Why CNC Machining with Aerostatic Tool Spindles is Becoming a Global Phenomenon

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Dr. Ralf Dupont, President of Levicron, has been involved in the development of non-contact bearing systems, for over a decade. AZoM Spoke to Ralf about Levicron's aerostatic tool spindles which can be used to increase the speed, precision and throughput of CNC machining processes.

Could you please give our readers an overview of aerostatic tool spindles?

The principle of gas-static bearings for linear and also rotating bearings has been around for several decades and is based on two different physical systems – a self-adjusting pressure distribution between the bearing part and the load carrying part, and a squeeze film damping.

The pressure distribution is created by feeding pressurized gas through jets into a gap between the bearing members which is only several microns thin. The smaller the gap is the higher the pressure after the jet. For a cylindrical shaft in a journal bearing any shaft eccentricity thus results in a restoring force that moves the shaft back in its centre position.

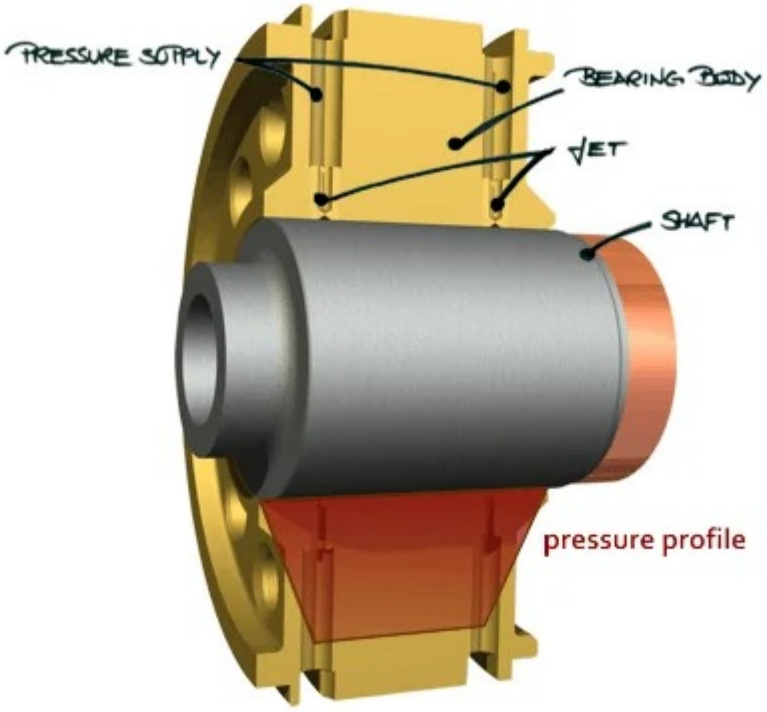


Diagram showing the different components of an aerostatic tool spindle and its pressure distribution

There are also outlet restricted bearing designs which create a pressure distribution by using a smaller gap at the end of the bearing gap. Although more simple in design they lack of stiffness and load capacity.

Vibrations and chip loads result in excitement which can push air to the bearing ends, resulting in motion between the bearing parts, which is not desirable as it results in errors. The squeeze-film damping squeezes the air and pushes it to the bearing ends. This requires time and energy resulting in a damping force that acts against the disturbance to ensure the spindle is precise.

Aerostatic technology can be applied to both radial and axial bearings.

Whilst the load capacity of aerostatic spindles is lower than it is for roller bearing spindles they have a higher stiffness, more than double the rotation speed and a significantly lower error of motion. This low error in motion is due to a compensation effect of the gas inside the bearing gap that allows a rotation that is much more accurate than the sum of all shape errors of the bearing parts.

This high stiffness, speed and astounding accuracy mean aerostatic spindles are better suited to the machining of optical components when compared to their roller bearing

counterparts.

Why haven’t aerostatic spindles been considered for CNC machining in the past?

Well, they have. But historically aerostatic spindles have been designed for applications other than CNC machining.

CNC machining requires a high level in automation and robustness and all of the aerostatic spindles that were on the market before focused on a high speed or a high precision. There have been many unsuccessful attempts to use these spindles for CNC machining which tend to fail as CNC machining requires a spindle produced for CNC machining.

