

STARRAG'S AEROFOIL BLADE MILLING MILESTONES

The Starrag Group recently presented UK aerospace OEMs and top-tier suppliers with an exclusive insight into the considerable extent and depth of the company's ongoing development programme into its continual improvements in aerofoil blade/blisk milling.

Results from current trials reinforce why Starrag enjoys a global lead in the effective and efficient machining of such parts, with the event at Sheffield's Advanced Manufacturing Research Centre revealing groundbreaking progress in:

- [] Blisk machining using the revolutionary, new NB Series machine concept which can achieve material removal rates of 1,000 cm³/min;
- [] 'Adaptive milling' of fan blisks and forged compressor blades;
- [] Chatter-free machining of thin-wall airfoils;
- [] Cryogenic cooling; and
- [] Nickel-based super alloy and gamma titanium blade machining.

A development of Starrag's highly successful LX Series machines, the innovative NB Series mill-turn machine is specifically designed for the machining of single- and multi-stage titanium and nickel-based super alloy blisks of any shape (as well as steel blisks for gas turbines). The

machine can accommodate workpiece diameters up to 1,100 mm and blade lengths up to 200 mm for most dynamic machining via the tip entry route, where the tool is applied radially.

The multi-axis machine – X, Y, Z, A and B axes – boasts a small footprint, high stiffness and minimal compensation movement in X and Z for ultra-high dynamics courtesy of low moving masses. It features high dynamics and an innovative design of B axis, which is positioned at 50deg to the spindle centreline. The tool centre points meets all axes.

Interestingly, the NB Series is also under development as a twin-spindle unit featuring similar parameters (including using the same coolant supply and chip removal route) but with separate toolchangers and independent axes and spindles for simultaneous yet independent machining. However, because all axes utilise the same machine structure, the twin-spindle option represents significant savings in floorspace and, importantly, in cost per spindle.

The NB Series will be supplied by Starrag as a process-ready package, complete with appropriate tooling, fixturing and automation, thus reinforcing the company's standing as a systems solutions provider.

Being applied successfully to both linear friction welded blisks as well as precision forged blades, Starrag's adaptive milling routines have been

developed to cope with the unique shape of each individual aerofoil. Using touch probing, each aerofoil/pocket is inspected and the resulting data is used to create unique NC programs/codes to achieve superb blending.

Starrag revealed the latest results of its continual research into the challenging process of machining thin wall parts, especially by avoiding chatter – caused by friction between cutter and workpiece, by thermo-mechanical effects on chip formation and/or by the waviness of the workpiece surface.

The use of specially-designed tools such as a tapered torus-type cutter (rather than a tapered ball nose design) in conjunction with simulation software to determine optimal cutting conditions, allows such tools to be applied at higher feed rates and spindle speeds. The result is reduced machining time, better surface finish and the elimination of premature tool wear.

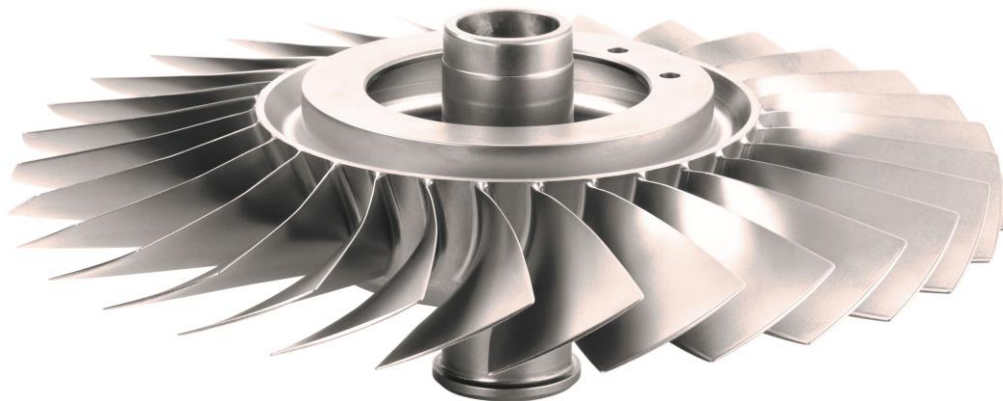
Underpinned by partnerships with tooling companies, Starrag's investigations into tooling include the use of cryogenic cooling, where the use of liquid CO₂ applied to the centre of the cutting tool via the machine spindle dissipates cutting temperatures and therefore minimises tool friction and swarf adhesion. Initial results have shown 70 per cent improvements in metal removal rates.

