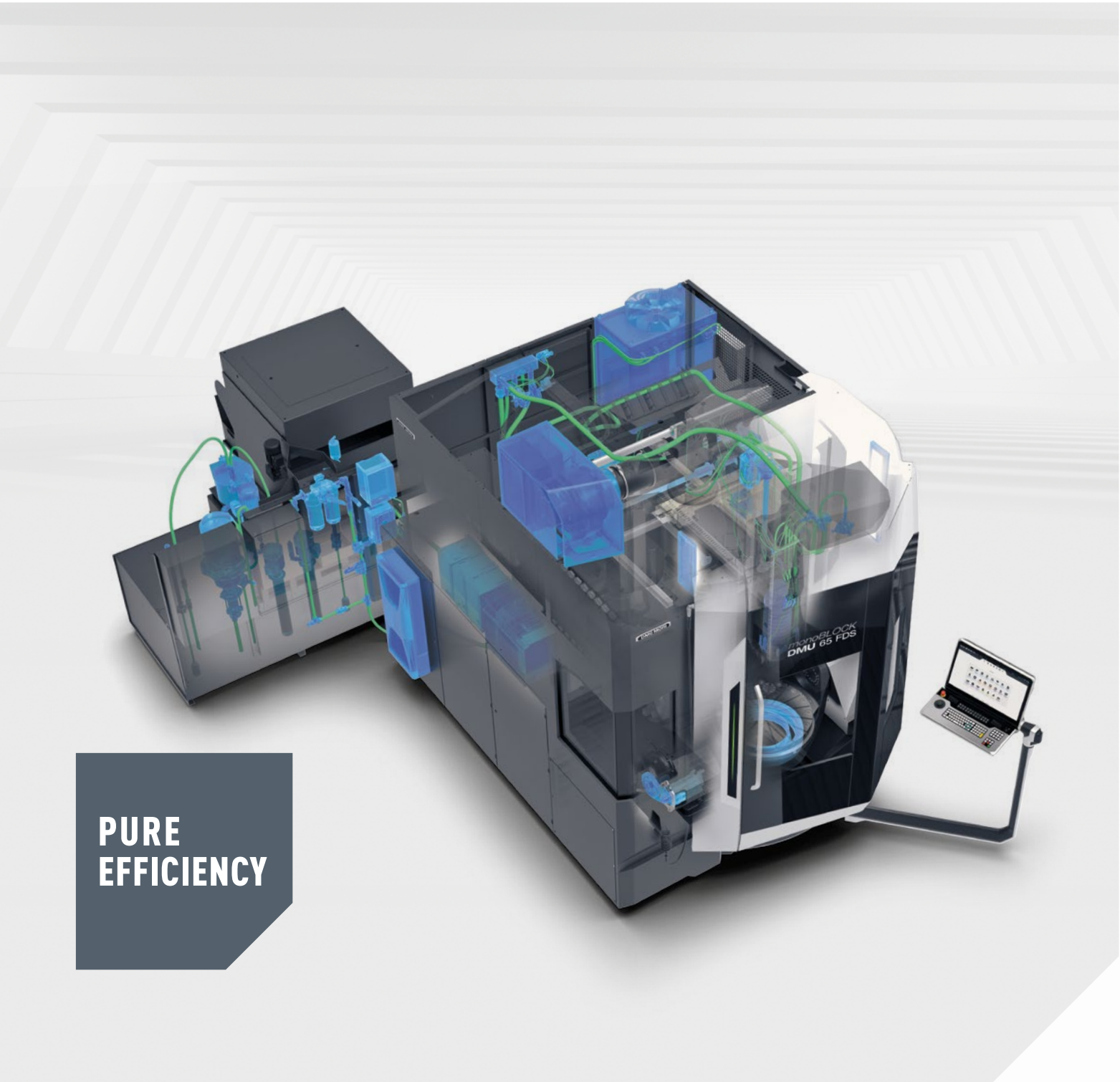
DMG MORI

ENERGY-EFFICIENT MACHINE TOOLS

GREENMODE

DMG MORI **GREEN**MODE



PURE EFFICIENCY

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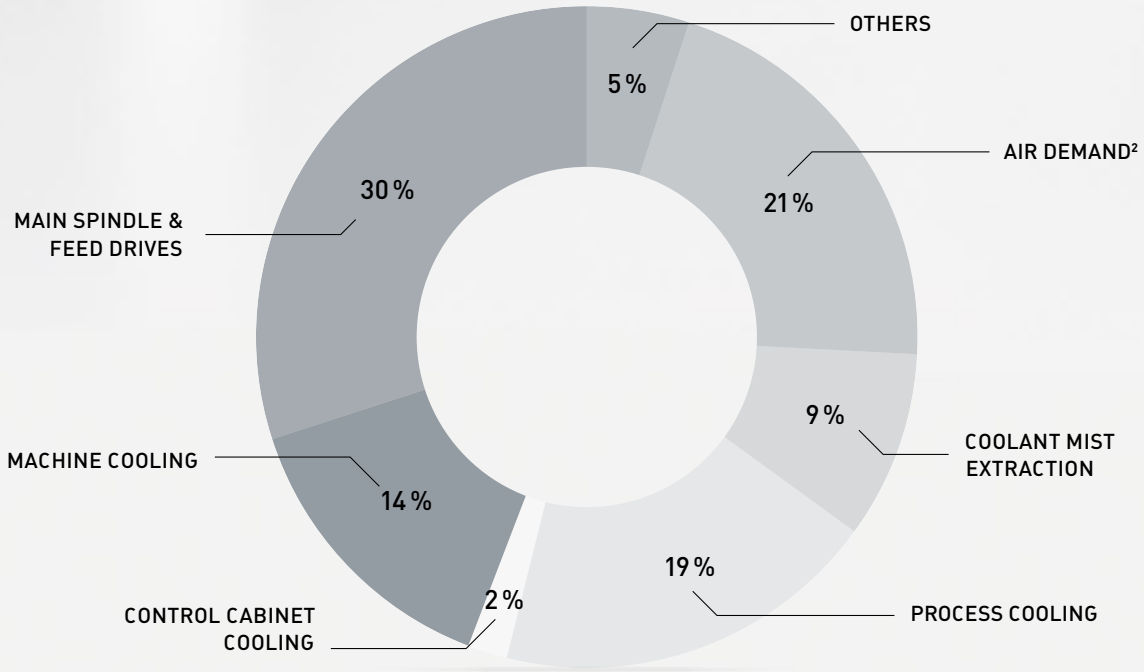
ENERGY-EFFICIENT MACHINE TOOLS

GREENMODE – Pure Efficiency

Improving energy efficiency in industry is crucial for achieving climate protection goals. Additionally, due to rising energy prices, a low energy demand in manufacturing is becoming increasingly important from an economic point of view. The economic pressure will further increase because of upcoming regulations regarding CO_2-prices in many countries. Consequently, energy-efficient machining will shape the competitive edge of manufacturers.

