Simulation systems: bridging the gap

Machine tool and robot simulation and programming have yet to move far outside aerospace, automotive and defence, yet the software could bridge the gap between design and production. Mike Nash reports

“Outside automotive and aerospace, manufacturing industry has been relatively immature in terms of its use of robotics. By definition, there is less demand for simulation and off-line programming.” So says Stephen Giles, sales manager at manufacturing engineering simulation tools developer Tecnomatix. Why? He believes the whole area is still “seen as a black art”.

But perhaps most important, there is a cultural divide between what Giles calls the “people that actually plan manufacturing”, and “those who produce”. He continues: “People working in a planning department sit at a desk using a computer: they’re unwelcome on the shop floor. Whereas production is about getting the job done.” In aerospace and automotive, the two camps have at least learned to live with each other.

Simple, inexpensive simulation software helped convince BAE Systems that Vosper Thorneycroft could produce sections of the new Type 45 destroyer to its satisfaction – and the software can be applied to visualising and optimising all sorts of commercial production (page 53)

Jacey

Potentially, simulation and programming tools for CNC machine tools and robots, which usually sit within manufacturing or production engineering and occupy the space between design and manufacturing, could be, as Giles enigmatically puts it, “the bridge between those two worlds”. It depends where exactly the function is located. “Some put it as a function of product design – or as part of operations/manufacturing. But more often it sits within planning,” reports Giles. On the other hand, some larger companies have established specific groups for simulation services.

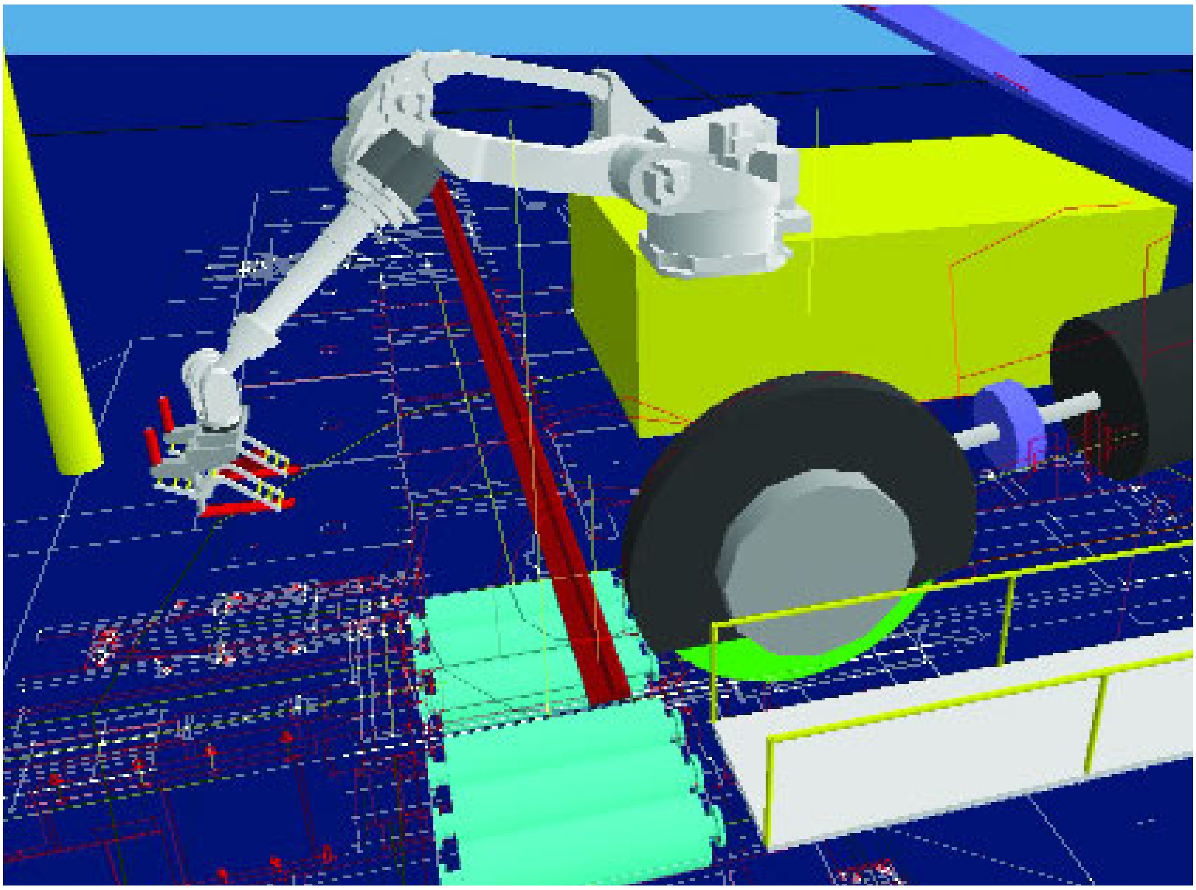
But let’s define what we’re talking about. Essentially, simulation tools are for anyone that wants to preplan manufacturing processes or make changes to existing plant and understand the consequences of those changes. Simulation helps to evaluate on-screen the alternatives available, both to support strategic manufacturing initiatives and to find ways of improving performance at operational and tactical levels. Typical examples include changes to a product mix, increases or decreases in volumes, adjustments to throughput and cycle times, varying lead times and examining customer response options.