In addition, the combined use of ceramic and carbide tooling – for roughing and finishing, respectively - is providing a step change in the way ni-based super alloys can be machined. While the machining of gamma titanium, which is increasingly being used as a lightweight, high temperature alloy, is also being investigated – with carbide tooling being applied at low cutting speeds but high depths of cut and high feed rates and with optimal cooling (including cryogenic).

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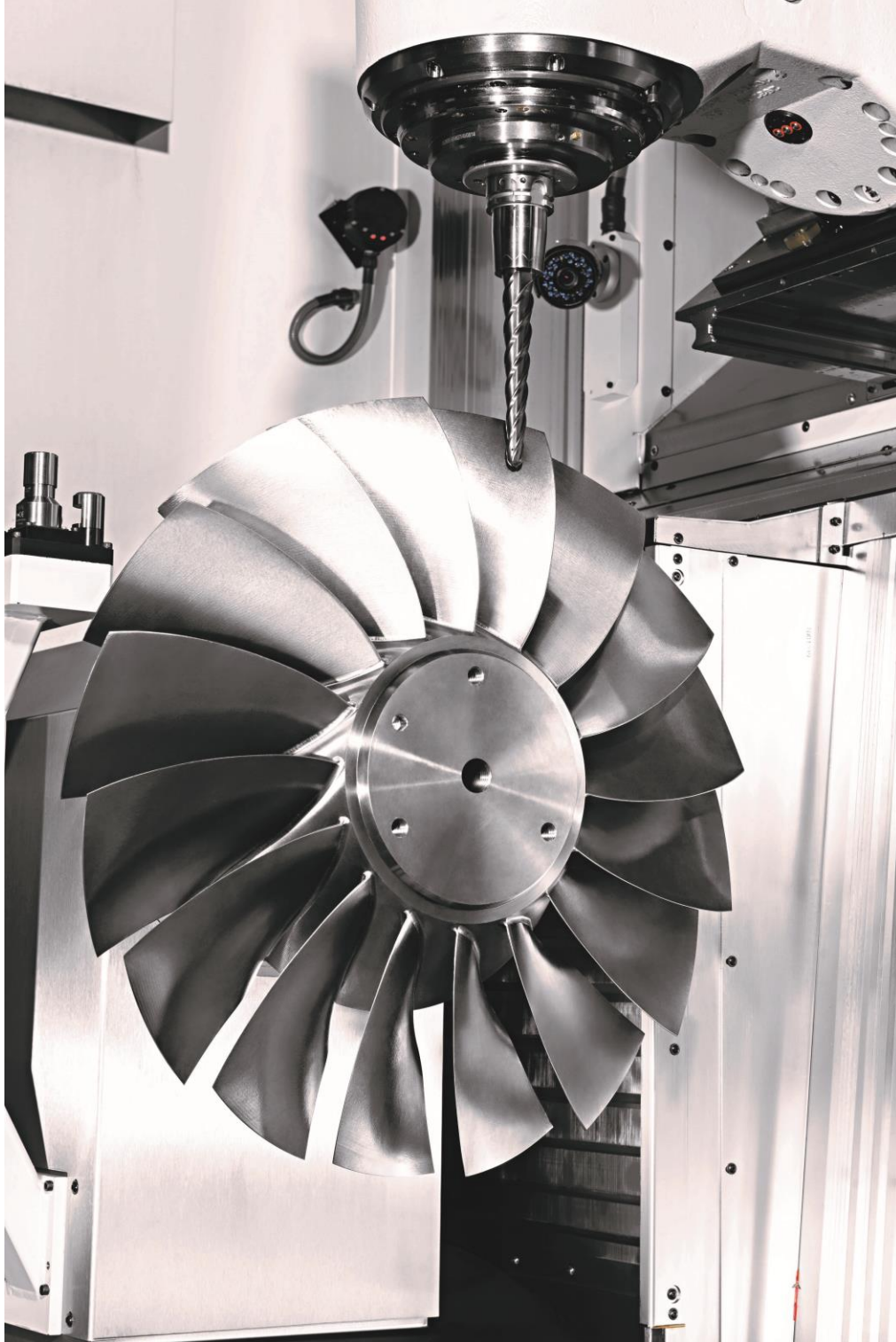


The NB Series from Starrag is equally successful on linear friction welded blisks as it is on forged blades



Forged blade before and after Starrag machining of snubber, edges,
root and tip

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Starrag's new NB Series machine in action