We are convinced that a transition to a net-zero economy is possible, and that together we can limit global warming to avoid a climate crisis. This is why we committed ourselves to the Science Based Targets initiative (SBTi)[1].

Exemplary shares of power demand in machine tools without energy-saving measures

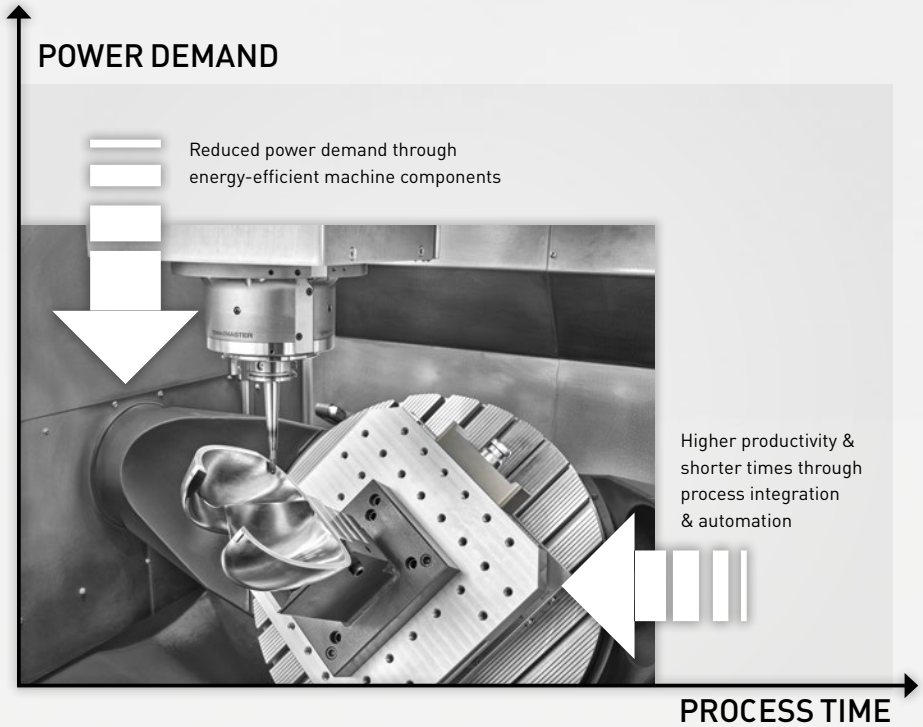


Measures for more energy efficiency & transparency

[1]https://sciencebasedtargets.org [2]Conversion factor: 0.12 kW/m³/h

With **GREEN**MODE, DMG MORI is redefining energy efficiency in production. Significant savings are possible, especially in process and machine cooling, which often accounts for up to 70 % of the power consumption of a machine tool. Thanks to innovative hardware components and software, we were able to reduce the energy consumption by more than 30 %. In this way, we support you on your way to energy-efficient production.

