Knowledge is power

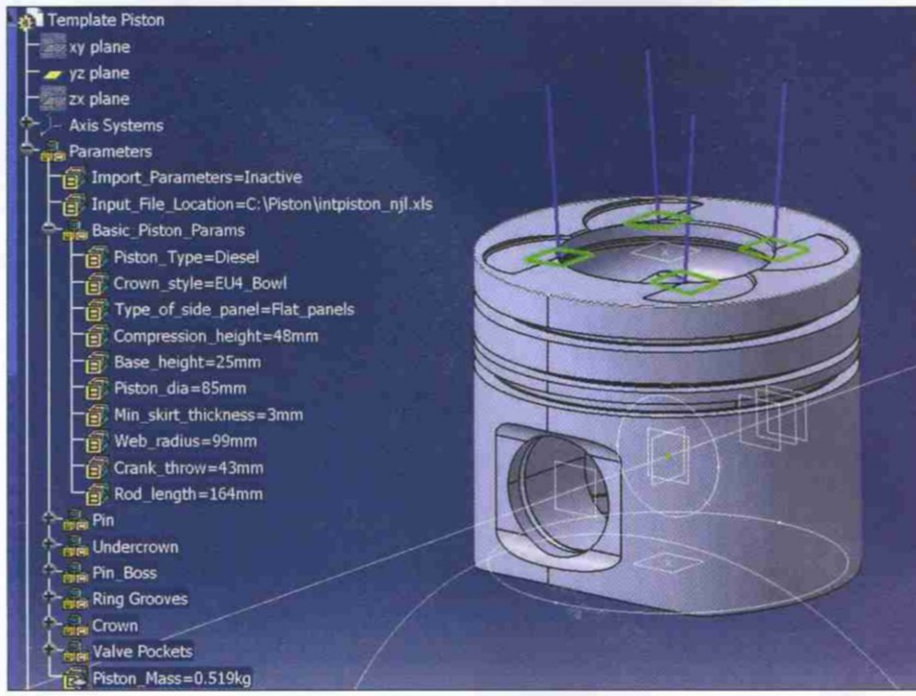
Ian McMath

Advanced knowledge-based engineering techniques are dramatically reducing the time taken to generate engine designs at one UK engineering consultancy.

UK automotive engineering consultancy Integral Powertrain (IP) has developed new processes that allow it to automate large parts of the work involved in designing, modelling and optimising new engine concepts. The result has been dramatic reductions in the time and effort required: crankshaft designs which used to take three weeks to complete using traditional methods can now be undertaken in only half a day, says the company.

IP's approach, which has been under development at its headquarters in Milton Keynes, UK, for around three years, involves a sophisticated database of 'rules' which govern the way the company's Catia computer-aided design (CAD) system creates models of engine parts and assemblies. The 5000 rules in the database control hundreds of aspects of the engine's design, from the detailed shape of bolt holes to the positioning of oil jets.

'Engineers make use of rules every day during the design process,' explains Luke Barker, technical director at IP, "They might be driven by material characteristics, company standards or their own design experience. What we have done is capture the best practice and embed these traditionally manual



