Robots in the classroom

April 20 2012, By Christina Benjaminsen

Credit: Geir Mogen

Tore Fløan smiles at me: “In the past we competed with European organizations, but now we have the Chinese breathing down our necks,” he says.

Fløan is Technical Manager at Glen Dimplex Nordic in Stjørdal, just outside Trondheim – a 16 500 m2 manufacturing facility that produces modern electrical wall heaters for the global market. Russia is the company’s biggest customer. Fløan says that it is robots that are keeping low-cost Chinese products at bay and that are guaranteeing that his company can continue operations in spite of the financial crisis.

About 120 employees work in the factory on a two-shift system, assisted by 15 production robots that work around the clock, 365 days a year.

The company, which was once the Norwegian-owned Nobø Fabrikker, and later merged with Siemens Electrical Heating, today is part of an international Irish industrial group that is willing to invest in state-of-the-art production line technology.

“I’m convinced that the Chinese cannot do what you are seeing here, either cheaper or better,” Fløan says.

He shows us two gigantic robots performing a dance as elegant and synchronized as an Argentinian tango. Every fourteen seconds the programmed dance steps produce a fully assembled component – entirely without human intervention.

These efficient unmanned robots have provoked no protests from the employees at Glen Dimplex Nordic. The technology has been embraced by the union, management, and the company’s board and shareholders alike. The first production robots were put to work as early as 1998. Their numbers have gradually increased, and more are on the way.

“In the early 1980s, when we were known as Nobø Fabrikker, we had already established a tradition of working with NTNU and SINTEF, and several of today’s production lines are the results of this collaboration. We are now involved with five other Norwegian companies in a research project called Next Generation Robots for Norwegian Industry. The aim is to develop robots with human capabilities that can perform more than just simple, repetitive tasks. We believe strongly that this is essential if we are to maintain our competitive edge,” says Fløan.

The global low-cost carousel

From the third floor of what is popularly known as SINTEF’s “Electric Garden” at Gløshaugen in Trondheim, research manager Ingrid Schjølberg looks out over the most historic part of the city. But she is preoccupied with the future. As project manager for the “Next

Generation Robotics" initiative, she believes so strongly in robots that she predicts that they will become part of our everyday lives in the not-too-distant future. But what really drives development in this field are companies like Glen Dimplex Nordic.

"If Norwegian manufacturers are to succeed in positioning themselves in a competitive global environment, then they have to think smart. This is why SINTEF and NTNU are working closely with industry to develop the next generation of robots – machines that can see, make their own judgements, and then learn from them. And last, but not least, perform the tasks that you and I would rather not do," says Schjølberg.

The project partners include Statoil, Hydro, Tronrud Engineering, SbSeating (HÅG) and RobotNorge. Tronrud Engineering has assumed the role of end supplier, taking care of commercialization and sound end product delivery.

Robots in heavy industry

The metallurgical industry is a vital supplier to other Norwegian industries, and there is a need to increase the level of automation at many stages in the production process so as to be better prepared for global market challenges. "However, the potential of robots has been poorly exploited," says Senior Engineer Odd-Arne Lorentsen.

At the aluminium plant in Sunndalsøra, the carbon anodes used in electrolysis weigh several tonnes. The anodes are incorporated as part of the electrolysis process and oxidize as the aluminium is being produced. After three or four weeks of operation, the anode residues are removed from the electrolysis cells and the anodes are replaced.

A layer of crushed electrolyte mixed with alumina is placed on top of the new anodes in order to reduce heat loss and avoid combustion of the anodes during the process. Since carbon is a valuable commodity, the electrolyte crust must be removed when the carbon residues are recycled and incorporated in a new production cycle.

“Today, we are using a more or less entirely automated anode cleaning station, but we have been having problems with this system because it does not remove the residues well enough. The residues can then end up in the new anodes, which results in a deterioration in quality,” says Lorentsen.