Our tool spindles are capable of ultra-precision, whilst also having the stiffness and load capacity required for CNC machining. Our solutions are also capable of automatic tool changes capability and tool clamping status monitoring whilst having an extremely high thermal stability.

What benefits can aerostatic tool spindles bring to the CNC industry?

The ultra-precise nature of our tool spindles allows customers to machine parts with an optical surface finish. For example, new LED-based head-light designs for cars require the precise machining of hundreds of LED sockets with an optical surface finish. Our spindles low errors in motion and high spindle speeds lead to an increase in both product quality and productivity.

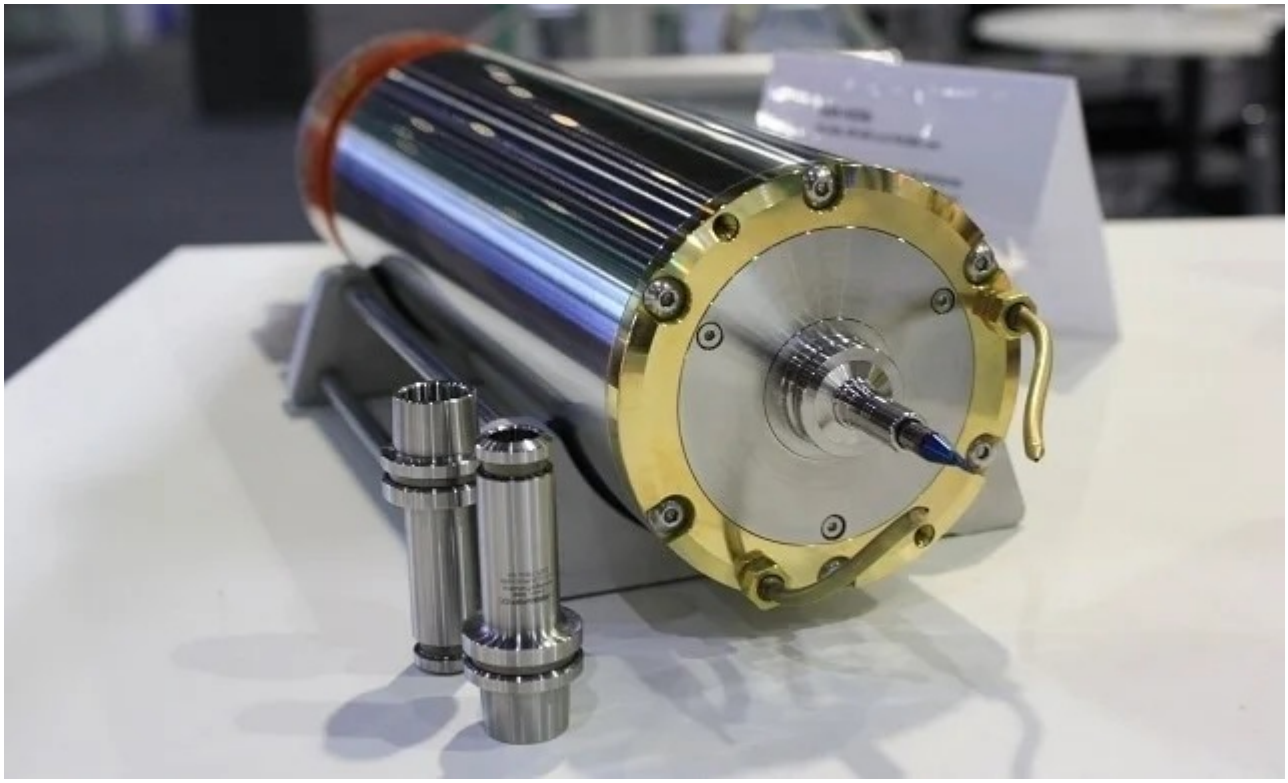
Also, once warmed through aerostatic spindles don’t change their properties whereas conventional spindles, which uses roller bearings, do. This allows machining of complex parts at constant part quality, even when machined at 100.000 rpm for days or weeks.

What aerostatic tool spindles do Levicron offer?