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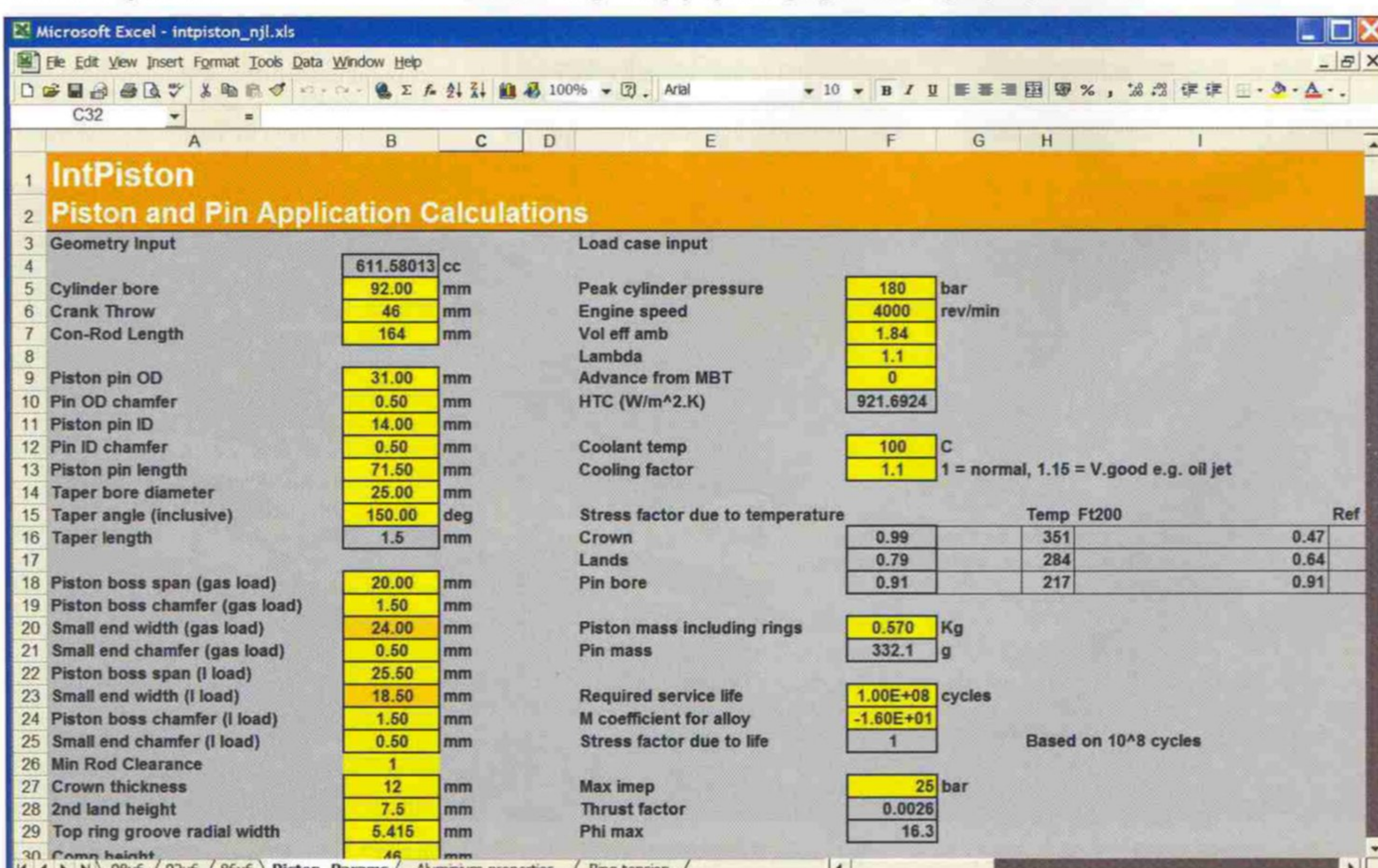


	A	B	C	E	F	G	H	I	
1	IntPiston								
2	Piston and Pin Application Calculations								
3	Geometry Input			Load case input					
4		611.58013	cc						
5	Cylinder bore	92.00	mm	Peak cylinder pressure	180	bar			
6	Crank Throw	46	mm	Engine speed	4000	rev/min			
7	Con-Rod Length	164	mm	Vol eff amb	1.84				
8				Lambda	1.1				
9	Piston pin OD	31.00	mm	Advance from MBT	0				
10	Pin OD chamfer	0.50	mm	HTC (W/m^2.K)	921.6924				
11	Piston pin ID	14.00	mm						
12	Pin ID chamfer	0.50	mm	Coolant temp	100	C			
13	Piston pin length	71.50	mm	Cooling factor	1.1	1 = normal, 1.15 = V.good e.g. oil jet			
14	Taper bore diameter	25.00	mm						
15	Taper angle (inclusive)	150.00	deg	Stress factor due to temperature			Temp	Ft200	Ref
16	Taper length	1.5	mm	Crown	0.99		351	0.47	
17				Lands	0.79		284	0.64	
18	Piston boss span (gas load)	20.00	mm	Pin bore	0.91		217	0.91	
19	Piston boss chamfer (gas load)	1.50	mm						
20	Small end width (gas load)	24.00	mm	Piston mass including rings	0.570	Kg			
21	Small end chamfer (gas load)	0.50	mm	Pin mass	332.1	g			
22	Piston boss span (I load)	25.50	mm						
23	Small end width (I load)	18.50	mm	Required service life	1.00E+08	cycles			
24	Piston boss chamfer (I load)	1.50	mm	M coefficient for alloy	-1.60E+01				
25	Small end chamfer (I load)	0.50	mm	Stress factor due to life	1		Based on 10^8 cycles		
26	Min Rod Clearance	1							
27	Crown thickness	12	mm	Max imep	25	bar			
28	2nd land height	7.5	mm	Thrust factor	0.0026				
29	Top ring groove radial width	5.415	mm	Phi max	16.3				
30	Comp height	46	mm						