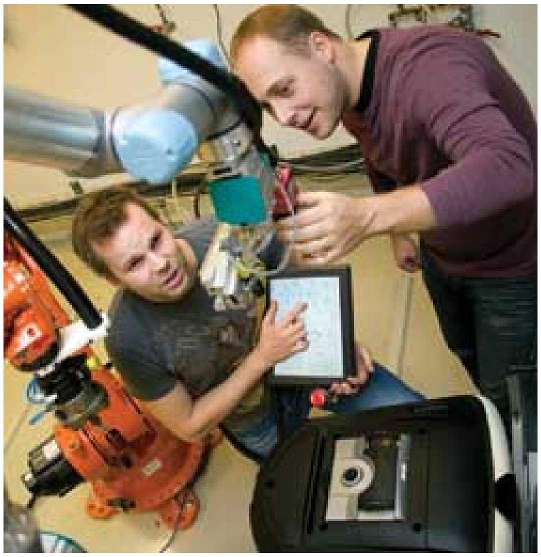
Hydro Aluminium hopes to automate the process by employing a robotic system, combined with visual detection methods that can identify the differences between fresh anode material and the recycling residues.

Moreover, there are currently several other stages in the process for which the company is considering automation.

“If we succeed in using robots for more of our operations, we will be able to improve our precision and remove personnel from noisy and high temperature working environments,” says Lorentsen. “We have enjoyed three years of collaboration with NTNU and SINTEF, and I’m convinced that this project will give us a foundation that we can build on for the future.”

Deep sea ROVs

Huge distances. Extreme cold.



In the robotics lab at SINTEF Raufoss Manufacturing, researchers Řystein Skotheim and Pĺl Ystgaard have succeeded in giving these advanced machines 3D vision, enabling them to perform increasingly more complex production line tasks. Credit: Gry Karin Stimo

Deep seas, brutal waves and toxic gases. It is perhaps not so surprising to hear that, given all the challenges the company faces, Statoil is also pinning its future hopes on robots. The company has been using robots called ROVs for several years. These are small remote-controlled submarines equipped with cameras, an array of tools and, last but not least, a computer brain built to perform technical maintenance tasks in one of the most inhospitable environments we know – the ocean bottom. But now the company is shifting its attention back to the surface with the aim of employing robots to perform operations on the decks of oil platforms.

“Have you heard of the ’Four Ds’ – Distant, Dull, Difficult and Dangerous?’,” asks Anders Røyrøy, Project Manager for Statoil’s robotic research efforts. Røyrøy has big plans for intelligent robots – but not purely for commercial reasons.

“We aren’t doing this to save money,” he says, “but to reduce the risks to health and loss of life. Our robots will carry out dangerous tasks in environments not suitable for humans. We aren’t exactly running a mass production system, are we?”

Things can go wrong on a platform, and today many processes are automated. For example, Statoil uses manipulators to handle heavy drill pipes on the drill floor to prevent them from dropping on personnel during drilling operations.

Company managers can see the day when the new robots might be employed to carry out more advanced functions, such as the monitoring of complex operations far out at sea, the detection of discrepancies, and the quality assurance of work carried out by others.

“We are well aware of our success on the sea floor, so now we want to get deck operations automated. But this is more difficult,” says Røyrøy. “Of course we use remote-controlled robots below the surface, but it is easy to assume that on a platform people can perform all the essential tasks.”

“The oil we are finding today is often in far removed areas associated with hazardous environmental conditions. There may be large volumes of sulphur compounds in the atmosphere. For example in the Caspian Sea we encounter hydrogen sulphide, which can cause paralysis. Moreover, temperatures can vary from between minus 40 to plus 40 degrees. If we are to succeed in these areas, robots remain our only option,” he says.

Statoil also envisages using some of robotics-derived technology in the future, for maintenance and modification work performed on wind turbines, which involve long journey times for personnel and where access is restricted.

Here, robots must be equipped with good vision, memory and the ability to fill in for the operator during the operation in question. The robots will also need a good navigation and positioning tool. In fact, SINTEF is now working on just such a system for these smart tough workers.

Artificial and cognitive

“There are many ways of teaching a machine to remember,” Ingrid Schjølberg explains. “All robots have a ’brain’ made up of a digital matrix which the robot searches until it finds the correct response.”

“That sounds logical enough, but how do you construct the matrix?”

“One of the approaches is so-called ’offline learning’. This consists of guiding the robot manually through the operations we want it to perform. Then we give it a reward when it performs the required movements correctly. The ’correct’ data is then fed into the matrix.”