Wrapped around a patented, ultra-precise bearing system our ASD-H25/A offers ultra-precision, high-speeds and the functionality of a state-of-the-art CNC tool spindle with an automated HSK-E25 tooling system.

Capable of speeds of up to 100.000 rpm and with a radial stiffness of up to 45 N/micron at the spindle nose no other tool spindle of the same size offers this unique mixture of

precision, speed and functionality.

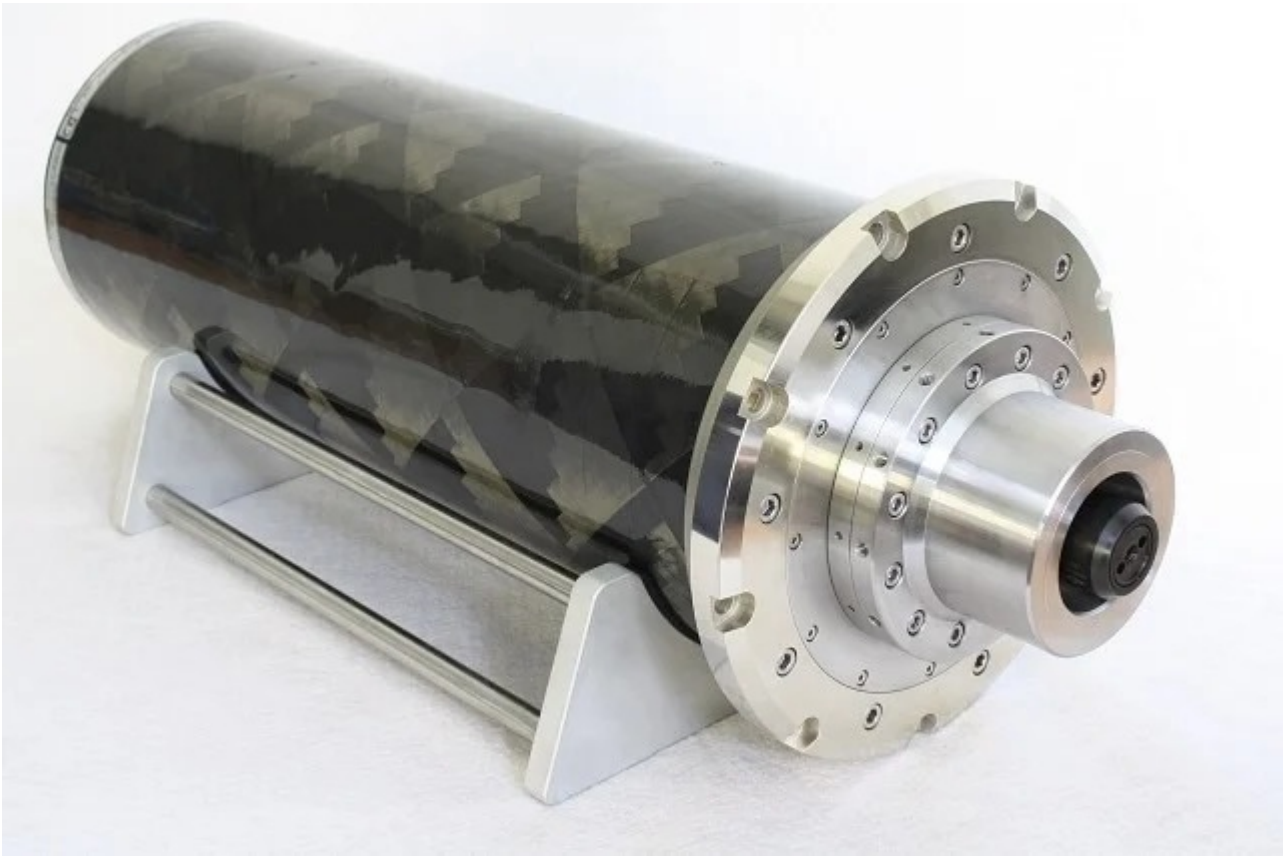


ASD-H25/A Tool Spindle

Based on the same bearing system our ASD-Cx offers the same performance and functionality, but with an automatic precision collet system.

