John Deere Forestry says NO to production downtime

Introducing remote programming has enabled the Joensuu plant of John Deere Forestry to virtually eliminate production downtime caused by re-programming of robotic production systems. The downtime for re-programming associated with making the frame of a new forest machine model has been cut from 100 hours to 15 hours. "It's less than a fifth of the downtime we used to have," says Raimo Sorjonen, head of development. Remote programming has thus given an average of 85 extra hours of production time. Since new products are continuously being developed, reprogramming robot cells is a factor of increasing importance.

John Deere Forestry uses its IGRIP remote programming and simulation software in product development too. Raimo Sorjonen explains that through the reach and collision tests available in robot simulation the accessibility of welding points can be established at the design stage. "If a product is intended to be welded by a robot, it must be designed to be welded by a robot; you cannot weld first and ask questions later. 3D modelling and welding simulations help us design a feasible production process at an early stage, and this increases the number of seams that can be robot-welded."

Photo. Timo Lavikainen is an expert at programming welding robots both on a PC and at the production line.

DELFOI
Delfoi Oy : Vänrikinkuja 2 : 02600 Espoo : Finland
Tel. +358 10 309 7700 : delfoi@delfoi.com : www.delfoi.com

FRAME WELDING ON A FOREST MACHINE IS A CRITICAL PROCESS

The John Deere Forestry Oy's forest machine production plant is located in Joensuu, producing more than 1,000 forest machines per year at present. John Deere Forestry has a total of 600 employees in Tampere and Joensuu, of whom 400 work at the Joensuu plant. The plant manufactures the frames, pillars and booms and assembles the machines; the manufacturing of other components has been mainly subcontracted.

Frame welding is a very important process. The Joensuu plant has a long history and considerable expertise in welding box-section structures. In 2006, John Deere Forestry received the Finnish Hitsaushuippu ('Welding excellence') award for its expertise in the field. The company is also a pioneer in robot welding, having reacted at an early stage to the chronic shortage of welders by deciding to invest in robot technology. Today, all frames, booms and pillars are welded by robot. The plant has four welding robots in production use, and a fifth is being installed.

Photo. Welding the frame for a heavy-duty forest machine uses up to 45 kg of filler metal. Source: Teknohaus.

A robot is much more efficient than a human. A welding robot can weld as many as six frames in the time is takes a human to weld one. The difference becomes even more marked with larger assemblies and more extensive preparations: there is more metal to melt, and movement becomes difficult for the human welder. The efficient robot welding stations can together weld 7-8 machine frames per day. The principle is that each robot cell produces a welded front frame and rear frame within one shift, i.e. every eight hours. This includes preparatory and cleanup work. The actual robot welding on the frame lasts between 2 and 4 hours, depending on the size of the frame. The largest rear frames require up to 45 kg of filler metal, though the average is between 20 kg and 40 kg per frame. The combined length of welded seams in a rear frame averages about 62 m, the length of a short sprinting track, although there may be as many as 200 individual seams.

SWITCHING TO REMOTE PROGRAMMING AND ROBOT SIMULATION

In 2001, John Deere Forestry was using two robot cells, and a third was acquired in 2002. The robots were programmed through online teaching. It took an average of three weeks working in one shift, or about 100 hours, to program a robot to weld a forest machine frame. While the robot cell was being programmed, it stood idle and unproductive. The pace of developing new products requiring welding showed no signs of slowing down, and in 2004 the company introduced IGRIP software to cut down radically on production downtime. The software was immediately taken into use at two levels:

- To improve the capacity for robot welding in new products, combined with the ProE 3D CAD software, and
- To help remote program the CLOOS robot stations and the Motoman robot station.

USING THE SOFTWARE TO IMPROVE FRAME WELDABILITY

John Deere Forestry has had a 'frame team' for ten years now, consisting of design and manufacturing experts. The team meets about five times a year in connection with new product projects. The IGRIP and ProE software have made the team's work much more efficient. What this means in practice is that the weldability of a new frame can be tested using robot cell simulation at the early stages of frame design. Production engineer Markku Patrikainen uses IGRIP to communicate the changes required to the construction for robot weldability. At this point, product development has only just published the first 3D master model of the new product. Markku Patrikainen notes that robot simulation has enabled the team to plan robot welding deep inside boxed sections of the frame. "We found in simulation that if there is a hole in the frame cover plate for the robot arm, the robot can reach inside the frame to weld seams. If we had not run the simulation, we would still be welding those seams manually." On older products, robots typically welded 65% of the seams. Now, the bar has been set much higher. "Our target for robot weldability on new frames is more than 90%, and we have already attained 93% on one new product, says Raimo Sorjonen."

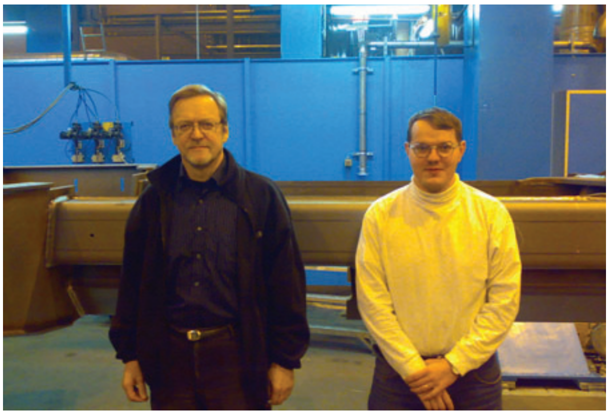

Photo. Raimo Sorjonen, head of development (left), and production engineer Markku Patrikainen.