Horses for courses

The kinds of simulation on offer include 3D modelling tools that simulate manufacturing processes involving robots or assembly operations, or quality tolerance (simulation of measurement devices such as co-ordinate measuring machines (CMMs)). Traditionally, it’s been assembly line builders (such as ABB or Kuka), supplying a group of manufacturing cells or a whole line, that have made most use of these kinds of tools. They’re used in bidding, planning, detailed design and in the verification and optimisation phases of delivering cells to an OEM. “In the automotive sector, for example, simulation has become all pervasive,” says Giles.

Then for machine tool programming, there’s a variety of 3D tools available that simulate machining of a component, say turning or milling tool paths, in the most efficient way. The aim is to condense the time taken from drawing or concept to a machined prototype or production part. GE Fanuc’s Manual Guide and Mastercam’s Router software are notable examples.

At the 2D factory level, there are also software tools for discrete event simulation, mimicking production flow for a whole factory or parts thereof. These are more about understanding throughput, bottlenecks, resource utilisation and so on. Often, manufacturing process management (MPM) planning applications feed into detailed simulation activities. Such tools can



Business Benefits

- Maximises asset uptime and utilisation
- Provides objective proof of concept and program verification
- Fast engineering to production flow

Right and below: Getting it right first time, every time: simulating and off-line programming of expensive robotic systems is the only way to go

be used in isolation or in conjunction with some wider deployment of manufacturing process management.

So much for the background. Recently, variability in product mixes and the requirement for smaller batch sizes have been driving some adoption of simulation tools outside aerospace, defence and automotive, and in general manufacturing where the ROI (return on investment) justification can be made.

Offline power

In the case of expensive robots, organisations have to maximise utilisation, and the issue here is that small batches and product variability mean frequent requirements to change what's been programmed. Conventionally, that's done online, which means taking a machine out of production, and spending minutes, hours or even days re-setting it. "In the last two years we have seen a dramatic increase in the amount of time people are spending online just to cope," affirms Giles. That kills the utilisation rates of robots that are normally used in multiple shifts on a 24/7 basis.

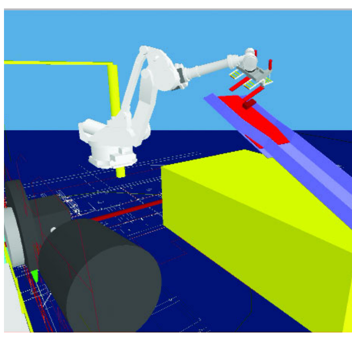
The bottom line: users simply have to move to off-line planning and programming for their robots, particularly in low-volume, high-variability manufacturing. Medical equipment production is an example, and there are many potential applications in painting across numerous industries. Safety is another major driver here: a simulation allows you to define exclusion and safety areas. As Giles says: "Online programming of a painting robot is not attractive or safe," he says. "You can't get too close, so how accurate are you going to be? You need to be in a simulation environment."

To illustrate this, at Skinningrove-based Corus Special Profiles (part of metals products manufacturer, processor and distributor Corus) competing simulation tool developer Delmia has created a virtual prototype of a hazardous robot cell using its IGRIP software, helping the company invest in its first industrial robot. For 100 years, Corus had manually taken samples from its red-hot steel to test strength and chemical composition – an arduous, skilled and dangerous task.

Bill Downing, manager of manufacturing services for Corus Special Profiles, says: "Two years ago, we had an idea that the sampling role could be carried out by a robot. We knew it was a tall order, as the process never stops and the size of steel to be sampled varies in size dramatically."

The steel is between 900C and 1,000C with the biggest sample pieces weighing 70kg, and the saw that cuts through the steel measuring 2.2 m in diameter and running at 500 rpm. "While potentially a man could jump out of the way of the advancing steel, a robot can't, so the positioning of the robot was absolutely crucial," observes Downing.

