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Spindle Converter Systems for machining of aluminium alloys

The specifications for spindles to high-performance machine aluminium alloys have continuously risen over the past years. When volume milling, it is necessary to machine as much aluminium as possible in the shortest period of time. So it is state of technology to reach a Material Removal Rate (MRR) of up to 8 l/min, at cutting speeds of 4'000 m/min. This requires spindles with high rotation speeds and high performance.

Finishing requires high rotation speeds, in order to reach sufficient cutting speeds (Chart 1) even with small tools which can only achieve a limited output of chips.

	Output	Rotations
Roughing	+++	++
Finishing	+	+++

Chart 1: Specifications for spindle capacity and rotations for machining aluminium.

At the moment, the focus on new developments lies on increasing the maximum available output, that is to say, on optimising the roughing process. Thereby a maximum rotation speed of 30'000 rpm is not exceeded, because a further increase of rotations can risk negatively influencing the reliability of the system and the available 30'000 rpm maximum rotation is sufficient for finishing. An increase of the available output is, among other factors, more sensible economically, since the decrease of the time for roughing at material removal rates of over 90 % of the structural part offer the greater potential regarding increase in productivity. As a consequence of increasing output, specific action must be taken in order to transform the output process safely into chips and also means that the spindle manufacturer must inevitably consider and control the whole mechatronic system (spindle and converter).

Fischer AG has developed a Spindle Converter System, taking into consideration the above described framework conditions. The system, which has been tried and tested in many applications, will now be introduced. The tests conducted show that the use of the system makes it possible to clearly push the shown boundaries towards higher productivity. To this end, the newly developed spindle MFW-2320/30VC HSK-A63 uses a synchronous motor specifically developed for this application, which is driven by its own converter. The developed synchronous motor represents the best in regards to power density in the given space. In comparison to conventional spindles, it was thereby possible to notice ably reduce the bearing clearance between the front and back bearing position. This has a positive influence on the structural dynamic properties of the spindle, giving it a more stable milling performance for larger cutting depths.

Furthermore, the spindle, due to its compact construction, is ideal for use in five-axle swivel heads. The balancing quality of the spindle is of great importance for general use as well as in five-axle swivel heads. Fischer spindles for volume milling are therefore standardly balanced so that a minimum excitation of the mechanical surrounding structure is warranted. The optimal balance is achieved by considering the amplitudes and vibra tional modes of the spindle, which are caused

by the rest imbalance. The influence of this completed dynamic optimisation by using the synchronous motor is reflected when calculating stability charts for tools being used as well as in practical usage, as has been confirmed during milling tests at the WZL (Tools and Machine Laboratory) in Aachen and at the PTW (Institute for Production Technology and Cutting Machines) in Darmstadt. Image 1 shows the calculation of a stability chart for typically used tools, which have been validated in practical tests. With this, one can determine the optimal working range of the spindle. This lies between 20'000 and 30'000 $^{min-1}$, i.e. in the normal application range for tools of this sort.

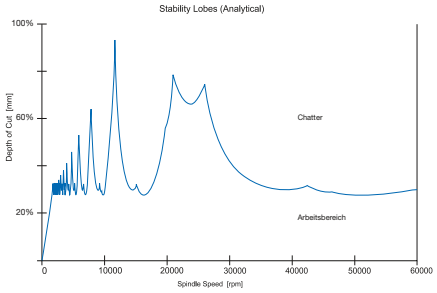

Image 1: Stability chart for a tool d = 50 mm, L = 120 mm (0.2 mm pitch, z = 4)

For the above mentioned university tests, it was possible to reach MRR values of up to 12 l/min, which is equal to an increase of 50 % against the existing upper limit. This increase leads to an impressive reduction of machining time and consequently an increase in productivity. With a structural parts weight of 1.5 t and a weight-related material removal of only 70 %, a reduction in machining time of 33 %, when roughing, would be achievable (Image 2).

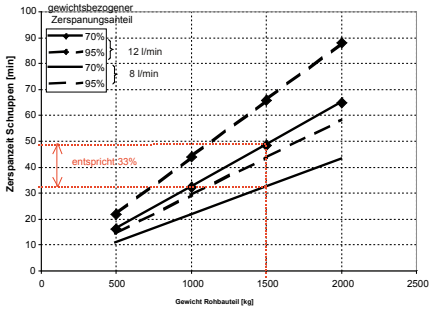

Image 2: Effect of increasing the MRR from 8 l/min to 12 l/min on the machining time for roughing.

In summary, one must point out that the new Fischer Spindle MFW-2320/30 VC HSK-A63 is a milestone in volume milling aluminium and a new milestone in spindle development regarding reliability and productivity.

MFW-2320/30 VC HSK-A63

Diameter	230 mm
Length	534 mm
Weight	107 kg
Max. rotations	30'000 rpm
Tool interface	HSK - A63
Motor type	AC synchronic
Voltage	523 V
Current	177 A
Output S1	100 kW
Torque S1	48 Nm
Output S6 40 % t=2 min	125 kW
Torque S6 40% t=2 min	60 Nm
Spindle Coolant	Water based fluid
Cooling system spindle	Bearing + Motor
Process cooling external	Valves M5 adjustable
Tool cooling internal	yes
Rotation monitoring	Shaft encoder
Motor temperature sensor	KTY
Dilatation sensor	option
Acceleration sensor	option
Bearing temperature sensor	PT 100

FISCHER frequency converter

Current control ASIC–based	cycle 2 µs
Modulation–frequencies	4 bis 20 kHz
Output	200 kVA
Current	300 A_{eff}
Cooling	Water

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