ROBOT REMOTE PROGRAMMING

John Deere Forestry chose robot operators to use the IGRIP software because of the operators' practical knowledge of the welding process and their experience of how the robots work and how they are operated. There are currently two senior robot operators running the software for remote programming, and more are being trained with the aim of having six remote programmers in place within a year. It is the aim of Messrs Sorjonen and Patrikainen that each new forest machine frame will be programmed by a single operator. This will prevent information transfer issues which arise if the programmer changes in midstream. It is better that one person designs and simulates the welding program from start to finish. It is also motivating for the operators to see how their creation works on the actual welding robot. Operators range from 23 to 35 years of age, so there is both solid experience and youthful enthusiasm among them.

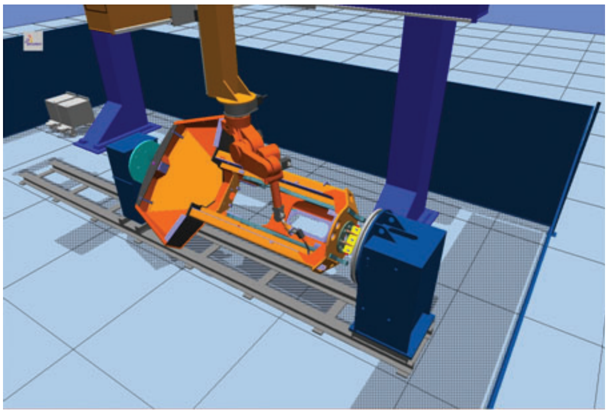

Photo. Remote programming is based on a 3D CAD model of the frame and a simulation model of the robot cell. The robot cell simulation model is an exact copy of the actual production cell.

A remote programming session consists of the following: reading the 3D model of the frame into the remote programming software; dropping it into the simulation model; programming; verifying the program by running a simulation; saving the verified program in the processing queue for introduction; and introducing and testing the program in the production cell. Testing takes about 15 hours (excluding seam finding), during which the program is fine tuned. The robot welding itself starts after this.

Programming based on online teaching caused production downtime of about 100 hours; remote programming has cut this to the 15 hours still required to test the program. The ultimate goal at John Deere Forestry is to eliminate the testing phase altogether and to transfer new programs directly from simulation to welding.

DIFFERENT CELLS MUST BE ABLE TO WELD THE SAME PRODUCTS: COPYING ROBOT PROGRAMS BETWEEN CELLS

The front and rear frames of forest machines are currently being welded by four (and soon five) robots. In practice, each robot cell can only weld those products for which it has been programmed. In other words, a product cannot be flexibly moved to another cell if it happens to be free when the original cell is undergoing maintenance or if production could be thereby streamlined: the production cells currently incorporate no production flexibility.

In connection with the IGRIP software, however, Delfoi also delivered to John Deere Forestry a 'conversion tool' which enables the copying of programs between cells even if the cells are different in structure. This enables more flexible production planning, as any frame can be welded by any cell. What this means in practice is that any new welding program will be designed for one robot cell model (the master cell), on which the software will be simulated. The verified program is then copied to the simulation models of the other robot cells, where the conversion tool automatically incorporates changes required in the program for each cell, taking into account the different seam finding functions and other properties of the robot model in question, different lengths of tracking on axles outside the stations, different rotation directions for joints, and so on. The conversion tool cannot automatically make use of the greater lateral movement available on the outside axles of the newer robots, so this must be programmed manually on site to enable a better welding position or to take the arm further away from the frame. Making adjustments to the cells to which the program is copied requires one shift, as a rule – the conversion tool cannot correct all differences between cells. Because the robot station selected for creating the master program is the smallest and oldest CLOOS station at the Joensuu plant, the robot operators are also making improvements to the programs to make use of the properties of the newer CLOOS stations.

The conversion tool is also used to transfer the existing programs in the old CLOOS station (created with online teaching) to the new robot stations. This avoids having to reprogram every existing frame on every station, which would lead to the aforementioned 100-hour production downtime per frame model.

FUTURE CHALLENGES

Head of development Raimo Sorjonen explains that in robot welding 80% of the problems that arise are compensation errors, including groove variability, for which the present robots cannot compensate. Adaptive robot welding is a future development project. Sorjonen also highlights a further challenge for construction design, remote programming and robot welding: "The continuum from design to robot welding must be flawless. All the seams in the design must be weldable by robot, and the programs created with remote programming must function in production as they are, without adaptation." He also refers to the simulation of the behaviour of welding cables as a specific remote programming problem. At present, it is only the experience and expertise of the operators that prevents the cables from wrapping around the wrist element or snagging on the corners of the frame. Not all the challenges involve welding, though, as the final assembly phase is also undergoing continuous development. The compatibility and assembly properties of new components must be ensured at the design phase. After all, physical building of prototypes is slow – and expensive.