In fact, the logistics of the robot's operating area were further complicated, with space limited and a great deal of equipment in the area. Also, several con-



flicting tasks, including scrap removal and equipment servicing requirements, meant that many, including the operators, were sceptical that a robot could match their skills and replace them.

With that background, following a site survey, a Kawasaki ZT165 shelf-mounted, industrial robot was chosen for the sampling task. An initial simulation using IGRIP proved that the robot, usually employed as an automotive spot welder, could perform the task – key hurdles to overcome being designing a gripper capable of withstanding the extreme heat and coping with the markedly differing sample sizes.

Subsequent detailed simulation proved that there was just one potentially problematic permutation, and that was resolved using the robot's maximum reach on pick up and put down. Key benefits in this case? Simulation saved time and money and illustrated exactly what had to be done for the set-up to work before installation and commissioning. 'Right first time' might be much trumpeted, but here simulation revealed issues that otherwise could not have been anticipated. Dismantling and moving the cell later would have been very costly in terms of production and time.

Bringing it together

In robotics, simulation boosts utilisation rates, specifically reducing the downtime in production otherwise caused by online changes to set-ups. Beyond this, it helps manufacturers decide when to commit to costs. "How else do I ensure that I don't commit myself to costs for robotics in tooling, fixturing and clamping too early?" asks Giles rhetorically. If you wait until you have bolted the robot to the floor before determining the fine detail of how the cell will operate, you stand a high chance that you will have to make fundamental changes to tooling, clamping and fixturing.

As Giles puts it: "You might buy stuff that doesn't work, or you would need to modify." Again, that problem is exacerbated by product variability. It is difficult to plan how to re-use tooling for a product variant, but simulation will highlight any opportunities, thus eliminating the need to buy more or different tooling.

Simulation also helps to prove multiple robot environments, sometimes even revealing that fewer robots could do the job, and thus reducing capital investment.

Payback is difficult to assess, but "no greater than 12 months," says Giles, indicating that there have been many cases where it was a matter of weeks. How? "In many instances the costs of losing production time far outweigh the costs of a simulation package."

That said, there are some key criteria for success. "It's important to upload from a robot what it's doing, bring that into the simulation environment and understand what you should change in order to accommodate something new," says Giles. So you have to interface with the robot's control software: that's the mechanism that ensures accuracy of simulation.

As usual, you also need a simulation sponsor within the production department itself, otherwise you're not going to get past the 'planning versus production' difficulty. Ultimately, success or failure depends on combining the knowledge of the production and planning worlds and the robotic world, and ensuring that everyone sees management commitment to the task.

And the cost? Most are unwilling to commit to numbers but it's not cheap; however, the price is usually a small proportion of the potential total outlay of investing in robotic machines. ■

"[Simulation] gave us an indication of where the problem areas would be and how to develp specific strategies"
Andy Shaw, strategic planning executive, VTS Shipbuilding

Right: simulation of Corus Special Profiles' robot arm for sampling hot steel

SHIP-SHAPE PRODUCTION

One of the biggest markets for simulation is shipbuilding. At Vosper Thornycroft Shipbuilding's (VTS) Portsmouth site, a Simul8 simulation package has been used to model the build of the new Type 45 destroyer for the Royal Navy. Although ostensibly a defence contract, the facilities will also be used for construction of commercial shipping.

The manufacturing process, which takes place within an enormous steel production hall (SPH) is, according to Andy Shaw, strategic planning executive at VTS, like "making a big Airfix model". The line consists of steel-working production equipment, laser cutting, automated robotic bar cutting and robotic and semi-automated welding equipment. The process incorporates cutting plate panels and welding them together to form larger panels. Stiffeners are cut from bar and welded to the panels. These are then assembled into units and finally blocks. The Type 45 is an assembly of such blocks.

These production processes were replicated using the simulation software, and essentially product was 'squirted' through the model to see how the manufacturing environment reacted. Key benefits for VTS were the identification of bottlenecks and confirmation that its SPH had sufficient capacity to do the Type 45 work – and, crucially, extra work, such as offshore patrol vessels.

It showed, for example, whether workstations were fast enough to handle the product throughput required, and went on to demonstrate how the plant would react when different products were blended. "It gave us an indication of where the problem areas would be and how to develop specific strategies," says Shaw.

And it wasn't rocket science or rocket prices, although it wasn't a trivial undertaking. Simul8 is an off-the-shelf and relatively inexpensive piece of software, but Shaw indicates that, with thousands of components involved "there was shed loads of data", and IT, production engineers and consultants worked on the project for three months. He doesn't say it was easy, but he does say it was worth it. "It convinced BAE Systems that we had built a facility that could meet their requirements in terms of throughput."