The energy demand for machining workpieces can be reduced through energy-efficient machine components and demand-oriented operation. However, by shortening machining times, reducing auxiliary times, and maximizing the utilization of the machine tool, the workpiece-related energy demand can also be decreased. Thus, efficient components and high productivity are a powerful combination to reduce the energy demand per workpiece. This is where DMG MORI's unique MX Strategy applies.



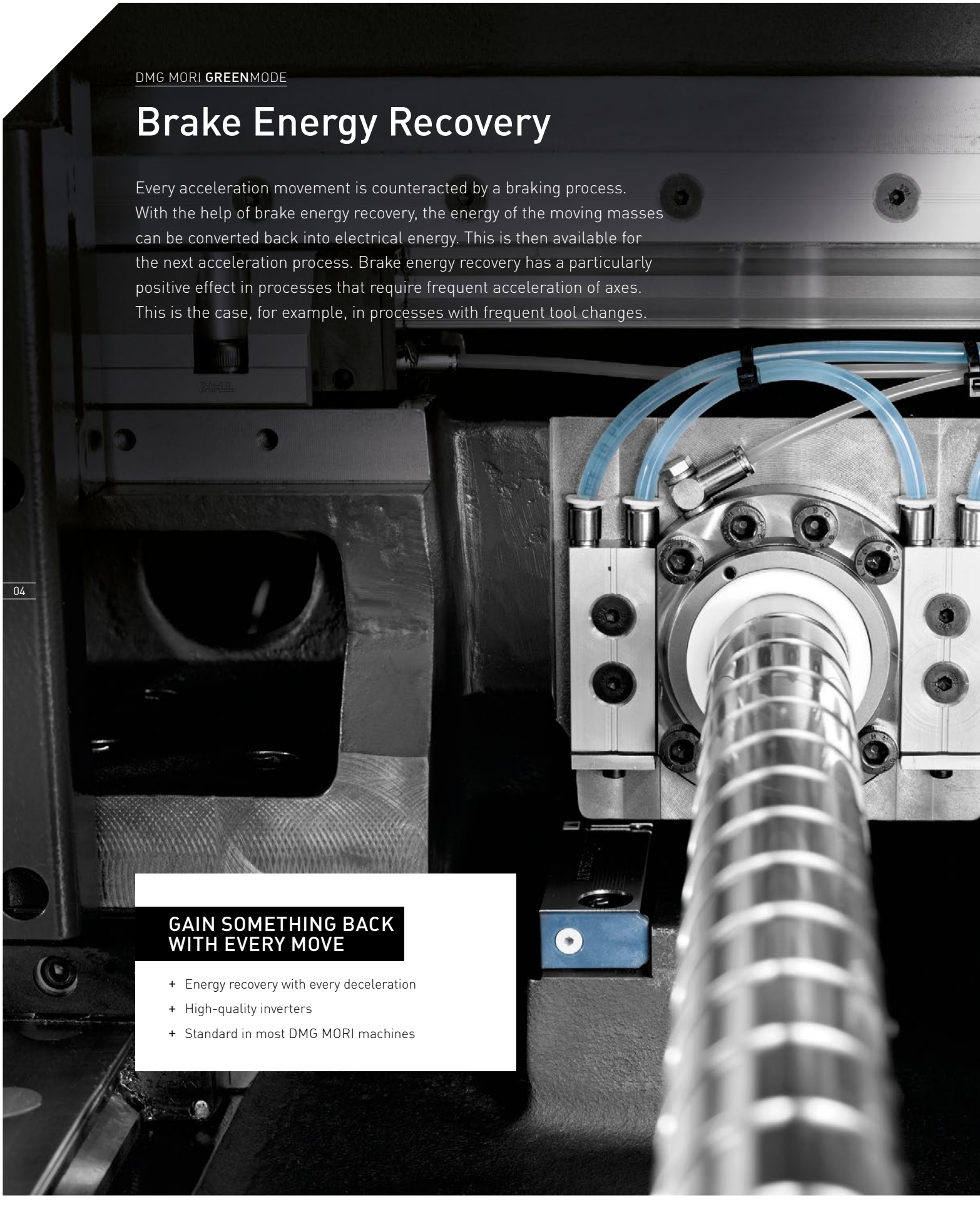
WHITE PAPER –
Energy Efficiency of Metal Cutting Machine Tools

In our latest free white paper, we give an overview on technical solutions to reduce the energy demand in machining and discuss the effects of process integration and automation.

