

Redefining carbon fibre machinery

Joseba Perez Bilbatua discusses his investigations into developing new technology for machining composite parts; research that will play a major role in health and safety in the workplace

What key issues do you seek to address through your research project?

The main purpose of the European Commission-funded project ASPIRATE is to develop an innovative technology for machining carbon and glass fibre composite parts, which is based on the internal extraction of all chip and dust produced during machining. The aim of ASPIRATE is to make obsolete all the external devices and suction pumps which are currently used to eliminate dust and chips from the work zone. Dust and chips reduce process flexibility and leave parts unclean, with consequential risks for operators' health as well as machine components (such as guides, drives and measurement systems).

There are two specific targets of the ASPIRATE project. Firstly we are looking to increase the machining rates from those currently being used in the industry by 25 per cent. This will come from developing the air flow through the cutting tool, cooling the cutting process (current processes are not cooled), and the application of customised surface coatings will delay cutting edge wear and reduce friction. Secondly, the project is seeking to eliminate 100 per cent of the dust produced during the machining of CFRP (Carbon Fibre Reinforced Composites) and GFRP (Glass Fibre Reinforced Composites) from the working area and the shop floor facilities. This will improve operators' working conditions, prolong the life of the moving components and lower the life cycle costs associated with the production stage.

Why are composite materials considered extremely difficult to manufacture?

Composite materials are heterogeneous and machining may affect differently each component of the composite's resins and fibres. Machining composites can easily result in defects as delamination, fibre pull-out, cracking and resin burning. Moreover, reinforcement fibres are, in the case of GFRP and CFRP,

extremely abrasive and very difficult to be neatly cut, putting high restrictive constraints on tool materials, geometry and cutting conditions. The fumes and dust coming from machining are carcinogenic if inhaled and present severe hazards to human health.

Can you outline the tasks performed by each of the critical components you seek to develop through ASPIRATE and your progress made to date?

Firstly, hollow cutting tools have been designed, adapted for constraints of composites machining, fabricated and probed by means of machining tests. After initial prototype testing, tools have been optimised in order to solve observed problems, regarding aspiration behaviour as well as general machining. Secondly, the main task regarding diamond coatings is focused on developing an interlayer between cemented carbide substrate and coating film, to act as a chemical barrier during coating deposition, preventing graphite formation. Research work on the coating application process and testing of performance on cutting tools is on the way. Finally, an internal chip aspiration demonstrator has been designed, fabricated and successfully set-up. This prototype is currently running on machining tests for the development of other project tasks. All the tests carried out up till now have shown the extraordinary performance of the whole system, being able to extract the 99.5 per cent of the dusts and chips produced on the milling process.

What is the role of the SMEs from across Europe in the project consortium?

The main role of Rho-BeSt Coating GmbH (Austria) is centred on the development of diamond coatings for cutting tools. Ortza S Coop (Spain) is responsible for building a machine tool suitable for the internal aspiration process. The contribution by Zubiola S Coop (Spain) is focused on the development of cutting tools, including diamond-coated



cemented carbide tools. As an end-user, Invent GmbH (Germany) will state the industrial requirements for the system, machine tools, cutting parameters, etc. and perform the validation of the process and equipment (machine, cutting tools, spindle) according to industrial specifications and requirements.

It should be also highlighted the role played by the other RTD partner, Fraunhofer IST, on the development of new coating materials and supporting the activity of Rho-BeSt.

What steps have been taken in optimising your tools so that they might be assimilated into industrial contexts?

The project is close to achieving the initial goals of having the system (machine, toolholder, spindle and vacuum system) integrated and working properly. Several hollow cutting tools have been also designed and tested with optimum results. In order to provide a completely industrial solution, the project will now focus on developing new tools of smaller diameters, as well as on the retrofitting solution of existing equipment and the development of customised machine tools for different applications.

