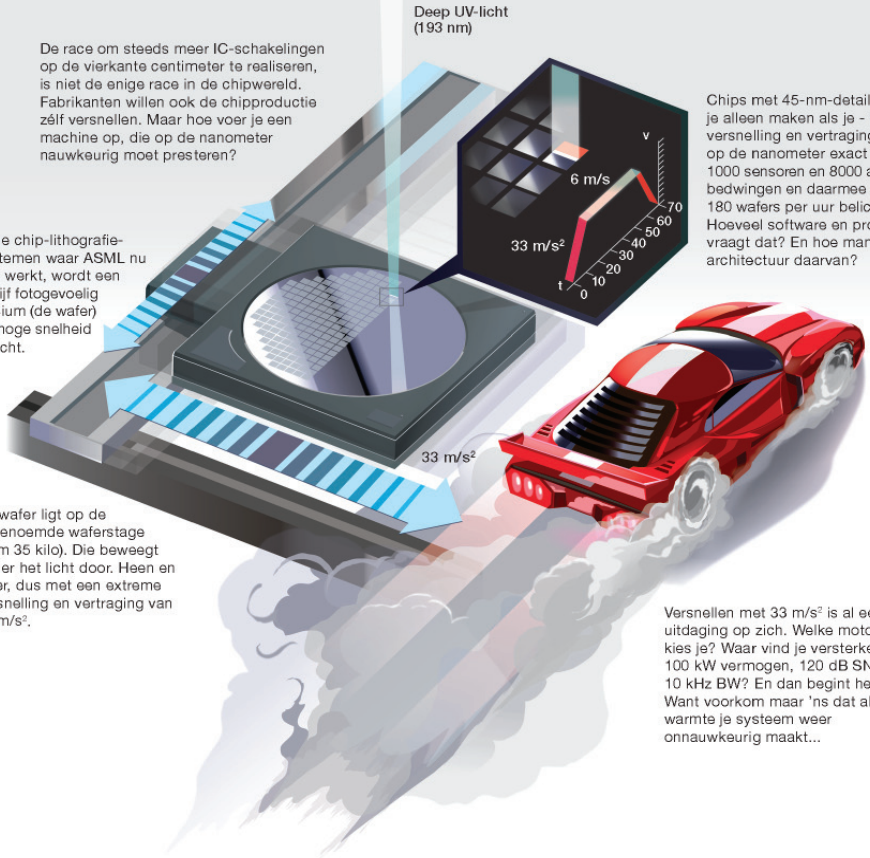
As everyone got a hungry after seeing this much technique lunch was scheduled after the tour.

The afternoon was filled with a case study and a presentation on the case. This case is a problem that still exists today, and no perfect solution has been found yet. It proves difficult to take a wafer and position it to the stage while keeping it perfectly flat. As the wafer is lowered to the stage it tends to take the shape of a dome. It was our job to come up with something that might solve this problem. A vast number of ideas were worked out by the groups, and then presented to each other. After the last presentation our former guide turned out to be a jury member that had taken a critical look at all the groups and their concepts. The group with the best ideas was given a small price, and some remarks were given on how ASML is currently handling this problem.

To conclude this most interesting day (non-alcoholic!) drinks were served in the lobby.

Don’t forget to check our website
www.taylor.3me.tudelft.nl
for the agenda and more information
about our activities!

Morgen kunnen we sneller chips maken. Vandaag mag jij ons vertellen hoe.



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ASML