SIMLab

Centre for Research-based Innovation

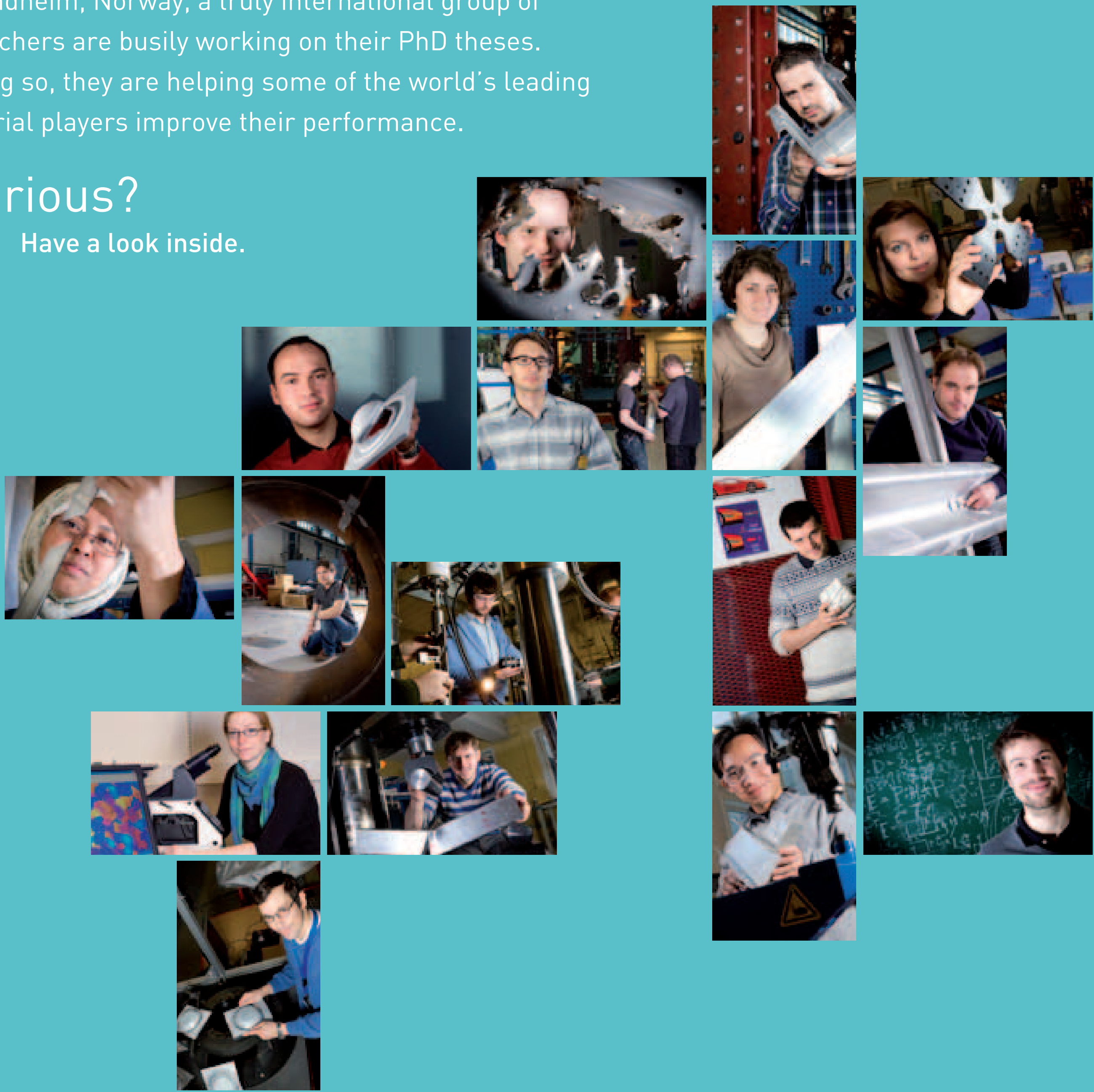
sfi Centre for Research-based Innovation
Established by the Research Council of Norway

Improving the best

In Trondheim, Norway, a truly international group of researchers are busily working on their PhD theses. In doing so, they are helping some of the world's leading industrial players improve their performance.

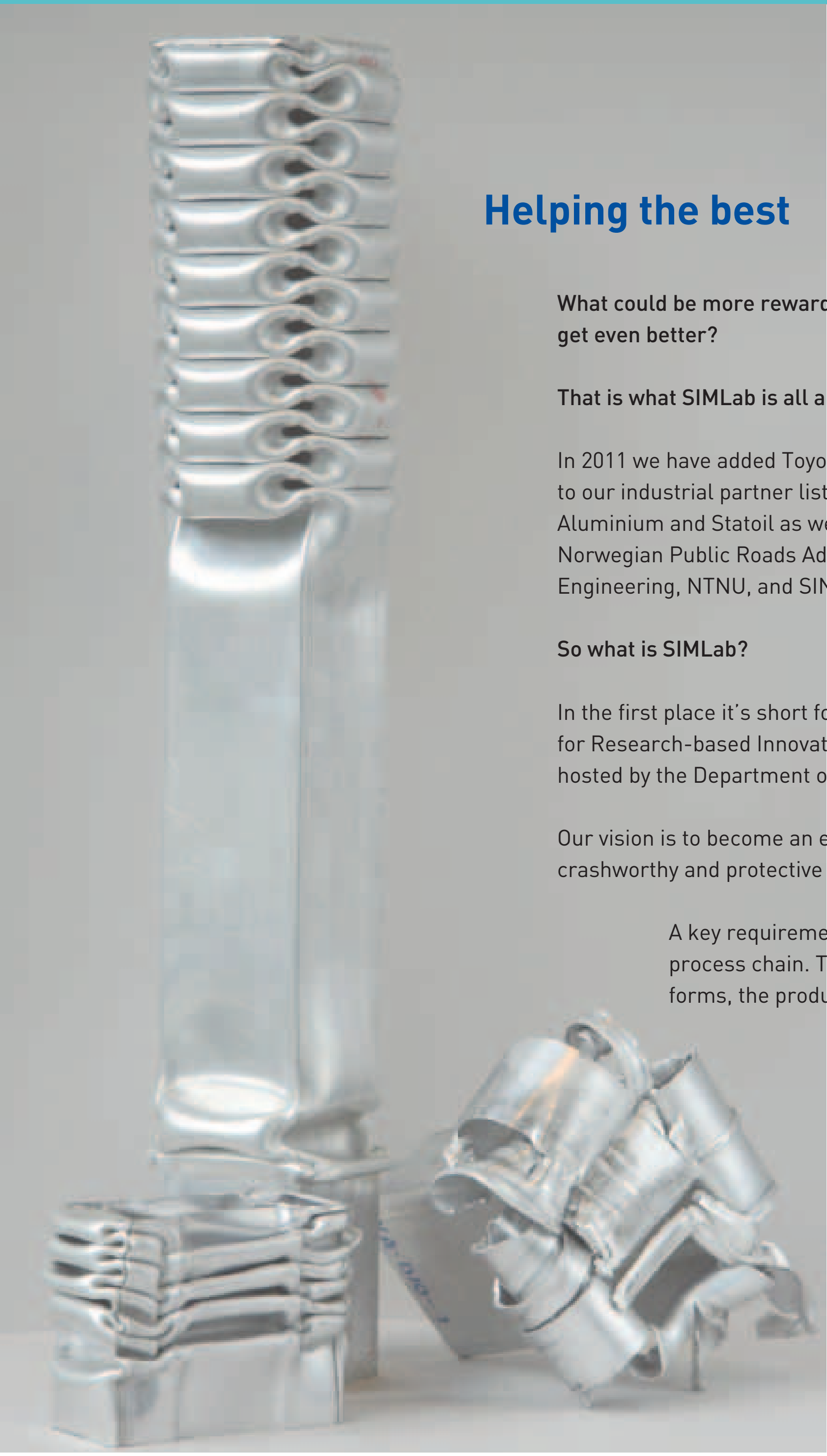
Curious?