The solution developed in ASPIRATE is a flexible and simple system when compared to the existing complex equipment

Improving high performance component technology

A team at the **IDEKO-IK4 Technology Centre** are exploring opportunities for machining carbon fibre reinforced composites, enabling progression in the efficiency and sustainability of the European machine tool sector

THROUGHOUT EUROPE, SMEs are making a significant contribution to the GDP of EU Member States. Representing 99 per cent of all enterprises in Europe, SMEs contribute more than two thirds of European GDP and provide 75 million jobs in the private sector. However, these SMEs are facing increasing competition from low-wage countries, which are increasingly turning out products of improved quality.

Within the European machine tool sector, nearly 90 per cent of companies are SMEs who have identified products and market segments, but these SMEs are struggling to retain competitive with the improvements in competence and cost of products being produced outside of the EU, particularly in Asia. To enable the sector to respond to this challenge, it is critical that technology stays at the forefront. A research team based at the IDEKO-IK4 Technology Centre is looking at ways to improve the efficiency, safety and environmental credentials of machining composite parts for the machine tool industry.

Led by Joseba Perez Bilbatua, the team is working on developing an innovative technology for machining carbon and glass fibre composite parts focused on eliminating the need for external devices and suction pumps. Known as ASPIRATE, the project, funded by the European Commission under the FP7 with grant number 232127, is providing both European SME machine tool builders and components manufacturers with the necessary technology and skills to produce, in a cost-effective and competitive way, high value-added and high-tech equipment.

CARBON AND GLASS FIBRES ADD VALUE TO MANY SECTORS

There are numerous industries around the world that choose carbon and glass fibre components, mainly because of the superior mechanical properties they offer. The main advantages of carbon fibre reinforced plastic (CFRP) and glass fibre reinforced plastic (GFRP) is that they both have excellent specific strength as well as strength-to-weight ratio. As a result, these composite materials are very attractive to industries needing to keep the weight of products to an absolute minimum

– such as the aerospace industry. The other major benefit of carbon fibre is that it has an almost null thermal coefficient, meaning that there is a high degree of dimensional stability across a wide range of temperatures.

CFRP and GFRP were first seen in military aircraft; subsequently, as the costs of producing composite materials dropped, commercial aircraft engineering began to seek parts made from these materials. Today there is a growing use of CFRP and GFRP in other sectors and industries, such as energy generation and non-aviation transport. Bilbatua is acutely aware that introducing composites into the infrastructure, construction, automotive or leisure markets is a process fraught with complexity. He explains that although they are capable of high performance, these composites are usually adopted into these new markets on the strength of their other benefits, such as corrosion resistance, weight savings and structure.

The production of wind turbine blades is an area that Bilbatua sees as a particularly strong growth market for CFRPs, but one that will be strongly influenced by the availability and pricing of carbon fibre: "Due to the tight supply situation and spiralling prices for CFRP and despite the lower performance of GFRP, this composite still dominates this market". Another key market for carbon fibre that is forecast to grow significantly is automobiles, in particular high performance and racing cars. The advantages that CFRP has over steel, including its improved thermal insulation, have also resulted in a rising interest from ultra-deepwater oilfield operators.

CREATING MORE EFFICIENT AND SAFER MACHINES

Machining of CFRP and GFRP can be a time-consuming process as well as a health and safety minefield. The main goals of ASPIRATE are to improve the rates of machining and to eliminate 100 per cent of the dust produced during machining. The ASPIRATE researchers have developed a new chip and dust internal aspiration and extraction system which they hope will improve the overall performance of the machining processes and achieve ASPIRATE's objectives.