With the great success of these two spindle models we have decided to design a high-load aerostatic spindle with a larger HSK tooling system for heavy machining. Coming soon.

Our work-holding spindle, the ASD-Px, has been recognized to be very useful for grinding applications, such as minimizing sub-surface-damages whilst grinding glass lenses. Our ASD010PH63M is shipped with a manual HSK-C63 tooling system and an optional high-pressure rotary feed-through.



ASD-Px Workholding Spindle

What sets your aerostatic tool spindles apart from those produced by your competitors?

Up until now no comparable aerostatic spindles can be found on the market which leaves us in quite a comfortable spot. We are prepared for this to change and our experience in the development and manufacturing of our spindles over the last six years give us a safe lead.

Our roots can be found in ultra-precision machining, and our spindle solutions are being used in this market to great success. Combined with the robustness and functionality of a CNC tool spindle we can provide solutions for both ultra-precision and CNC machining.

Bottom line, customers working in ultra-precision machining benefit from the functionality of CNCs and can add a great deal of automation to their machines. On the other hand, CNC machine tool builders can now use ultra-precise machine parts without scarifying functionality, safety and productivity.

We’re using the expertise we’ve gained to develop a new generation aerostatic tool spindles for CNC machining which will even outperform hydrostatic spindles with respect to

their load capacity, surface finish, cost and energy consumption.

It is not only the spindle itself which gives a unique solution for our customers, we also provide very competent and comprehensive solutions for machine integration and applications as well as a first-class post market service.

The different components that can be integrated to create a fast and effective machining system

How quickly is your new technology been adopted by machining companies?

With typical cycle times of 10-15 years we have clearly underestimated the time required to establish our products and our company in the CNC machine market. It's not only machine builders that we have had to show about the advantages of our spindle solutions, but also the end-customers.

By first targeting the German CNC machine tool market we have not only been able to successfully establish our brand and our spindle solutions in this country, but also in

Switzerland where our aerostatic tool spindles show outstanding performance for the machining of watch components. The success in these markets has ensured a very strong organic growth for our first 4 years.

Asia is on track to become our biggest market with more and more major CNC machine tool builders using our spindle solutions. Our great success in Asia has led to a further organic growth of 25 % and an increase in sales of 70 % with skilled agencies in Taiwan, China and South Korea. Based on the current growth, and with our new development for heavy CNC machining, we are looking at an organic growth of around 50 % for the next 3 years.

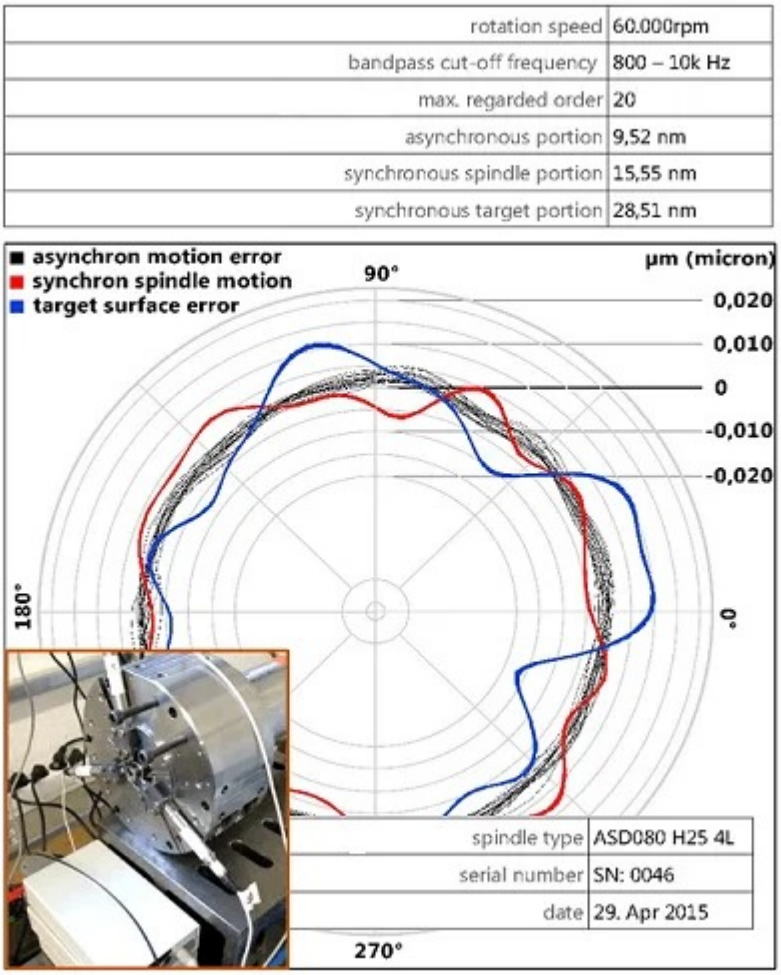
Levicron operates from Germany, Switzerland, the US and (more recently) China, South Korea and Taiwan