Have a look inside.



NTNU – Trondheim
Norwegian University of Science and Technology

SINTEF



Helping the best

What could be more rewarding than helping some of the world's top industrial players get even better?

That is what SIMLab is all about.

In 2011 we have added Toyota Motor Europe, BMW and Benteler Aluminium Systems to our industrial partner list, a list that already comprised Audi, Renault, SSAB, Hydro Aluminium and Statoil as well as the Norwegian Defence Estates Agency and the Norwegian Public Roads Administration. The Department of Material Science and Engineering, NTNU, and SINTEF Materials and Chemistry are research partners.

So what is SIMLab?

In the first place it's short for the Structural Impact Laboratory. Second, it's a Centre for Research-based Innovation established by the Research Council of Norway and hosted by the Department of Structural Engineering, NTNU.

Our vision is to become an established world-leading research centre for the design of crashworthy and protective structures.

A key requirement for success is the efficient modelling of the whole process chain. This involves a strong coupling between materials, product forms, the production process and structural behaviour.

We follow this by implementing the developed technology through the mutual exchange of personnel between the Centre and our industrial partners.

Among our academic goals, of course, is helping a significant number of PhD candidates to successfully complete their doctoral education. This leaflet gives you a chance to meet them. Enjoy!

Text: Albert Collett. Photo: Ole Morten Melgård

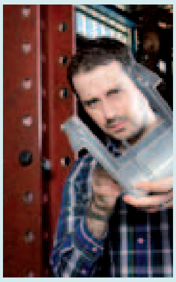
Industrial partners in 2011

HYDRO · Statoil · Forsvarsbygg · RENAULT · SSAB

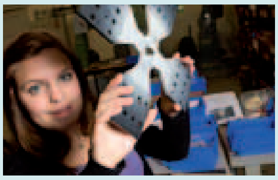
Statens vegvesen · Audi · BMW · TOYOTA · BENTELER Automotive

Meet . . .

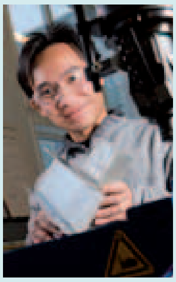
... Anizahyati Alisibramulisi from Malaysia. She might give you a lesson or two in Silat Gayong, an ancient martial art in her homeland. She might also expand your knowledge about the behaviour of welded aluminium structures...



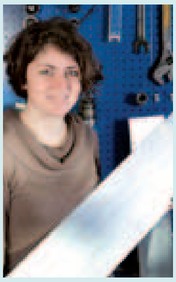
... Octavian Knoll from Germany, who helps Audi make even lighter and more reliable rocker rails and pillars for their cars. Octavian traces his engineering roots back to an early childhood fascination for screwdrivers and hammers.



... Anne Serine Ognedal from Norway. Anne Serine loves plastic. Before joining SIMLab, she worked on advanced medical manikins and learned how you can modify the structures of plastic to get the properties you want.



... Nguyen-Hieu Hoang from Vietnam. He could end up being named the wizard of Vinh. That is, if he succeeds in gaining sufficient control of his magic wands. In Hieu's case, the wands are self-piercing aluminium rivets for the car industry.



... Marion Fourmeau from France, who plays the oboe. She also studies the fractures of high-strength aluminium alloys. These alloys are particularly tough thanks to hardening precipitates inside the aluminium grain.

Meet these 5 as well as 11 other PhD candidates on the following pages and get a glimpse of 16 fascinating histories, personalities and programmes.

Martial and other arts

Since primary school Anizahyati Alisibramulisi has loved drawing. In secondary school she took up martial arts as well. Beware! Malaysian martial arts are no joke.

Some people actually claim that martial arts legend Bruce Lee died after losing to a master of Silat Gayong. Enough said? Possibly not. Anizahyati is all smiles and looks very innocent. Maybe further warning is in place. Joking aside, we don't really think so.

Structural behaviour

It's not for everyone to understand the complexity of PhD programmes. Anizahyati had that in mind when she put down ten sentences to describe the content of her thesis at SIMLab. Sentence one explains that the aim is to improve the modelling of the structural behaviour of welded aluminium structures, with emphasis on the effect of heat affected zones, since these cause the main problem in welded aluminium structures. To an amateur that's partly understandable, but only partly; "what exactly does she mean by structural behaviour?"

Anizahyati explains: "A structure refers to a system of connected parts used to support a load, whereas the behaviour of the structure to withstand that load is called structural behaviour."

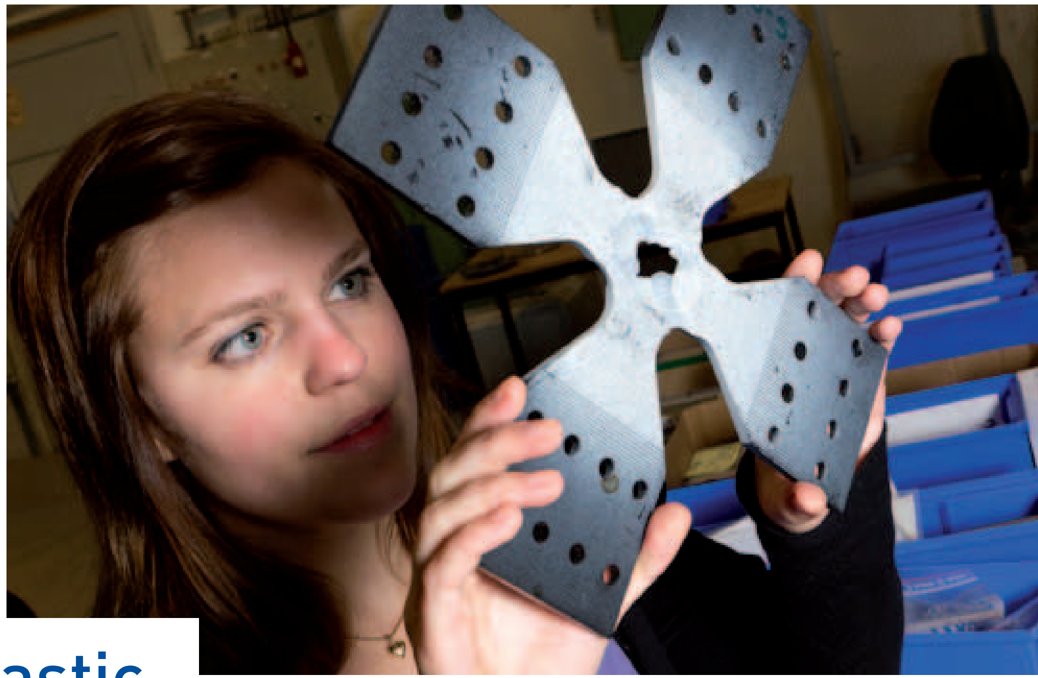
Aunt Gerda

Anizahyati also helps with the last sentence. This is aimed at aunt Gerda: "What I am doing is all about getting to know my best friend Ms Aluminium – what are her strengths and weaknesses when heated. Then Mr Computer will try to show what she has gone through on the screen. If it is correct, Mr Computer can be her new "aluminium forecast" like the weather forecast."

Our conclusion? Thank heavens for aunt Gerda. Anizahyati's conclusion? She looks forward to return home with her newly acquired expertise, not only in aluminium but also in personal relations.

Friendly professors

"The professors here are so friendly. They treat us like colleagues. I will also bring back the way we work with industry and the time we have for research. In my university we have to teach at least 20 hours a week. The equivalent here is six hours. When I return home I will tell my university that we need more time for research. Finally, I will contact the car industry in Malaysia to check on the possibilities to continue industry-related research."



Plastic fantastic

"I love plastic! It's a fantastic material with endless possibilities," says Anne Serine Ognedal. She feels extremely privileged to be able to pursue her curiosity at SIMLab.