“How do you reward a machine?”

“Of course, the robot must get something that it understands – such as numbers. For example, we can give it positive or negative points depending on how well it performs a task. In this way we feed it with artificial experience so that it will be able to make judgements for itself.”

“As the robot continues to work, it will begin to learn from its own experience, just as we do. The challenge is developing search algorithms that are efficient and fast enough to ensure the points system works in practice.”

Traditional and innovative

The historic town of Røros is the location of the chair manufacturer SbSeating (HÅG), which has a long tradition of working with SINTEF and NTNU. Here, 265 000 chairs in more than ten thousand varieties come off the production line each year. Everything is manufactured to order, and the chairs are dispatched on the day they are made.

"We have worked closely with researchers to develop our production system, and the calculations we made during this process convinced us that we had everything to gain by bringing in internal logistics and robots," says Stein Are Kvikne, vice president of production development at the company. Today we have excellent production flow and logistics in place. Our challenge is to minimize the number of heavy, manual and technically demanding tasks."

"Many of our components are delivered in bulk. Equipping the robots with vision that allows them to select parts scattered at random in a box will be a major boon to the efficiency of our factory. The same applies to the automation of our packing process, which today is both physically demanding and repetitive."

Recognize and grasp

"Mass customization is today's buzzword," says Pål Ystgaard, a research scientist at SINTEF. "The market demands that more and more products are individualized, and this trend means that the major manufacturers must mass produce goods according to a design supplied by the customer."

Ystgaard and his colleague Øystein Skotheim are fine-tuning a production robot in the laboratory. The robot is almost two metres high and looks like a cross between a giraffe's head and a gigantic orange drill. This is a "smartbot" robot that can grasp different components depending on what it needs to perform the task at hand. The robot works in a team of two – it has a silver companion by its side, which is equipped with a 3D vision system made possible by the combination of a laser and an advanced camera. The system enables the robot to recognize and locate different components on a production line.

Skotheim has become a specialist in robotic vision by working with a variety of techniques, from the digital imaging of prehistoric rock carvings to quality assurance for automobile components. “The sensor acts as the robot’s eye and uses a laser to generate a light strip which is monitored continuously by the camera,” he explains. “When objects enter the robot’s field of vision, the laser strip changes shape. This enables us to generate a 3D image of the objects that the robot sees.”

When an object has been scanned, the image is fed into to a specially designed software application that identifies the component and its location and orientation. The orientation is sent to robot number two, which converts the information into a specific movement. In this way the robot can then grasp the component in question from the production line, regardless of its type and orientation.

“At present we don’t have systems that make robots sufficiently versatile to recognize and grasp many different components at once. This is because the robots are only equipped with two-dimensional vision and can only perform highly standardized movements,” says Skotheim.

This means that even a small modification of the production process requires complete reprogramming of the robot, a costly and demanding process.

Skotheim and Ystgaard have now succeeded in providing these advanced machines with the ability to “see” in three dimensions, so they can now perform more complex production line tasks than previously.

“Technologies that make it possible to combine customization with mass production will enable Norwegian manufacturing industries to remain competitive in a world where we are competing with countries that have much lower production costs,” says Ystgaard.

Our job now is to find out how to do this in the smartest possible way – how to get the machines to perform tasks that people would rather avoid, and at the same time learn from the mistakes we make so that we can optimize their efficiency.

Generic technologies

“He comes when you signal, he can help you carry things, and follows you faithfully wherever you go until you tell him to stop. We call him ‘Rulle’,” says Ingrid Schjølberg. “I don’t think he’s all that handsome, so we’re planning to improve his design,” she says as she strokes the practical, but none too pretty, “carrying tray”, which is a component of the robot. The tray can raise and lower itself automatically as the user requires, and the little chap would have no trouble getting a job clearing tables in a restaurant, canteen or residential institution.

“The robot technologies that we are currently developing are so-called ’generic technologies’, which means that they are easily transferable to a variety of applications. Welfare-related technology for the elderly is fast becoming a hot topic. For example, we envisage that Rulle might be able to assist elderly people with simple tasks such as carrying laundry or shopping,” says Schjølberg.

Provided by NTNU

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