DMG MORI **GREEN**MODE

Brake Energy Recovery

Every acceleration movement is counteracted by a braking process. With the help of brake energy recovery, the energy of the moving masses can be converted back into electrical energy. This is then available for the next acceleration process. Brake energy recovery has a particularly positive effect in processes that require frequent acceleration of axes. This is the case, for example, in processes with frequent tool changes.

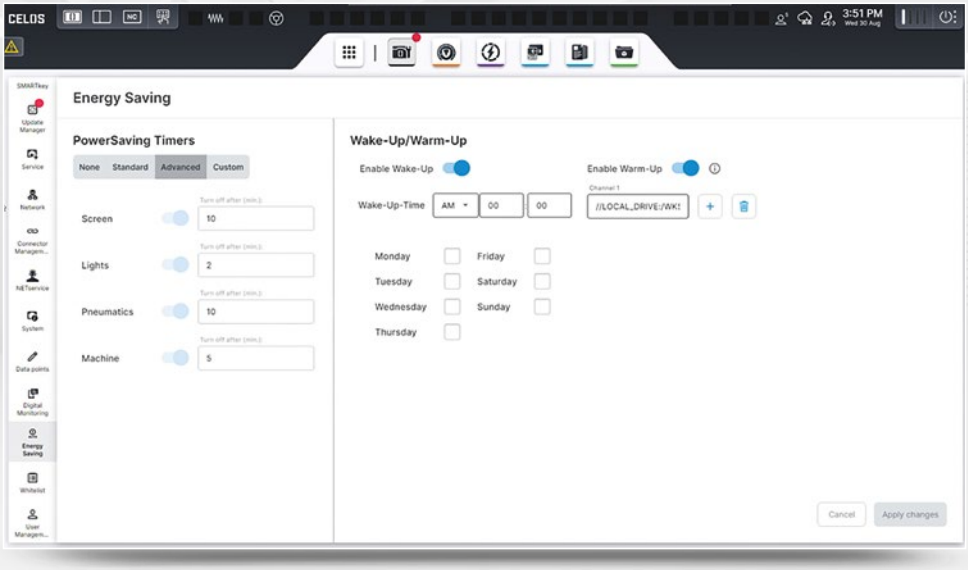


GAIN SOMETHING BACK WITH EVERY MOVE

+ Energy recovery with every deceleration
+ High-quality inverters
+ Standard in most DMG MORI machines

Advanced Auto Shutdown

Demand-oriented shutdown and wake-up of machine components



Machine tools already have high power consumption in standby. By specifically switching off components that are not required at the time, energy requirements can be significantly reduced. With the DMG MORI Advanced Auto Shutdown, the machine automatically switches off unneeded units and restarts the machine precisely. It is possible to select the time and day for the automatic restart and to define the NC-code for an automatic warm-up of the machine.

INTELLIGENT SHUTDOWN OF AGGREGATES

+ Automatic shutdown of unnecessary aggregates in standby
+ Reduced electricity and compressed air requirements