Before being recruited to her programme, Anne Serine worked on Laerdal Medical's most advanced manikin. The anatomical model gives correct responses to all kinds of impulses, pupils expanding with increased adrenalin and all. Price tag: the equivalent of a small car. Just as well Anne Serine left Laerdal. If not, who knows; she might have been developing a new model, replacing us all at the workplace.

Wanted to know

"At Laerdal Medical I experienced how you can modify the structures of plastic to get the properties you want. You can make geometries of plastic like no other material. I also discovered that no one knows the exact properties of the materials. I always wanted to know more, so when I got the chance to become a PhD candidate here at SIMLab, I decided to take the opportunity," she says.

Small pores

The title of Anne Serine's programme is "Damage and fracture of polymers". This means that her work deals with exposing pieces of plastic to large deformations. If you ever tried to deform a piece of plastic yourself, you might have seen that it turns white. Anne Serine's PhD work basically starts where the plastic turns white and ends where it breaks. She tries to find out how much polymer materials can take before they turn white and after that how the white evolves and causes fracture.

What we perceive as white when we look at it, really is lots and lots of micrometre-sized pores. They are formed as the material is deformed. The pores look white (when we don't look at them in a microscope) because light is scattered when it hits them.

All this has to be expressed in mathematical terms so a computer can understand and compute the whole process.

Incredible

If Anne Serine succeeds in her research, computers will be able to predict how a bumper deforms when a car hits a pedestrian. This can be used to try out different designs on the computer in search of a bumper that doesn't hurt the pedestrian.

Useful? Definitely. Fun? Anne Serine puts it like this: "People don't know how great it is to do a PhD. Little me working with world-class scientists. When I entered the programme, the professors asked: "What would you like to do?" Incredible."

What do you do when your ambitions reach further than a degree from your local university can get you? You break up.
Meet **Dmitry Vysochinskiy**.

The Russian exclave of Kaliningrad is surrounded by the EU; Poland to the south, Lithuania to the north and east, and the Baltic Sea to the west. Until 1945, Kaliningrad was Königsberg, capital of East Prussia, home of Immanuel Kant. More about him later.

Technical guy

Meet Dmitry Vysochinskiy first: "I was a technical guy right from the start, good in maths and natural sciences. After obtaining my bachelor's degree I decided I didn't want to spend my life as a construction engineer in Kaliningrad, so I found a master's programme at Chalmers University in Gothenburg. After that I landed a job as a pipeline engineer with Reinertsen Engineering here in Trondheim," Dmitry recounts. After two years in industry, he filed an application at SIMLab. It's still early days, but the topic of his programme is clear: the forming of metal sheets. The experiments will be carried out with an aluminium alloy; exactly which one is yet to be decided.

Stretching limits

Like many of his colleagues, Dmitry will subject his material to large plastic deformations and examine what happens when the material fails in different ways. He is particularly interested in stretching. When a material is stretched, a number of phenomena may occur.

The sheet can simply tear if the metal is not ductile enough. Then there's the plastic instability. If you stretch, you want to do it uniformly but you may experience local instability. Plastic deformation concentrates at one place; the metal sheet becomes thinner and eventually fractures there.

Shear instability may be regarded as a special type of fracture and is yet another phenomenon to be studied.

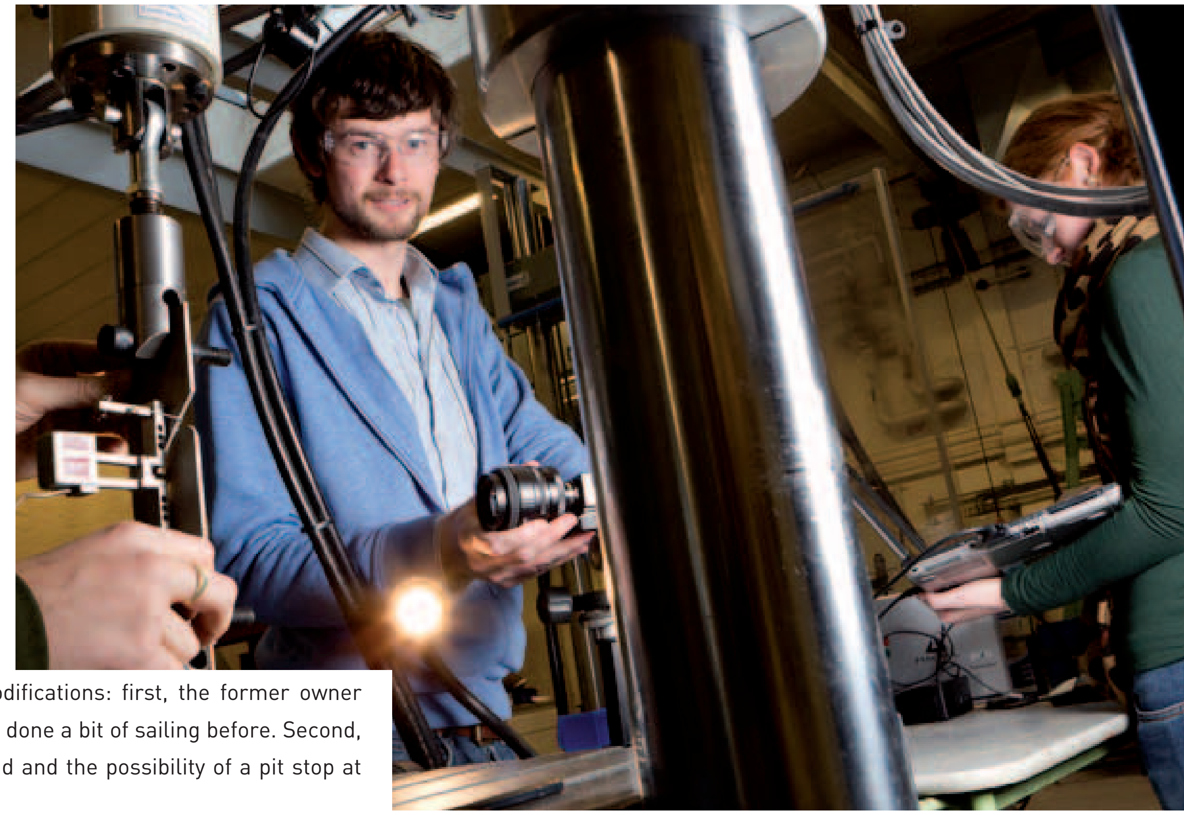
Idealist

"The main question is how the material properties influence the forming limits. We can determine the material properties. We can also determine forming limits for some simple cases of forming by experiments. The challenge is to combine these two and predict the forming limits for more complicated cases of forming," Dmitry says.

He confesses to be a bit of an idealist. That harmonizes well with fellow citizen Kant and his doctrine on transcendental idealism, which maintains that the human experience of things is similar to the way they appear to us. It remains to be seen whether Dmitry's thesis will be in accordance with this.

Setting off for Spitsbergen

Listen to this: Egil Fagerholt had never set foot in a sailboat. The first thing he did after buying one in 2008 was to head for Spitsbergen. That's six days and nights of sailing due north in Arctic waters.



Two comforting modifications: first, the former owner came along. He had done a bit of sailing before. Second, there is sight of land and the possibility of a pit stop at Bjørnøya half way.

It ended well, with a little help. As they closed in on Spitsbergen, fog closed down visibility. The VHF had broken down so they never got the message that a massive ice floe was heading their way. Neither did they know that several other boats were caught in the ice nor the fact that the Norwegian Coast Guard was searching to stop them in time. Luckily, the fog lifted just before they reached the ice. Right in front of them was the Coast Guard, blocking the way to give a clear message.

And now, science

So, there's a daring scientist for you. Maybe that's why he's not afraid to enter new territory. Where others study fracture and crack propagation through testing and calibrating with numeric simulations, Egil has chosen the camera as his tool, taking advantage of the extreme developments in technology. 10 000 high resolution exposures a second is way beyond an Instamatic. Typically several hundred digital images are recorded in a single experiment.