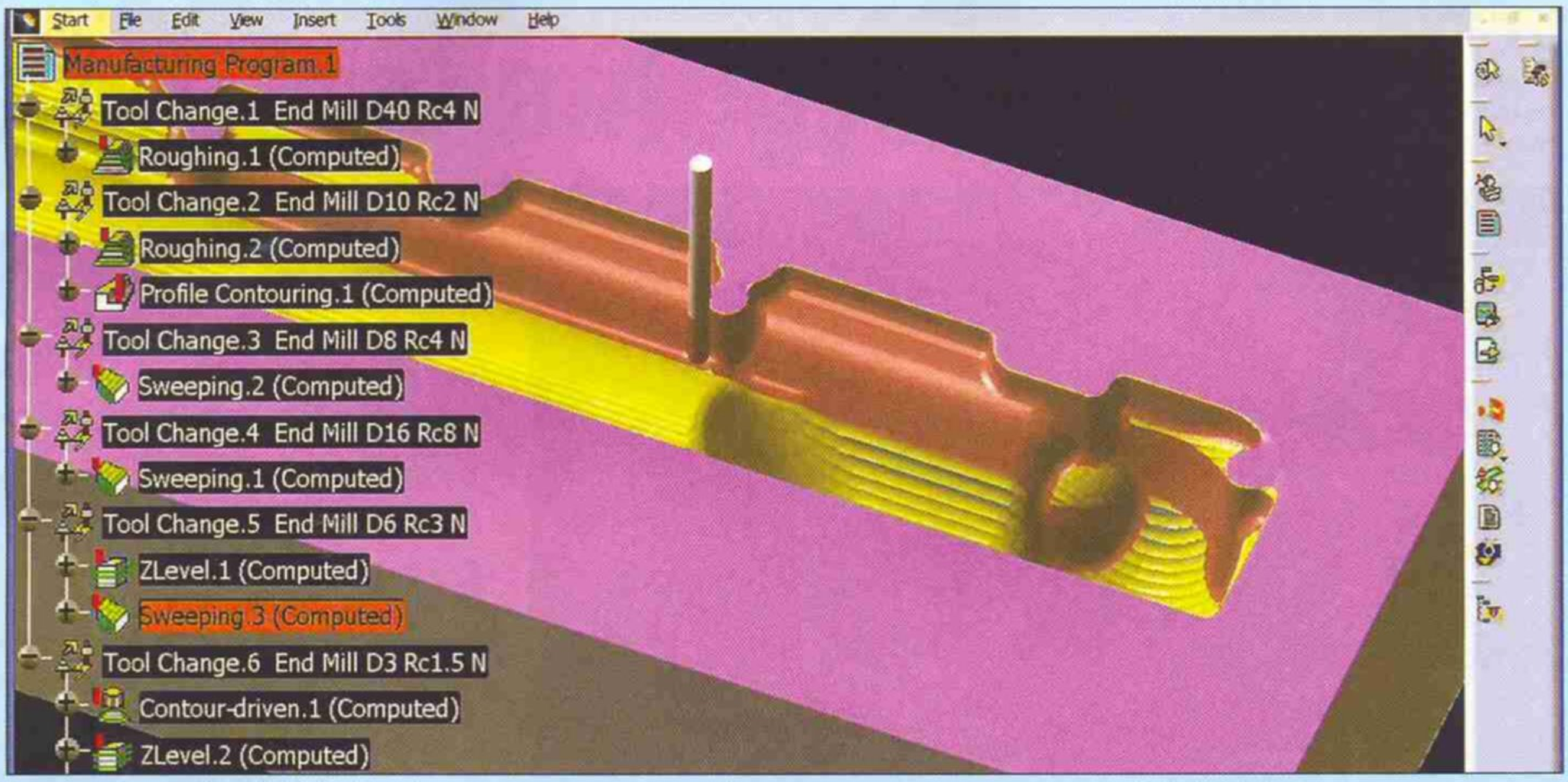
Quick to the cut

In their work with the F1 motorsport industry, engineers at Integral Powertrain realised that the CNC programming process was an area with considerable potential for time savings and quality improvements. In response, they have extended the AID approach for the generation of CNC programs. The process uses a series of 'templates', each developed for a particular type of tool or part. When applied to a CAD model, the template automatically identifies key features and applies toolpaths using pre-established best practice in terms of cutter selection, speeds and feed rates.

The template approach means that the development of machining strategy is taken off the critical path of a project. Once a template has been developed, it can be applied to a new design iteration, reducing programming time by up to 70 percent and the overall time to produce a new casting tool by nearly 20 per cent.

A project with Cummins concentrated on the production of prototype tooling for a series of sand-cast aluminium parts which Integral Powertrain supplied to the diesel engine maker. It is the first application of the new approach outside the F1 sector. According to Jerl Purcell, Chief Engineer, at Cummins, the new approach has been useful, not only because of the time it saves, but also as it ensures that prototype tools are dimensionally accurate. 'With the new system Integral Powertrain are moving automatically from design to tool, with the knowledge that the CNC programs they generate will use the optimum machining strategies for the job,' he says. 'This gives us prototypes that are always dimensionally representative of production tooling.'

The use of the templates to capture knowledge and automate its application in new designs is an approach that Integral Powertrain has applied successfully in a range of sectors. Its Automated Intelligent Engine Design system, for example, can rapidly generate new designs for engine components.



The AID (Automated Intelligent Engine Design) system can also generate CNC programs

calculations and decisions directly into the CAD system, so anything that can be automated, has been.'

The resulting 'templates' - CAD models of engine components with rules attached - can then modify themselves according to the requirements of each design task. The piston template, for example, is a single model that can be adapted from a gasoline to a diesel design just by changing certain key input parameters.