What gives you the confidence that your aerostatic spindles are so precise?

Our ultra-precision tool spindles ASD-H25/A and ASD-Cx and our ultra-precision work-holding spindle ASD-Px are being widely used for traditional ultra-precision (UP) machining. Their high popularity, their metrology results and our continuously improved testing methods on spindle dynamics and error-motion makes us confident we are providing an ultra-precise solution for CNC machining.

The automated tool change capability and their functionality and safety features has allowed companies such as the US based, AMETEK Precitech Inc.– a leading force in ultra-precision machining technologies – to become closer to CNC machining productivity-wise.

Back in 2013 Levicron has partnered with AMETEK Precitech Inc. who have become the distributor of Levicron products in the Americas and Asia for ultra-precision machining. With Precitech on our side - who make good use of our spindles with their ultra-precision machining solutions, by the way - we are confident to deliver ultra-precision not only for customers in this industry.



The errors in motion observed using an ASD080 Spindle

What products do Levicron hope to introduce to the CNC industry in the coming years?

We are currently working on a high-load aerostatic spindle with a larger HSK tooling system.

With a housing not bigger than 120 mm in diameter the spindle won't be much bigger than our ASD-H25. But with a load capacity and stiffness at the spindle nose of more than 6.500 N, 120 N/micron the spindle is suitable for heavy machining, whilst also allowing ultra-precise machining at 60.000 rpm.

This spindle is specifically being designed to outperform hydrostatic spindles, which only allow speeds of up 40.000 rpm and consume 60% more energy, whilst also being cheaper as no hydraulic system, filtering, cooling and maintenance is required.

Other than a heavy-duty and ultra-precision bearing system all parts of this spindle will be developed and manufactured in house. This includes the spring-less tool clamping system, a high-pressure rotary feed-through, a micro rotary encoder and a high-torque synchronous motor with 4 Nm constant torque. With this spindle the user will be able to rough and finish machine mold and dies made from hardened steel to optical surface qualities.

Beside the development of the described high-load aerostatic tool spindle a high-speed spindle with 130.000 rpm and a smaller HSK-tooling system for the Swiss watch industry is also in the process of being developed.

Where can our readers find out more about Levicron?

Information about our spindle solutions can be found on our website.

Our website is currently being re-designed and we hope that we can upload the new version within the next month. We are also happy to send anybody who is interested catalogues or to answer their questions personally so don't hesitate to get in touch.

We're also going to be attending the following trade shows, make sure to give us a visit;

- Optatech, Frankfurt, Germany, June 7-9
- Photonics China, Shanghai, China, March 15-17 (together with AMETEK Precitech Inc.)
- AMB, Stuttgart, Germany, September 13-17
- IMTS, Chicago, USA, September 12-17 (together with PMDi Inc.)
- JIMTOF, Tokyo, Japan, November 17-22

About Dr. Ralf Dupont

For more than a decade, Ralf has been driven by non-contact bearing systems like air bearings as well as precision engineering and machining.

Coming from a high-speed drilling spindles and centrifugal compressors background, Ralf founded Levicron back in 2010 and yielded to his temptation of precision machining and high-speed spindle systems.

Ralf holds a degree in industrial engineering from TU Kaiserslautern.

Ralf previously worked for Air Bearings Ltd, MAN Turbo AG, Fischer-Precise AG and the University of Kaiserslautern.