Develops software

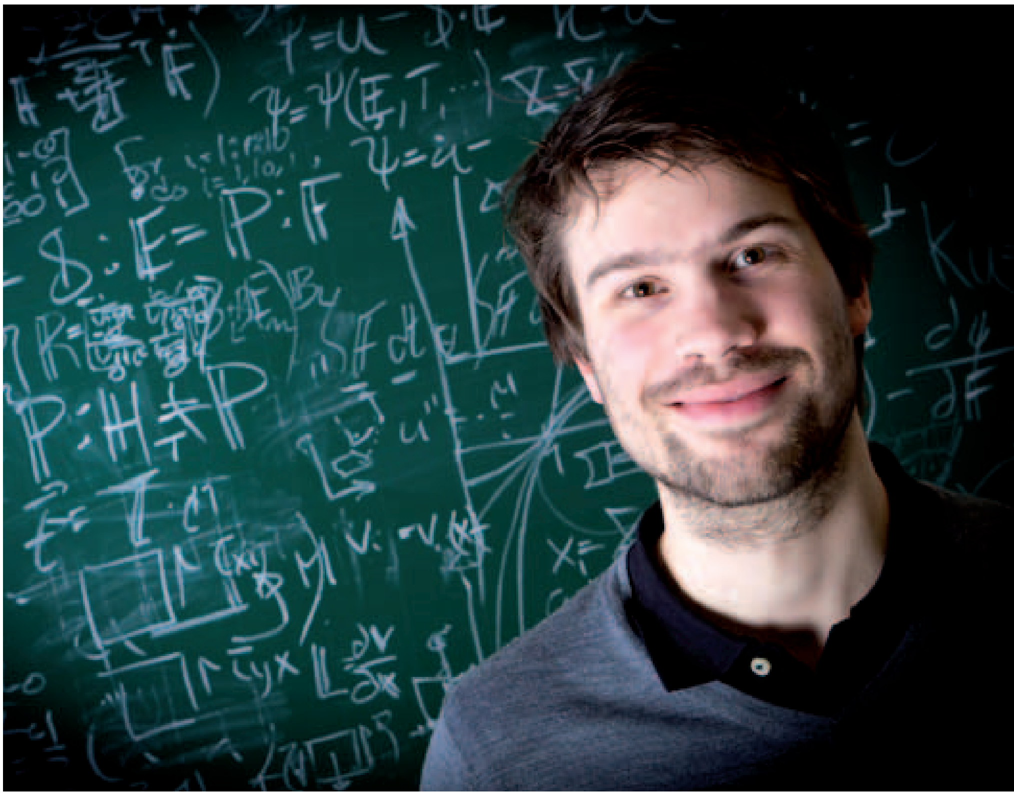
"The camera generates massive amounts of field info directly from the test. The method can be compared to numerical simulations but my approach moves in from the other side, so to say. Where others use commercial software, I develop it. The challenge is to measure samples with crack propagation. The main task in this PhD work is developing software algorithms to analyse such image series. That part of the work is also the biggest kick for me," Egil confesses. He truly enjoys being able to concentrate on a project for a long time and has already accepted a position as Post Doc.

Ready for release

After defending his thesis later this year, Egil hopes to develop his software further towards a user-friendly application. Only time will tell if it can be turned into a commercial product.

"In principle it should be interesting for experiments with any material – steel, aluminium or plastic," predicts Egil.

Searching for the soul



We all know it. Judging merely by looks is foolish. In the long run inner qualities count more. Not only when it comes to people. The same goes for materials.

The question is how you find the soul of steel and how you describe it . **Espen Myklebust** is doing just that.

"When you look at a material, it looks homogeneous. However, if you subject it to an increasing load, something will happen. At a certain point the material will weaken in one place or other. What inner qualities make this happen? If you look at the material in a microscope, you will see variations. These variations are not taken into explicit consideration when the strengths and weaknesses of the material are modelled. That's what I intend to do something about. My aim is more realistic models," he says.

Double benefit

Espen's method is to describe the variations, to disclose the soul of the material as it were, and then to make models and perform analyses. In the verification process he will see if the same things happen in experiments as in the models and if the model could be applied to more metals. There are double benefits:

"First, the models will help us find good designs for existing materials because we will have a greater understanding of how the structures of the material influence its mechanical behaviour. More correct models may also diminish the need for safety factors.

Second, the models will help us design new and better materials. For instance, we can better decide the right size of material building blocks.

The exciting part is the principles and methods: can we do this? Can we actually make these models? If the variations from the computations match the variations from the lab I have succeeded," Espen sums up enthusiastically.

Planes and bicycles

His interest for engineering is easily explained. His father works for Volvo Aero Norway, producing plane parts. Espen developed an early interest in bicycles and soon became the popular bicycle mechanic for all his mother's friends. Before long he made money from his expertise, working part time in the local sports shop all through secondary school.

His decision to start studies at NTNU came as a logical consequence: "I went to an education fair to look for a good place to become an engineer. NTNU's folder had a fancy sketch of a bicycle on the front page. That did it!"

The steel tormentor

As far as we know, steel doesn't feel pain. Just as well. Gaute Gruben is putting it through all kinds of strain.

Imagine being pulled by your head and heels till you actually split in two. Just the thought of it is torture. Gaute Gruben may be a tough guy, but he wouldn't dream of such an experiment. Give him steel, though, and he's ready for anything. As it is, no one suffers from his work, with the possible exception of his girlfriend. Gaute admits being a bit of a workaholic.

Norwegian wood

He started out as a carpenter in his home town of Mo i Rana in northern Norway. Then he developed his interest to become a civil engineer. At the end of his fourth year at NTNU, Centre Director Magnus Langseth from SIMLab suddenly turned up in class. He had been given five minutes. That was enough. Gaute's interest was caught. He sent an email and received an invitation to visit. Before long he was taking his master's degree at SIMLab.

Swedish steel

SSAB supplies Gaute with the two millimetre steel plates he needs for his experiments. The Swedish steel producer is one of SIMLab's partners. In return they get advanced knowledge about the qualities of their products.

What Gaute does, is to take specimens of different shapes and pull them till they break in the middle. He then simulates the experiments with numerical models from which he collects data that determine the fracture characteristics of the material. This data is then used to calibrate different types of fracture criteria.

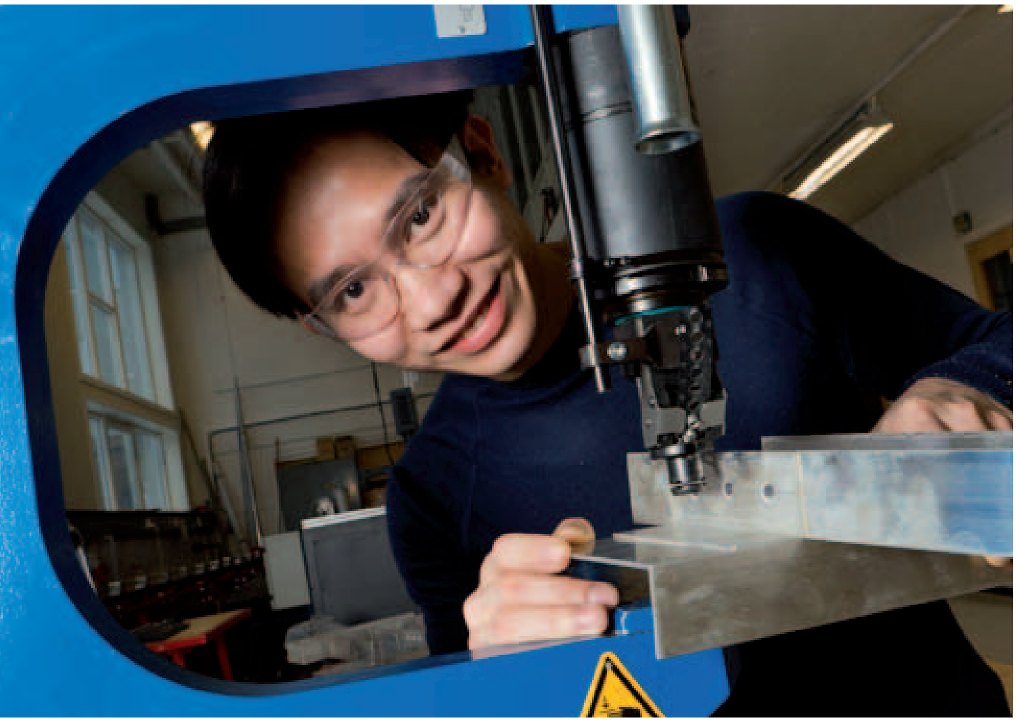
"We need different types of tests; first we need tests for calibrating the criteria, and second we need tests for validating the criteria. Afterwards we can foresee when the fracture occurs," Gaute says.