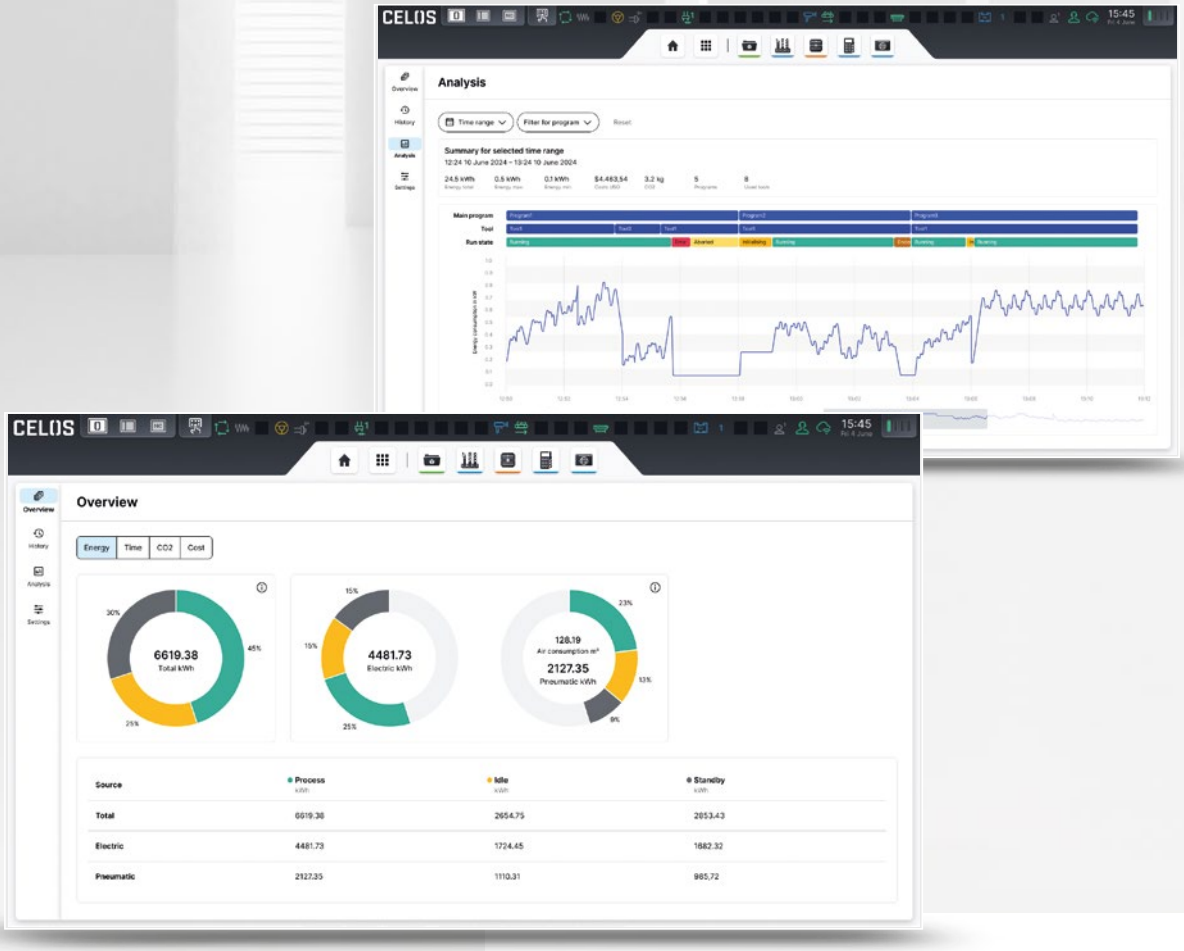
Easy to configure

+ Switching off aggregates individually configurable
+ Precisely ready for use thanks to time-based wake-up of the machine

DMG MORI **GREEN**MODE

Advanced Electrical Energy Monitoring
Workpiece-specific energy consumption

How much energy did the process require? What are the energy costs for the component? How high were the CO_2 emissions for production? Advanced Electrical Energy Monitoring by DMG MORI answers these questions reliably and transparently. In addition to the documentation, it is also possible to quickly evaluate process improvements.



FULL TRANSPARENCY OF ENERGY DEMAND

+ Measurement of the electrical energy requirement
+ Machine and component-specific evaluation of the energy requirement
+ Automatic calculation of CO_2 emissions and energy costs
+ Standard in most DMG MORI machines

DMG MORI **GREEN**MODE

Adaptive Feed Control

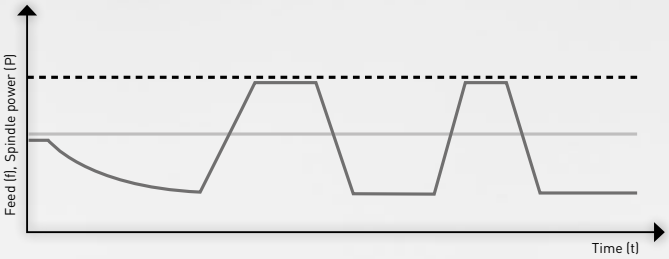
Less energy demand per workpiece because of higher productivity

Due to the high fixed energy requirement of machine tools, increasing productivity has great potential to reduce the energy requirement per component. An effective option for this is the Adaptive Feed Control, which is available for many machines by DMG MORI.

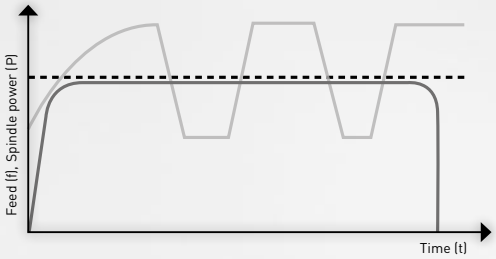
BENEFITS OF ADAPTIVE FEED CONTROL

+ Automatic detection of process sections with low spindle power and adjustment of the feed
+ Freely programmable feed ranges
+ Lower energy requirement per component due to shorter processing time

Without Adaptive Feed Control:



With Adaptive Feed Control:



