NEW TEACHERS, NEW MOTIVATIONS, NEW TRAINING COURSES

Inventas is a leading training institute in the Dutch high-tech ecosystem. Recently, it has employed two new teachers, updated its 'classic' Design Principles training and introduced two new dynamics training courses. Underlying these developments is the ongoing miniaturisation in high-tech systems and the associated need for ever higher accuracies and, hence, better predictability of dynamic behaviour.

Sixteen years ago, mechanical engineer Jos van Grinsven, then a teacher of design principles at Fontys University of Applied Sciences in Eindhoven (NL), founded the Inventas training institute in Nuenen (NL). Nowadays, Inventas employs over a dozen experienced freelance (part-time) teachers to provide a wide range of mechanical engineering training courses for companies, large OEMs as well as SMEs.

The Inventas training portfolio ranges from Design Principles, Reading Technical Drawings, and Tolerance Analysis, to Machine Dynamics, Design for Manufacturing, and Consultative Advising for Engineers. The target group includes engineers at intermediate technical, higher professional and academic level. All training courses are tailored to the training goals of the individual students and are preferably presented in a classroom setting, for live interaction with a small group of (a maximum of ten) students and with lots of practical exercises.

Design Principles

As the cornerstone of the Inventas training portfolio, Design Principles is firmly based on the famous Dutch canon of (precision) mechanical design, with teachers such as Wim van der Hoek, Rien Koster and Herman Soemers. This training is concerned with creating a mechanical design that is lightweight and has the right stiffness and the right degrees of freedom. Questions to be answered: What are well-functioning constructions and modules for (accurate) movement and positioning? How do you apply elastic elements in your design? How do you make smart use of sheet metal and other materials? And so on.

The ultimate goal is to achieve the required dynamic behaviour while avoiding precision-disturbing phenomena such as play, friction, hysteresis, micro-slip and wear. Even high-precision machines exhibit friction, which causes static position indeterminacy, also known as virtual play. This phenomenon and its avoidance are becoming increasingly important due to process and product miniaturisation.

While Van Grinsven for many years presented the Design Principles training on his own, he recently decided to further intensify personal attention to students by forming a duo with a teacher who is new to Inventas, Arne de Roest. De Roest graduated in mechanical engineering at Eindhoven University of Technology (NL), in the group of Nick Rosielle, one of the champions of the ideas of Wim van der Hoek. After having worked as a mechatronic system architect and mechanical engineer at Prodrive Technologies in Son (NL), he now is a freelance (lead) mechanical engineer and system architect.

De Roest decided to become a part-time teacher because of his passion for knowledge transfer (Figure 1), drawing on his experience in solving precision positioning challenges in his daily work. "That is also what we ask of our students, to immediately apply what they have learned during the training in their daily practice and come back to the following training days with practical examples, which we then discuss."

Van Grinsven: "If a student presents a practical situation in a training course, for example a set of drawings of a device, Arne quickly arrives at the core of the problem with a few specific questions. Not everyone has that much technical insight." De Roest: "In that respect, I follow the approach that Van der Hoek and Rosielle have advocated; each time trying to put yourself in the position of the object you are designing, to understand how it works by asking yourself: what do I feel, how am I being pulled at, what positions am I fixed at, in what degrees of freedom can I move? And so on."

Over the years, students have come up with new questions, Van Grinsven and De Roest observe. About the circular

EDITORIAL NOTE

This article was based on interviews with Inventas director Jos van Grinsven and teachers Arne de Roest and Jurnan Schilder.

Arne de Roest teaching Design Principles. (Photo: Inventas)

economy, for example. "We contribute to this based on Van der Hoek's philosophy of creating as much effect as possible with as little material as possible – lightweight – and making a sustainable design that does not need to be replaced every five years. The less friction and play you allow in your design, for example, the more wear is prevented. We do not focus on the end of the lifecycle, on recycling, but rather on the beginning: making smart constructions that are sustainable, lightweight and energy efficient."

Current demand for the Design Principles training is also driven in part by the need for new platforms for machines and devices. "Companies have sometimes been working for decades with a platform on which they have continuously developed new versions. But because it has to be smaller, faster and more accurate, such a platform will no longer perform at a certain point in time and a completely new platform has to be designed. Standard off-the-shelf components and modules then no longer suffice for this, so mechanical engineers have to develop these themselves from scratch. That is why they first attend our training."

Consequently, new questions arise together with new motivations to follow the training. At the same time, Van Grinsven and De Roest are working on renewing the training itself, including an update of the teaching materials to make these even more practical. This may lead to an extension of the training duration, now four days spread over four weeks.