Danish girlfriend

Moving from Norwegian wood to Swedish steel it's only natural that Gaute has a Danish girlfriend. But that is a total deviation, of course. Let's get back on track.

In the last part of his PhD project, the plan is to test different numerical techniques for simulating crack propagation. The element erosion technique will be compared with the node splitting technique and the extended finite element method. The simulations will be compared with experimental data.

"The car industry is interested in this. Some phenomena linked to fracture have not been thoroughly explored. At the end of my PhD programme I hope I have made a contribution to better understanding."



The wizard of Vinh

Every American child knows the wizard of Oz. It remains to be seen whether Nguyen-Hieu Hoang will be named the wizard of Vinh and be as well known in Vietnam.

Don't rule it out. If Hieu succeeds in his efforts to introduce aluminium self-piercing rivets in the car industry, he may have done the environment a great service. Hieu rightly sees his little tubular rivets as magic wands. They may be smaller than the one in Oz, but they surely have the potential to work wonders. And they are plentiful.

Adding heat

Until now self-piercing rivets are made of steel. There may be over a thousand rivets in a modern aluminium car body. Thus, it is a costly and difficult process to remove the steel rivets when recycling the car body. It would be much cheaper and easier with aluminium rivets. The aluminium alternative would also reduce the car's weight.

Therefore BMW, Audi and Renault are following Hoang's experiments with interest. "Riveting with aluminium rivets is a challenging task, since the strength of aluminium alloys is much weaker than that of steel. The aluminium rivet can be severely deformed when compressed into the aluminium plates, and hence no connection is formed. Heating the aluminium plates to be joined before riveting might be used to facilitate the process, but we still aren't where we want to be," he admits.

Different alloys

Hieu's experiments also show that the aluminium rivet may fracture when riveting aluminium plates. Through further experimental and numerical work he hopes to find out what 'potion' (i.e. a right relation between the strength of the rivet material and the plate materials to be joined) will provide good mechanical behaviour. His work includes self-piercing rivets and plates in different aluminium alloys. He is not trying to modify the geometry of the rivet. That will be left for future research.

All these elements are of extreme importance since the "strength" of a car depends not only on the behaviour of the car components but also the strength of the joints.

To learn English

People have all kinds of reasons for coming to Norway. Hieu already knew French from home in Vietnam and improved it further when he took his master's degree in Rennes. "Therefore I was looking for a place to take my PhD where I could improve my English," he explains. He is happy about the choice: "The scenery is beautiful and people are open."

Hieu claims to be a patient person, but everyone has their limits. "I hope I gain sufficient control over my magic wands before I become crazy. If I succeed, I can call myself a wizard. That's when I will have deserved the PhD," he smiles.

How to bake a bumper

If you want to bake the perfect loaf of bread, finding the right balance between time and temperature is crucial. The same goes for bumpers, of course. Ask Ida Westermann.

She fell in love with aluminium at the age of eighteen. Raised in the Danish village of Bredebro, she was invited to spend two weeks at the nearby plant of Norwegian aluminium firm Hydro. That started it all.

Not in the family

"My mother is a midwife and my father a veterinarian. There was nothing in the family to suggest I should become interested in physics. But I did. I discovered it in high school and readily accepted the invitation from Hydro when it came," she says.

After two weeks learning about extruding and plastic forming, she was also invited to visit NTNU in Trondheim as well as the Hydro plants in Sunndalsøra and Raufoss. By then she was hooked: her future was in metal. If all goes well she will have earned her PhD by June.

A bumper in the oven

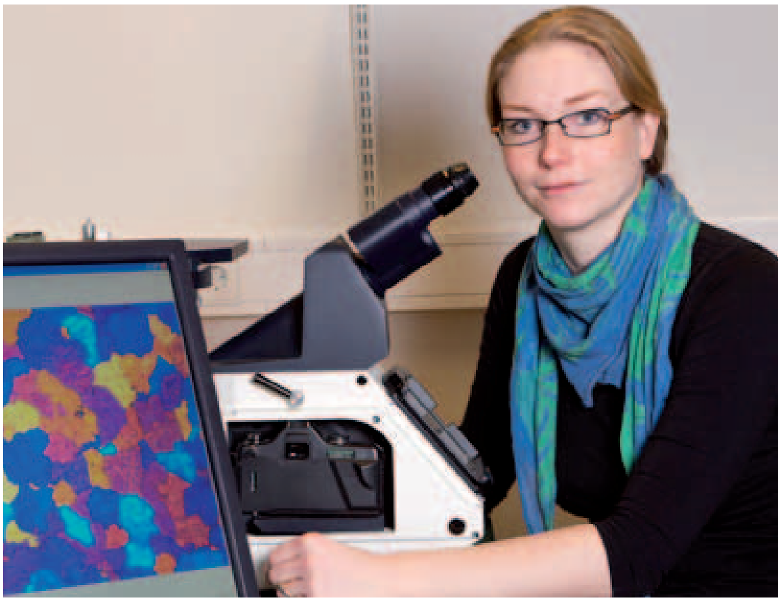
When Ida puts a bumper in the oven, artificial ageing is the correct scientific term for the baking process. Small nanoscale particles can be created to increase the strength of a component. The mechanical response is greatly dependent on the microstructure, i.e. what the interior of the metal looks like on a nano-/micro-scale level.

"Strength will increase with time up to a certain level. After that it sinks. The same is valid for temperature. To be able to control this process, it is important to know what happens inside the material. In my PhD project I am trying to find a mathematical relationship between microstructure and strength of aluminium based on experimental investigations," Ida says.

Shooting electrons

A possible aim for finding the right balance is to reduce weight. Another is to find the strength. If the metal is very strong, it may become crunchy. Reducing the strength a bit increases bendability and ductility. These are properties that are needed in bumpers for maximum reduction of injury to people.

To study what happens, Ida cuts tiny disks, 3 millimetres in diameter, one tenth of a millimetre and downwards thick, and etches a whole in the middle. Then she puts them in the transmission electron microscope. The area nearest the hole is very, very thin.