Optimized spindle power
Feed rate
Actual spindle power

EXAMPLE

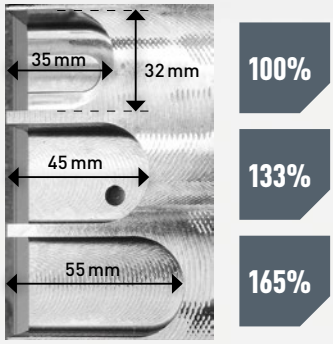
Process time: 80 s
Tool: 16 mm HPC end mill
Material: Ti-6Al-4V

open slot / depth: 32 mm

Conventional: 4× full groove cut + 4× partial cut
Q = 24 cm³/min

Trochoidal milling: a_p = 32 mm
Q = 32 cm³/min

Trochoidal milling + AFC: a_p = 32 mm
Q = 39.6 cm³/min



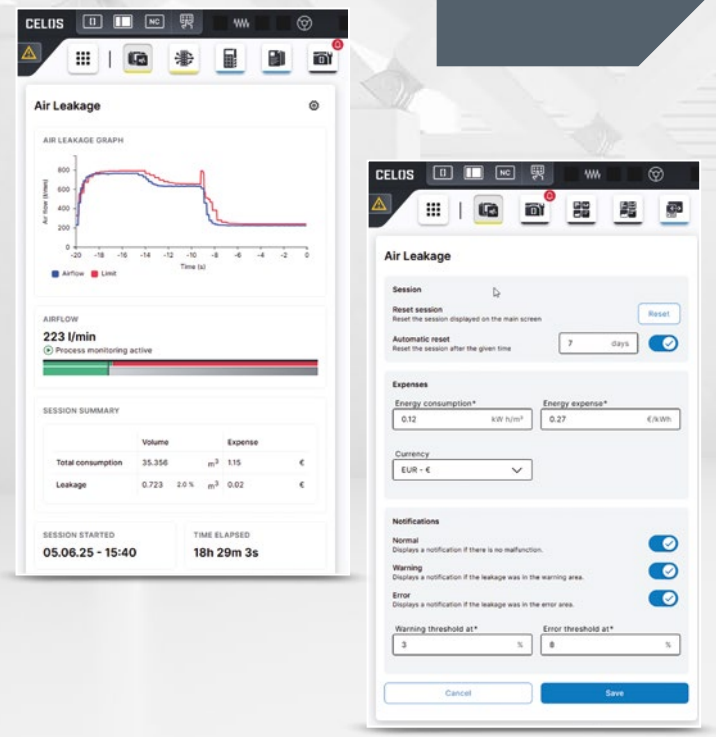
EXCLUSIVE TECHNOLOGY BY DMG MORI

DMG MORI **GREEN**MODE

Pneumatics Monitoring

Air demand monitoring and detection of leakages

With Pneumatics Monitoring by DMG MORI, the air demand can be monitored and leaks detected quickly. By this, energy and costs can be saved.