INTELLIGENCE

ASPIRATE

INCREASE OF PRODUCTIVITY, SAFETY, GREENNESS AND CLEANLINESS IN THE MACHINING OF CARBON FIBRE REINFORCED COMPOSITES

OBJECTIVES

- To develop an innovative technology for machining carbon and glass fibre reinforced plastic (CFRP and GFRP) parts, based on the internal extraction of the produced chip and dust particles through the whole machining system (cutting tool, tool holder, spindle)
- To develop a new hollow cutting tool, with optimised edges geometry and diamond coatings for machining CFRP materials with anti-adhesive and wear-resistance properties
- To characterise the CFRP machining process, with the aspiration technology, in terms of productivity, efficiency and safety

PARTNERS

IDEKO, Spain • Rho-BeSt GmbH, Austria
• Fraunhofer Institute for Surface Engineering and Thin Films (IST), Germany • INVENT, Germany • Ortza, Spain • Zubiola, Spain

FUNDING

EU Seventh Framework Programme (FP7)

CONTACT

Joseba Perez Bilbatua
International R&D Projects Director

Ideko
Arriaga Kalea 2
20870 Elgoibar
Spain

T +34 943 748 000
E jperez@ideko.es

www.aspirate.eu

.....
JOSEBA PEREZ BILBATUA has an academic background in physics, mechanical engineering, robotics and advanced manufacturing systems. He is currently Director of International Research Projects at IDEKO-IK4 Research Center, and coordinator of the ASPIRATE, DYNXPPTS, CAMEL-MCG and MIDEMMA EU FP7 projects. He is involved in several manufacturing initiatives and working groups in aerospace and railways industry.



Bilbatua believes this new technology has created a straightforward answer to help prevent any human health hazard from the dust and particles generated during machining: "The solution developed in ASPIRATE is a flexible and simple system when compared to the existing complex equipment," he enthuses. One of the real benefits is that the ASPIRATE system can be easily integrated into existing equipment, keeping the costs of retrofitting and replacement to a minimum. This means many of the SMEs currently machining composite materials can take advantage of the new technology.

The new system represents a significant improvement on existing systems. Bilbatua's team has tested out a range of different processes, including milling, trimming, drilling and pocketing, and have shown in all cases what they consider to be an unbeatable performance with the new system. "Moreover, the internal aspiration air flow has a coolant effect, keeping temperatures lower on the working point and preventing the tool wear and damage on the machined part surface," Bilbatua explains. Now that the machine, spindle and vacuum system are working perfectly, the next steps for ASPIRATE will be to focus on the hollow cutting tools, new edges design and reducing the tool diameters.

DELIVERING A FEASIBLE SOLUTION FOR INDUSTRY

One of the main challenges the group has faced has been connecting the rotating spindle to the static aspiration pump on the machine tool. Bilbatua explains that a new coupling system between spindle rear and aspiration system has been designed which has permitted spindle rotation as well as a watertight union: "Besides that, the internal conduct of the spindle has been duly modified to allow the

flow of the chips and dust, without jamming the conduct," he points out.

With regard to the cutting tools, the key challenge has been in enabling the hollow tool and the edge geometry to be able to cut composites whilst avoiding both pull-out of the fibre and delamination, but at the same time favouring chip internal aspiration. The team has developed a diamond coating that has had a positive effect on the tool life, reducing wear and avoiding dust adhesion on the tool edges. In order to make this new system both profitable and feasible for industrial use, the cutting parameters (cutting speed, feed, depths of cut, etc.) had to be perfectly characterised.

GLOBAL APPEAL

Because the extraction of dust and chips when machining CFRP materials is a common international problem, the ASPIRATE system has international relevance. Existing external equipment does not provide enough flexibility, and is not able to completely extract the generated dust volume, having areas of the work piece where the external extraction system is not able to reach and that could even crash if the programming is not accurately done. "All these drawbacks are solved with our innovative extraction process," Bilbatua states.

As European machine tool builders, component manufacturers and end-user SMEs are facing loss of competitiveness due to the high competences of low-wage countries, ASPIRATE looks set to be able to deliver a solution. Bilbatua is in no doubt that ASPIRATE is making a significant contribution to European innovation by helping differentiate the products of European SMEs to support EU competitiveness in the global market.

.....
THE ASPIRATE TEAM