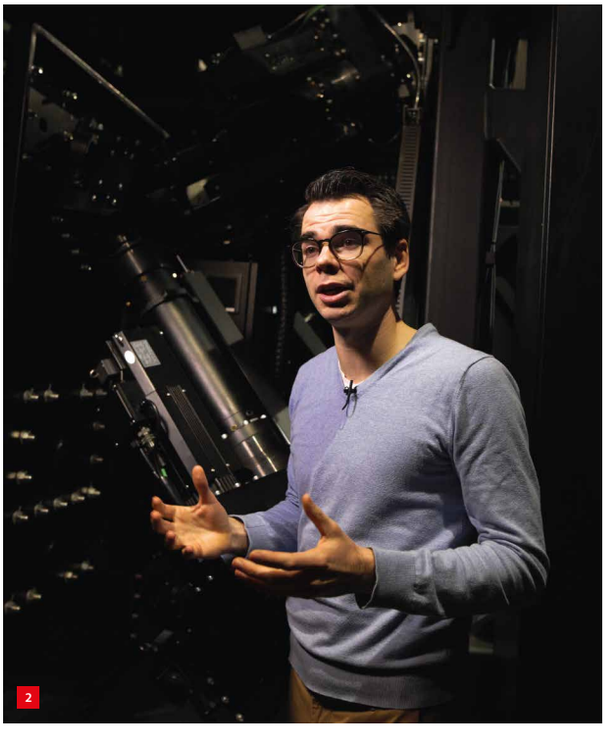
Dynamics

A completely new training course in the Inventas portfolio is Machine Dynamics, which was first offered in 2021. It is taught by a new (part-time) lecturer at Inventas; Dr Jurnan Schilder, assistant professor in Structural & Multibody Dynamics at the University of Twente (NL). In 2022, he will also teach the new Engineering Dynamics training course for the first time, which serves as an introduction to the domain of dynamics.

Schilder's research interests are in the field of flexible multibody dynamics, while his passion also lies in education (Figure 2, next page); in 2014, he was the winner of the University of Twente's Best Teacher Award. He prefers to work with a blackboard and chalk (or tablet and tablet pen), to create the flow of calculations and explain the subject matter step by step, in order to keep every student's attention – always without slides, like every teacher at Inventas working without PowerPoint.

Because of the tightening dynamic requirements in high-tech system design, and facilitated by the ever-increasing computer power, nonlinear calculations and 3D simulations are becoming ever more important for accurately predicting the impact of deformations and vibrations on machine behaviour. Ultimately, this leads to a convergence/combination of finite-element models and multibody models.

Here, multibody refers to the connection of individual (deformable) bodies through joints and other links, such as elastic elements. In principle, every object is multibody, Schilder admits. "But in the 1970s, finite-element modelling (FEM) and multibody modelling, for computational efficiency, have become separate branches of the computational engineering tree. On the one hand, FEM has become very popular with mechanical engineers to analyse individual bodies and derive mechanical and dynamic properties from their CAD models, given a particular load



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Jurnan Schilder presenting for the YouTube channel 'Theme Park Science', showing the motion simulator of 'This is Holland', the 'ultimate flight experience' in Amsterdam. (Photo: Dekate Mousa)

case and the associated boundary conditions. While on the other hand, systems engineers and control engineers, for example, use to reason in terms of multibody models with lumped masses and stiffnesses allocated to joints."

FEM can now be used to calculate properties for each body that is incorporated in a multibody model, Schilder explains. "This model is then built up in an absolute coordinate frame, in which the movements of the various bodies are described, while each body has a local coordinate frame in which its deformations are calculated. From the various FEM models, the elements of the overall mass-stiffness matrix of the multibody model can be calculated. The dynamic simulation of the multi-body model, covering a wide workspace (without linearisation), is then performed and the stresses and strains of the local bodies can be calculated in post-processing."

When system elements are getting lighter and more high-frequent vibrations are being introduced, while strokes are becoming bigger, this combined approach is required to model system dynamics in sufficient detail, in order to enable even faster movements without compromising accuracy. Application examples include extremely fast accelerating stages, robots with rotating arms, hexapods that can control a platform with six independent legs, the unfolding of solar panels for satellites in space, and roller coaster dynamics (Schilder's 'guilty pleasure' specialism).

The new Machine Dynamics training course covers the basic skills that mechanical designers must master to communicate well with a multibody model expert. Think of the principles of dynamics calculations and the distinction and connection between kinematics and dynamics: when can calculations be restricted to the kinematics and when have the dynamics to be incorporated? In the end, the students will be able to understand what happens when dynamics calculations are performed using one of the available commercial software packages.

Ultimately, the two training courses that Schilder now teaches, Engineering Dynamics and Machine Dynamics, are to become part of a series of four courses, which together cover the field of dynamics in increasing order of complexity. The last two training courses have already been developed and are now awaiting their debut in 2022: Vibrations, and Flexible Multibody Dynamics, in which Machine Dynamics and Vibrations come together to produce the state-of-the-art in dynamic systems modelling.

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