

FIRMLY ANCHORED IN WIM VAN DER HOEK'S IDEAS

The Design Principles training course underwent considerably changes this year – in a sense. The foundations laid by the renowned professor Wim van der Hoek, the Dutch doyen of precision engineering, remain a strong anchor. The biggest changes are fresh trainers and a few elements of new material. And also the name: the course is now called “Design Principles for Precision Engineering”.

EDITORIAL NOTE

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Piet van Rens was the face of the Design Principles training course for years. He remains connected to the course, but Huub Janssen of Janssen Precision Engineering is the new figurehead. The common denominator

between them is that they both come from the school of professor Wim van der Hoek. Last June, the renewed course was run for the first time – with full attendance. In addition to Janssen and Van Rens, other trainers contributing to the course are Chris Werner and Roger Hamelinck from Entechna Engineering in Eindhoven, professor of Precision Engineering Dannis Brouwer from University of Twente, and Kees Verbaan from NTS-Group.

“This reference work, including the improved solutions, became so well known that eventually everyone found it an honour when their design was included”, says Piet van Rens.

New elements

Van der Hoek's successors, the professors Rien Koster and Herman Soemers and associate professor Nick Rosielle, enriched that foundation. “The new-style Design Principles training course builds on the legacy of principally correct design engineering that we have had in the Netherlands for decades”, says course leader Adrian Rankers of Mechatronics Academy, the partner responsible for all mechatronics training courses at High Tech Institute.

There are also new elements, however. The course now places more emphasis on damping and on advanced elastic elements with a somewhat larger stroke. Elastic elements are often limited in their range of motion, but there are concepts that are able to achieve larger strokes. This is one of the research topics addressed by Twente professor Dannis Brouwer, who provides one day of training on flexure mechanisms.

Brouwer also deals with energy compensation and gravity compensation techniques (think of the kitchen cabinets that you can open and close vertically and that stay in position while still moving up and down easily). “That includes balancing mass-like issues”, says Adrian Rankers. “As in a complex robot system, where you try to get rid of the reaction forces on the floor by having another body simultaneously make the right moves to compensate for those forces. That can be complicated, so we called it ‘energy compensation’, but you could also call it ‘energy balancing’.”

Mechatronics

Rankers emphasises that the ‘mechatronic context’ recurs throughout the course. “On the one hand, it provides additional requirements for mechanics; on the other hand,



1 Piet van Rens was the face of the Design Principles training course for years. While he is still teaching, he has reduced his input this year.

Van der Hoek's design method still broadly underpins “Design Principles for Precision Engineering”. In the sixties and seventies, Wim van der Hoek devised a number of essential design principles, such as the famous flexure hinges with which machine builders could achieve nanometer precision. In addition, he wrote a syllabus from which he gained great fame. In Chapter 13 of that syllabus, named *Des Duivels Prentenboek* (The Devil's Picture book), he collected unsuccessful mechanical designs.

2 Course leader Huub Janssen is the new figurehead of the Design Principles training course. The precision engineer honoured Wim van der Hoek by naming the new meeting and demo room at Janssen Precision Engineering after his great inspirer.

it offers an alternative solution space. It used to be that if you created a positioning system, you did that with a cam drive and a drive chain up to the element that you had to position properly. In that chain you came across all kinds of friction and play, all of which was very annoying. In a mechatronic movement system, however, you have sensors on your payload. They say exactly what the position or position error is. In principle, you won't be bothered if there is a bit of friction or play in between, because you already have that information and can immediately compensate. These kinds of trends have shifted the subject focus in the Design Principles training course, although it remains the case that you can never get a high-quality system solution with rattling mechanics”, says Rankers.

“We have cut a bit in the less important topics to make room for the new topics.”

Precision engineering

Course leader Huub Janssen has set himself the goal of structuring Design Principles in the spirit of Van der Hoek. “We are talking about design principles for precision engineering. That is the world of complex machines and instruments for the chip industry, astronomy and space travel. In order to position with accuracy greater than a micrometer, you cannot simply use standard functional elements such as bearings. So you come to elastic elements, without friction and those kind of things. Then it becomes exciting, because then you are very close to the underlying physics.”

Thought experiments

Janssen states that manufacturers must recognise that they cannot buy standard parts from the catalogue. They have to think a bit further, analyse all the problems that may arise. Then they have to do thought experiments: where can things go wrong? Once they can see that, the solution direction is close.

Van der Hoek used to ask his students to do thought experiments, says Janssen. “I still remember Van der Hoek asking us to crawl mentally into a ball bearing, to imagine the outer ring and the inner ring with all the balls in between. We had to make ourselves small enough to sit between those spinning balls. Then you could see that the ball on one side was against the ring, while the other side exhibited play. Then you saw that a ball was not completely round; it had butts and didn't roll nicely. You didn't have to have much experience, but you really needed imagination.”

It is no coincidence that Janssen wants to enrich the training course with experience and exercises. “The solution directions are important. I don't do much with formulas. These are necessary, but calculations are the last ten per cent. Designers especially need to get a feel for the details. What should they pay attention to? How do they solve it? You first need to know where things can go wrong and come up with a good conceptual direction. First of all, I want to instil intuition. The maths comes after that.”

Cases first

To that end, he wants to introduce cases. Van der Hoek did that in his Devil's Picture book, in which he published many failed projects. “Participants have to work on cases on their own and in groups. Then we discuss them in the larger group. I don't want to give a lecture, I want interaction.”



Exercises, interaction and working on practical cases are distinctive elements in the training courses that Mechatronics Academy and High Tech Institute bring to the market. Other course providers also offer the course, but in a three-day variant. "Some clients make the Design Principles course compulsory for secondment. Engineering firms then sometimes opt for the three-day variant on the basis of cost or for a variant that runs in the evenings", says Piet van Rens, who also has experience as a trainer in the three-day course.

He thinks this is a less sensible choice, as participants in the short version really miss something. He feels that exercises are the most valuable components of the Design Principles course. They ensure that the subject matter really sticks and that participants actually understand the content and are able to apply it in their daily work. It is precisely that hands-on element that is killed in the shortened version. "The three-day and evening trainings are not bad, but they rush through the content in a short time. Especially in the evenings after a normal working day, people are tired. If you only 'send' rather than offer exercises, then the result is noticeably less", Van Rens concludes. ■

Topics

The five-day "Design Principles for Precision Engineering" training course covers the following topics:

- The role of stiffness and compliance in mechanisms and how to evaluate these mechanisms
- Controlling degrees of freedom
- Optimal use of elastic elements
- Friction, hysteresis and micro-slip
- Real and virtual play
- How to realise damping
- Balancing manipulators

The training material was originally developed by Prof. Ir. W. van der Hoek (Philips and Eindhoven University of Technology (TU/e) from 1962 until 1984) and Prof. Dr. Ir. M.P. Koster (Philips, TU/e and University of Twente from 1984 until 2008).



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