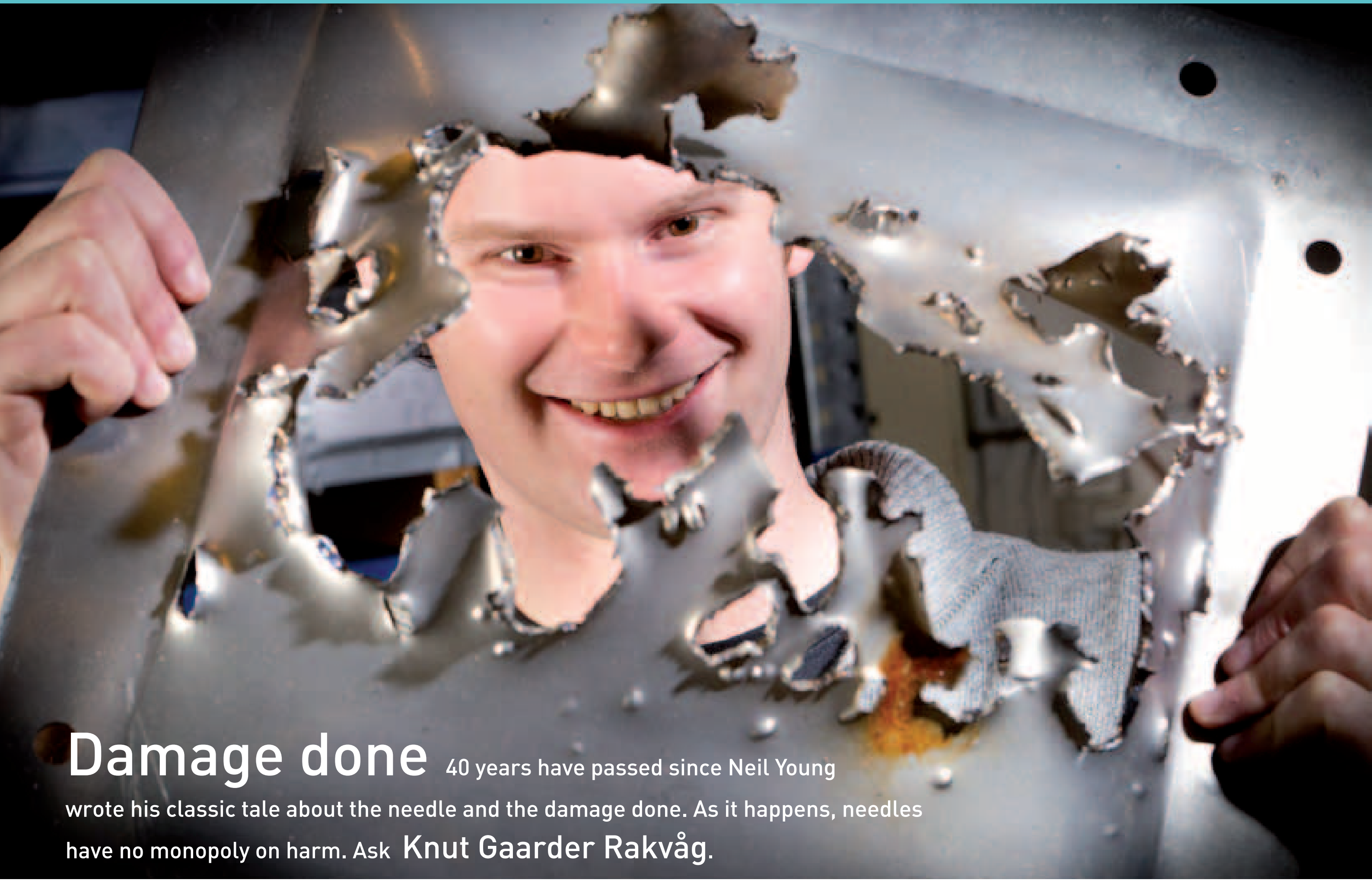


"I shoot electrons through the thin area and study the effect. I can see a picture of how the particles are distributed and the size of them," she says.

Full of praise

Ida is full of praise for SIMLab: "The atmosphere is great. Our professors are competent and strong personalities. It's their achievement that we have such good relations with industry."

After finishing her degree, Ida hopes to continue her research as part of Trondheim's academic environment.



Damage done

40 years have passed since Neil Young wrote his classic tale about the needle and the damage done. As it happens, needles have no monopoly on harm. Ask Knut Gaarder Rakvåg.

"What I study in particular, is the synergetic effect that occurs in explosions. Existing design methods for protective structures treat the shock waves and fragments separately. This has limited value as long as experimental evidence shows a synergetic effect. Design codes to protect should take this into account," he says.

This is all about security. Military, industrial and government structures could all be exposed to an explosion; vehicles as well, both military and civilian ones.

No-fly material

Concrete has traditionally been the chosen material in this field. A lot is known about its properties in stationary constructions. However, flying concrete walls from the USA or Norway to Afghanistan is impractical, to say the least. The need for mobile and lightweight protective structures is steadily increasing, both because of international operations and for temporary assignments like protecting an embassy for a limited period of increased threat. That's where Knut's curiosity comes in handy.

What's inside?

As a child Knut liked everything to be speedy and noisy. Although he was not particularly interested in explosions, he has always wanted to know what things looked like inside. The interest wasn't exactly hampered by his father being a car mechanic. He watched, asked and got answers. At school his interest for mathematics and physics was born. Before long he knew he wanted to be an engineer. Precisely in what field was more uncertain for a long time, until a desire was born when travelling in and out of the fjords on the western coast of Norway; why couldn't they build bridges across all of them? With age and knowledge, interest shifted towards computational mechanics, exploring the limits of what is possible. That's where destruction comes in.

Tests in the UK

Knut collaborates closely with the Norwegian Defence Estates Agency carrying out his experiments. He also has access to a rig in the UK where he can test how steel and aluminium plates react to shock waves, specifically how the shape of holes in plates influence crack propagation.

Trouble on the seabed

Martin Kristoffersen has a fascinating photo on his computer screen. It shows fish investigating a pipeline hit by an anchor. Unfortunately, Martin doesn't know what the fish found out.

Which means that he will have to do the job himself; how much can a pipeline take, when does it break, what kind of damage follows different kinds of impact, how does the damage develop, at what level must production come to a halt, when is the pipeline beyond repair?

"When the pipeline is finally released, it recoils back towards its initial position. After such a complex history of local deformation from the impact and global deformation from the anchor hook, we need accurate models in order to describe the behaviour accurately," Martin explains.

Costly cut-off

His photo is from a real case. In November 2007, a ship's anchor hooked onto a pipeline from the Kvitebjørn field in the North Sea and dragged it out of position. Luckily the anchor chain broke before the pipeline. After inspection, production was restarted. However, in 2008 a gas leak was discovered and production was shut down for half a year until it could be repaired. In the end, the area of the impact had to be cut away and replaced by a new pipe. It was the first time in history that such an advanced operation was carried out by remote control at such depths. It was an expensive repair.

Maths and football

Martin's engineering studies started at home in Narvik in Norway's north, where he took his bachelor's degree. After that he turned to maths and moved to Tromsø, even further north, before ending up at NTNU to take his master's degree.

"I love learning, so when the head of SIMLab, Professor Magnus Langseth asked if I was interested in aiming at a PhD, that was perfect for me," he confesses.

A lot of his childhood friends from Narvik also study in Trondheim and in their spare time they play football. Martin is a skilled player, doing some good work on the field for Kvik in the third division.

Industry interest

Hopefully he isn't as destructive on the football field as in the lab: "We have a test rig in which we crash a wagon into the pipeline to ensure our models are accurate. After that we put the pipe in Statoil's stretch machine here in Trondheim to study the crack propagation. The ambition is to find good models for estimating the residual strength of the pipeline. Statoil is very interested in what we are doing," he says.

Mass Effect

In his free time, **Mikhail Khadyko** is often found deeply involved in a DOS-game from the 90s or in Mass Effect 2. In his PhD programme, mass effects of quite another nature are in focus.

Mass effect one: if you take a cube of metal and press it flat, the sheet will probably end up more or less like a square.

Mass effect two: If you make a cube out of just one grain of metal and press, the sheet will become elongated.

"We call the former behaviour isotropic and the latter anisotropic," Mikhail explains. In other words, the properties of a piece of metal differ from the properties of each grain.

Quests

The differing types of behaviour are the platform for Mikhail's quests.

Theme of quest one: How do the mechanical properties of metals depend on the properties of the grains and their orientations?

Theme of quest two: If we have a metal sheet where the grains on the surface are oriented one way and on the inside in another way, will it be different from a sheet where all grains are oriented randomly?

Sci-fi

If you find the quests odd, Mikhail might have the appropriate explanation:

"I'm the typical nerd," he says. Computer games is one indication, sci-fi novels another. Neal Stephenson, Peter Watts and Alastair Reynolds are all on his favourite list of authors.

The inclination towards engineering may be traced to his mother, who was educated as a construction engineer back home in Arkhangelsk in the north of Russia.

"I always thought that engineers are able people. They are needed in society and will always find work," Mikhail says.