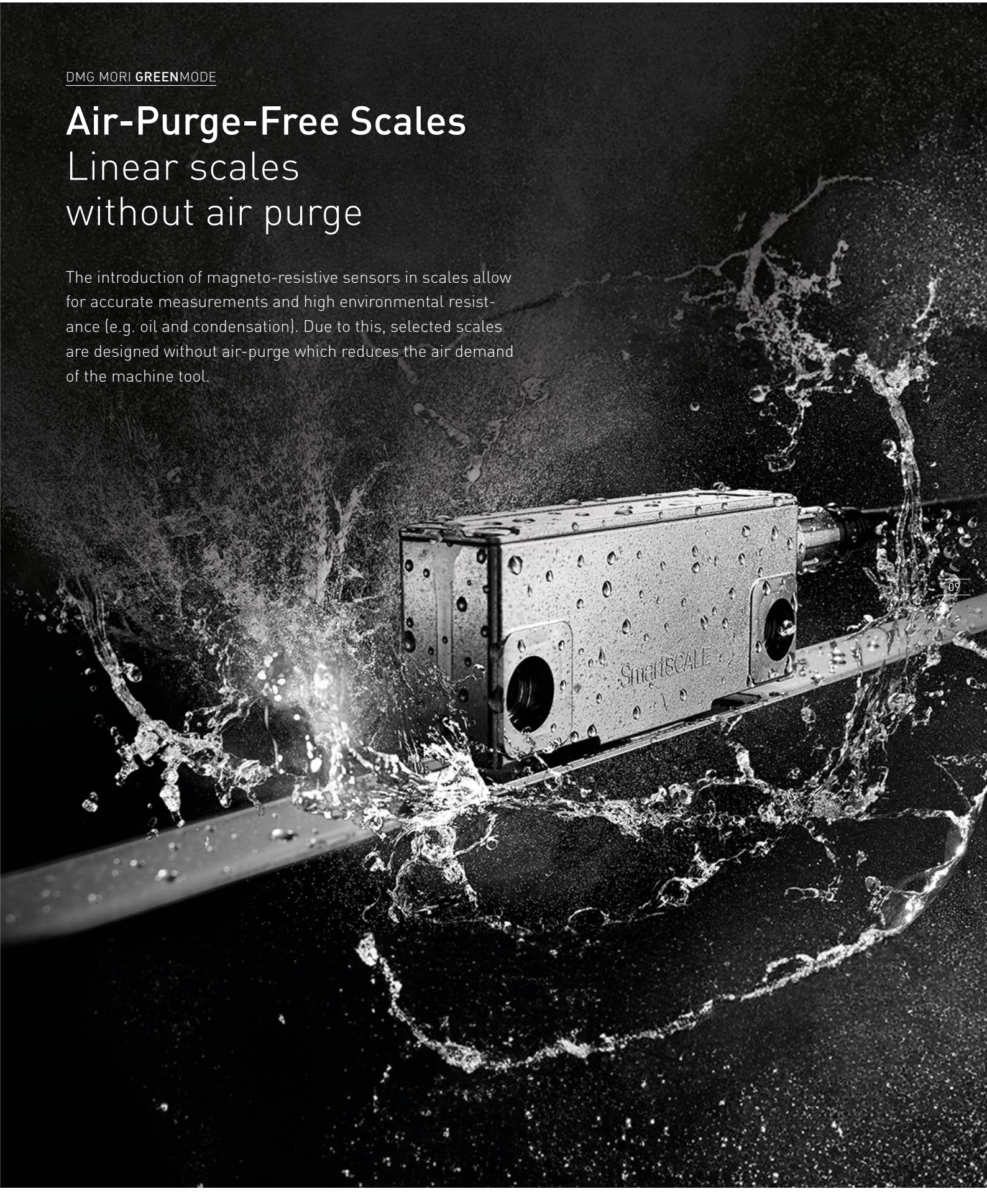
DETECT COMPRESSED AIR LEAKS FASTER

+ Comparison between target and actual compressed air requirements
+ System ready-to-use with machine delivery
+ Freely configurable monitoring limits

DMG MORI **GREEN**MODE

Air-Purge-Free Scales
Linear scales without air purge

The introduction of magneto-resistive sensors in scales allow for accurate measurements and high environmental resistance (e.g. oil and condensation). Due to this, selected scales are designed without air-purge which reduces the air demand of the machine tool.



DMG MORI **GREEN**MODE

Highly Efficient Chillers
Best-in-class machine & cabinet chillers

DMG MORI stands for precision and the highest machining accuracy. An important prerequisite for this is the thermal stability of the machine tool. In addition to design measures, active cooling systems are used. However, the active cooling of the machine and control cabinet can amount to up to 45 % of the total energy requirement of a machine. In order to reduce energy requirements while maintaining accuracy, DMG MORI relies on the most modern technologies incl. low GWP refrigerants.

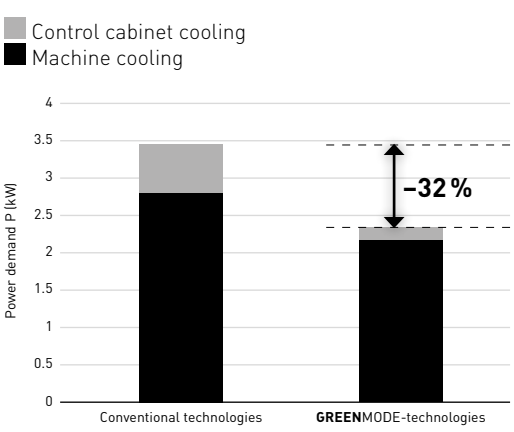
EFFICIENT MACHINE COOLING

+ Water admixture technology or frequency-controlled aggregates available
+ Particularly high efficiency in partial load operation
+ Use of refrigerants with reduced global warming potential (GWP)

DEMAND-BASED CONTROL CABINET COOLING

+ Frequency-controlled cabinet cooler
+ High energy efficiency in partial load operation