'Instead of worrying about the details of geometry creation, our engineers can control the model by entering higher level parameters, such as bearing size, cylinder pressure and rotational speed,' continues Barker. "From the resulting models, we learn very quickly whether a particular engine concept is going to meet our requirements. We can look at many more options during the concept design stage and because the quality of the data produced by the system is so good, we can apply sophisticated digital mock-up and analysis tools to verify our concepts. Then we can move forward with a more competitive solution that we know isn't going to throw up costly problems further down the line.'

Integral Powertrain calls its system 'Automated Intelligent Design' (AID). Barker estimates that the consultancy has invested 3700 man-hours in the creation of the rule base, but points out that productivity benefits achieved in use have far outweighed the time invested in the project. 'When we started using this system on customer projects we were able to complete one engine design iteration in ten weeks - significantly faster than with traditional methods," he says. "The latest version, which has a substantially more sophisticated rule base, more part templates and a refined user interface, is an order of magnitude more powerful again. In one recent project - again lasting ten weeks - we were able to investigate and optimise engine architecture to enable a single engine family covering three engine configurations to fit three vehicle platforms. Certain key components were iterated 50 times to deliver the solution.'

IP is now extending the AID system to automatically generate machining data for prototype part production (see box). Barker sees the use of such approaches as critical to his company's competitive advantage in the future. 'AID is a vessel that enables us to capture and evolve our best practice. Our people can tap into that best practice, which lets them spend their time creatively developing class-leading solutions for our customers.'

For further information contact David Meek, Integral Powertrain Ltd., Denbigh Road, Bletchley, Milton Keynes, MK1 1DB, UK. Tel: +44 (0) 1908 278600, Fax:+44 (0) 1908 278601