His fluent Norwegian has another explanation: "I came here in 2004 through a student quota programme. I wanted to see the world. When I had learned Norwegian and finished my bachelor's degree, I decided I was better than that. After obtaining my master's, I thought the same: I'm better than that. So here I am!"

Why

So, who would want to know how the properties of metal vary with the orientation of the grains? Hydro Aluminium for one. Or Mikhail himself. If you can change the orientation of the grains through heat, pressure or extrusion, perhaps you can obtain just the properties you need for a vehicle designed for outer space, ready for the great challenges of Mass Effect 2?

Oboe

The first aluminium oboe* may not have been built yet, but who knows what will happen when **Marion Fourmeau** finishes her PhD on high-strength alloys.

Both Marion's parents are music teachers, so her musical tendencies should come as no surprise. As a child she played the piano, but now it is the oboe and she is a member of a brass band.

Fragile boundaries

Since brass is not studied much at SIMLab, Marion has chosen another metal: "My research project concerns the fracture of high-strength aluminium alloys. These alloys are particularly tough thanks to hardening precipitates inside the aluminium grain," she explains.

However, there are hidden problems. The grain boundaries are very weak and make the alloy brittle. What Marion is trying to study is the way the alloy will fracture depending on the kind of loading it is submitted to: compression, traction or something else.

Two laboratories

She will also look at the characteristics stemming from the fact that this alloy mainly is obtained in plates by successive rolling operations, making the grains flat and elongated in the rolling direction. As a consequence, the mechanical properties are not the same in all directions. Turn the plate 90 degrees and you get another material, so to say. This multiplies the number of tests necessary to get a complete model of the behaviour of the alloy.

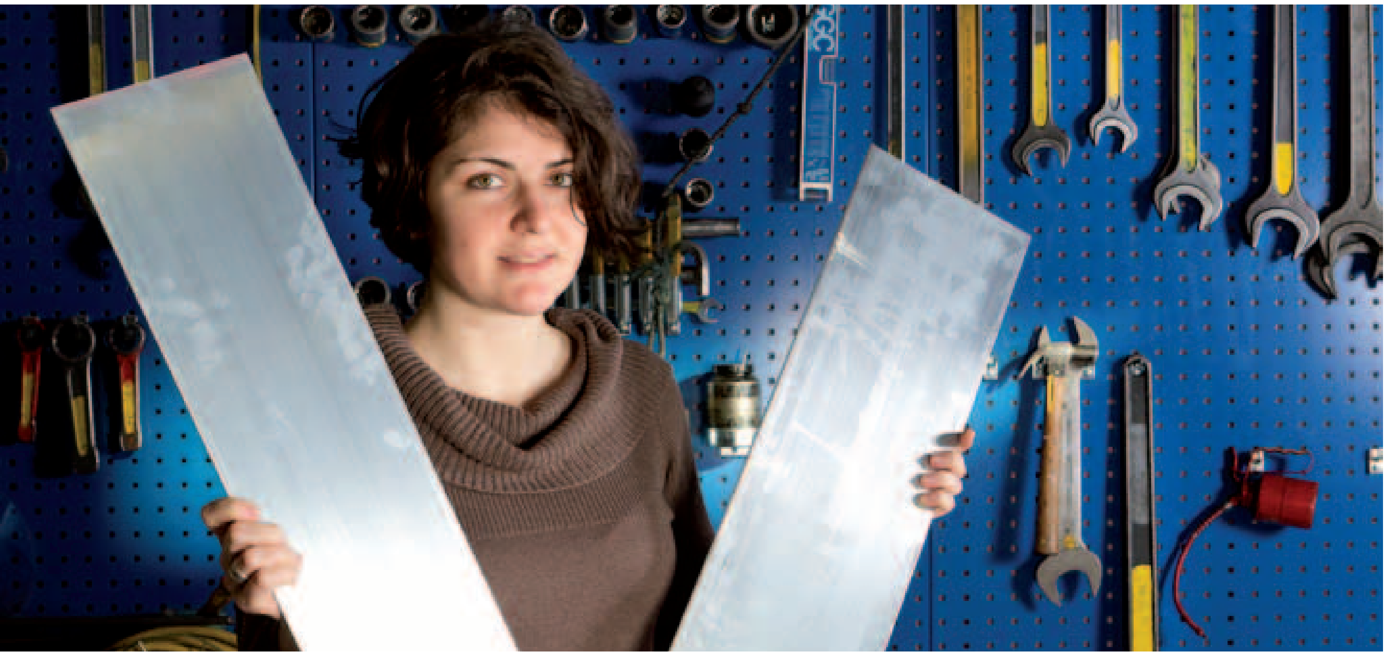
Marion divides her time between the two universities cooperating on the project; NTNU in Trondheim and LMT in Cachan, France. This gives her access to two laboratories and expands the number of tools.

Scandinavia calling

Marion had her mind set on Scandinavia for the last part of her studies. Maybe the love of hiking is involved. Her parents took her to the Alps from the age of six and she still loves a good walk in spectacular scenery.

"I knew that nature is beautiful in Scandinavia. Trondheim came up because of NTNU's cooperation with LMT. I did the first year of my master's internship in Trondheim and SIMLab challenged me to apply for a PhD. I accepted right away simply because I wanted to come back," Marion confesses.

** On second thoughts, building an aluminium oboe may not be so easy. It would represent a contradiction in terms. The word oboe is Italian, but the origin is a phonetic approximation to the French haut bois, literally: high wood, referring to its pitch. So perhaps that muffles that idea.*



How Renault lost their man

Virgile Delhaye worked with Renault all the way through his PhD programme. Now they've lost him to a girl from Trondheim. Love conquers all.

"There's a very good chance I will stay in Trondheim for a long time. It's easier for me to work as a scientist here than it is for my girlfriend to get a job as a psychologist in France," Virgile says. So he's landed a job with SINTEF continuing his research on ductile thermoplastics for crash applications.

Investing time and money in the development of highly skilled staff always carries a risk. Renault knows that as well as anyone and they are prepared to run the risk. Sometimes you win, sometimes you lose.

Protecting pedestrians

Not everything is lost, though. Virgile's findings are there for the picking and they are right at the heart of Renault and any other carmaker's needs: the ever on-going search for better bumpers. In more scientific terms, they deal with the characterization and modelling of ductile materials for crash applications. Virgile has looked at two particle-reinforced thermoplastics. One is rubber-modified; the other mineral-filled.

Such reinforcement is common in the car industry. The particles naturally change the behaviour of the materials. Virgile has investigated how. He has subjected them to varying degrees of tension, compression and shear at quasi-static and dynamic strain rates. All the tests have been instrumented by the help of a digital image correlation technique to acquire the strain field.

To make a four-year story very short, finding good models for the mineral-filled material proved more difficult than for the rubber-modified version. Still, his thesis is a solid contribution towards reducing financial and personal bumper-related costs.

Additional challenge

Virgile came to NTNU via Renault's long-time cooperation with SIMLab. All through the programme he divided his time between Trondheim and Renault's Research and Development Center in Versailles, spending six months at a time in each place.

Cooperating that closely with an external partner has given extra spice to his work. Renault's approach has of course been industrial. They will always want specific answers. The challenge has been to combine the need for an academic thesis and please Renault at the same time. All indicators point towards success: Virgile was awarded his PhD, SIMLab's cooperation with Renault goes on.

With a passion for cars

You could say that Andreas Koukal is your classical western European male, playing soccer since childhood, skiing and snowboarding in the Alps, getting his first motorcycle at 16, his first car at 18.

"You could also say that working on my car was a passion right from the start," he admits. Just as well. Like most 18-years-olds, he didn't have the money for a brand new vehicle, so the passion may have grown out of necessity.

Working with Audi

Andreas' home town Landsberg in Bavaria is not only close to the Alps. It is also close to the Technical University in Munich and to Audi's headquarters in Ingolstadt.

During his master's, Andreas had a professor who cooperated with Audi. Through this cooperation Andreas got a supervisor at Audi who was working with SIMLab. This partly explains how he ended up where he is now, with a PhD programme on crash and fracture behaviour of polymers in pedestrian protection.

Half way through his programme he is also very closely involved with SIMLab's programme partner Audi, having only spent one month in Trondheim so far.

"I spend four out of five weekdays at Audi and hope to continue working for them after finishing my PhD," he confesses.

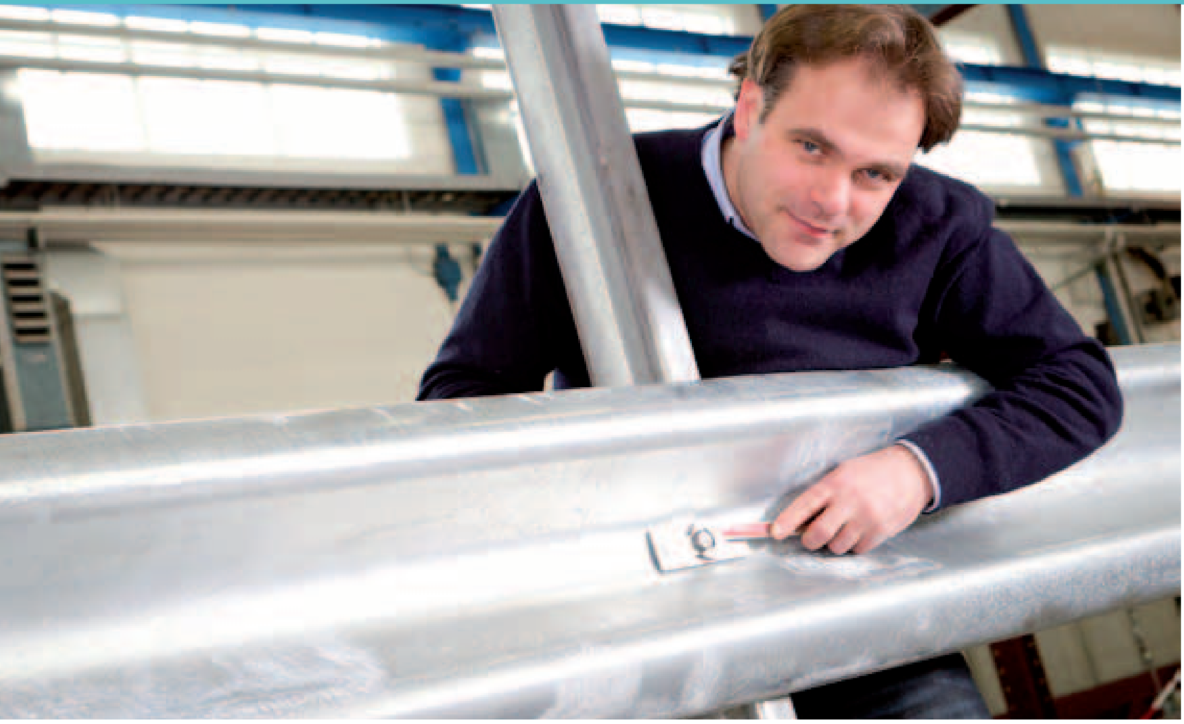
Pedestrian protection

Did you think that your bumper is there to protect yourself and your car? Well, Andreas looks at it from quite the opposite angle. That means he is concerned with protecting pedestrians. To achieve this, the car industry carries out physical tests and computer simulations whenever they develop a new model. The tests involve impacts on the bumper, subjecting it to large deformations and possibly fracture. The bumper and most of the other pedestrian protection relevant components are typically made of polymers.

"The object of the project I'm working on is to improve the knowledge and understanding of crash and fracture mechanics of polymers," explains Andreas.

Reinforced polymers

Andreas' particular field of interest is glassfibre reinforced polymers, which behave differently from the unreinforced polymers. The latter can be treated almost as isotropic, the former not. His ambition is to implement an anisotropic material model for the fibre reinforced polymers. On his way there he is setting up mathematical models taking the manufacturing influences into account. This includes fibre orientation. The results are correlated and verified with experimental data and finally integrated in component and vehicle simulations. His ambition: better pedestrian protection.



Rivets and bolts since 1660

Few people can trace their professional roots 350 years back. Henning Fransplass can. He is a master of the same trade as the one introduced to his hamlet more than ten generations ago.

It all started around 1660 when a man called Franz came from Holland or Germany to the Norwegian highlands. His expertise was wanted. The hamlet of Lesja attracted foreign craftspeople when iron ore was found. This particular iron ore was rich in chrome and was perfectly suited for making the rivets used in shipbuilding. Franz knew how. He came and he settled. His place was named after him - Fransplass.

Like a hammock

Henning Fransplass works in the same field, almost. Instead of iron rivets, he's making steel bolts. The topic of his PhD is the bolts used in road safety barriers.

The aim is to understand better how bolted connections behave in a safety barriers when hit by a vehicle. An optimal barrier should work like a hammock; gently containing and redirecting the vehicle back onto the road without bouncing it over to the oncoming lane.

No small challenge, by the look of it. Henning puts it like this: "The challenge is to control the large kinetic energy difference. Between a small car and a bus it is about 1 to 18. The aim is to maintain the functionality of the barrier throughout the whole scale of impacts. To achieve this, the bolt has to break at exactly the right moment to obtain the hammock effect."

Saves time and money

In the SIMLab laboratories Henning is carrying out experiments with scaled bolts. This is a huge time- and cost-saving process as it reduces the need for full-scale experiments to a fraction.

Henning then develops life-like animations by using commercial software. The information from the animations is used to improve accident analysis. This enables him to study design and limitations of safety barriers.

Against death penalty

Henning's aim is the same as that of the Norwegian Public Roads Administration (NPRA), where he is employed: "The road transport system should be designed in such a way that roads, vehicles and road users interact to ensure safety. Human errors shouldn't carry the death penalty."

NPRA is a SIMLab partner. When Henning's thesis is ready, they will have more specific recommendations for the properties of bolts than today. Many lives may be saved and injuries reduced.

Lighter and more reliable

Casting aluminium allows thin-walled components with complex geometries, but a die-cast is more brittle than sheets and less homogeneous than extruded aluminium. So, what can we do? Well, Audi, SIMLab and collaborating university KIT in Karlsruhe have put Octavian Knoll on the job.

Audi needs die-castings for rocker rails and pillars in their cars. They want the components to be as light as possible and at the same time as reliable as possible in a crash situation. This is where Octavian comes in:

Filling a mould

"The challenge in the design and virtual crash analysis of such components is that the mechanical properties depend on the process chain," he explains. Let me give an example:

"When you pour liquid aluminium into a mould of a large component, fronts are built where the metal comes into contact with air during the filling time. When these fronts meet, you get a part of the component with different mechanical properties and a potential breaking point."

The cooling process also influences the properties. As a result the deformation behaviour can vary significantly within a component. This complicates the crash simulation.

Keep it simple

To deal with this, Octavian is performing detailed material characterization, component testing and numerical simulations.

"I divide my time between the institutions. Here at SIMLab I enjoy the benefit of the support from the entire group and their experience in material modelling – especially in aluminium alloys. They help me to interpret test and simulation results as well as to establish a new method in material modelling of aluminium die castings. Audi wants to keep it simple. Too much detail makes the model too complicated, so what I'm looking for is a model that works on an everyday level – for example in the field of full-scale car crash simulations. In other words, the goal of my PhD is to develop a simulation methodology that allows reduced weight and increased reliability in the components," he says.

Started in construction

Octavian's first steps as an engineer were in the construction business. Both his parents are architects. When Octavian was a child, they had the huge ongoing project of building their own house.

"I soon discovered that I lacked their creativity but I did enjoy the more mechanical aspects like screwdrivers and hammers," he recalls. He also has a tendency to get totally absorbed in what he's doing. Combine that with a certain lack of ability to say no and you have a very busy person.

"Of course, those are not entirely positive qualities. Hopefully they are compensated by my dedication and loyalty," says Octavian.

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