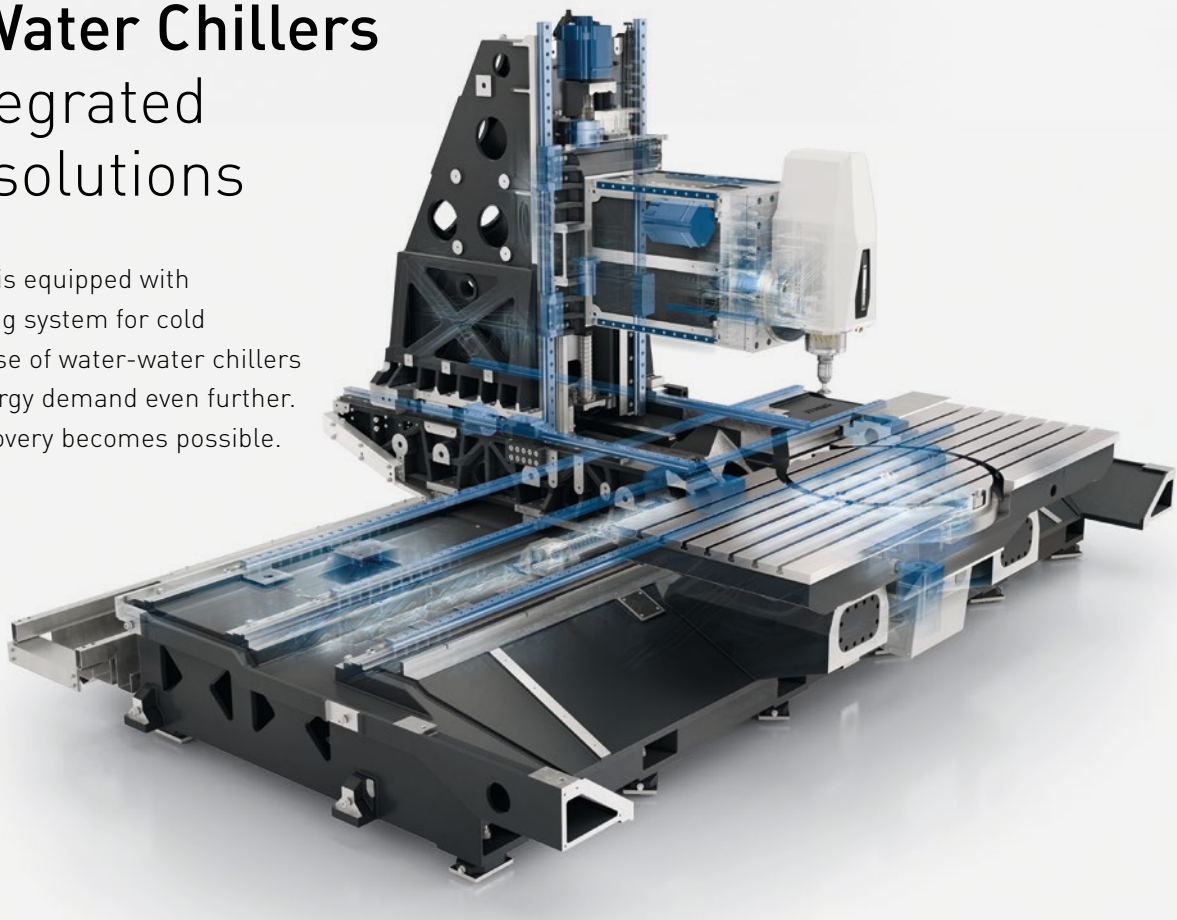
ENERGY SAVINGS WITH HIGHLY EFFICIENT CHILLERS



*Mean power demand in machining at DMG MORI Energy Consumption Test Cycle

Water-Water Chillers
Fully integrated cooling solutions

In case the factory is equipped with a centralized cooling system for cold water supply, the use of water-water chillers can reduce the energy demand even further. Moreover, heat recovery becomes possible.



DMG MORI **GREEN**MODE

Frequency-Controlled Pumps
Efficient cooling lubricant supply

Conventional pumps always pump at maximum capacity. If the pressure in the system rises above a limit value (e.g. 80 bar) due to small cooling channels, part of the cooling lubricant is returned directly to the tank. Thus, the pressure is reduced. In contrast, frequency-controlled coolant pumps allow an adjusted coolant supply.

DEMAND-BASED CAPACITY THROUGH FREQUENCY CONTROL

+ The delivery rate of the pump is adjusted to the pressure specification via frequency-control
+ Reduced energy requirement in partial load operation

*zero*FOG

For a clean working environment

Here is the video about *zero*FOG:
youtu.be/REnne6gEwa8

EFFICIENT EXTRACTION OF COOLANT MIST

+ Turbo fan powered by a high-efficiency motor for powerful suction
+ Stable and constant suction power
+ Degree of separation over 99.97 % for 0.3 µm particles

COMPACT DESIGN

+ Attached directly to the machine, no additional floor space required
+ Compact, built-in design
+ No on-site installation work necessary

EXCLUSIVE TECHNOLOGY BY DMG MORI

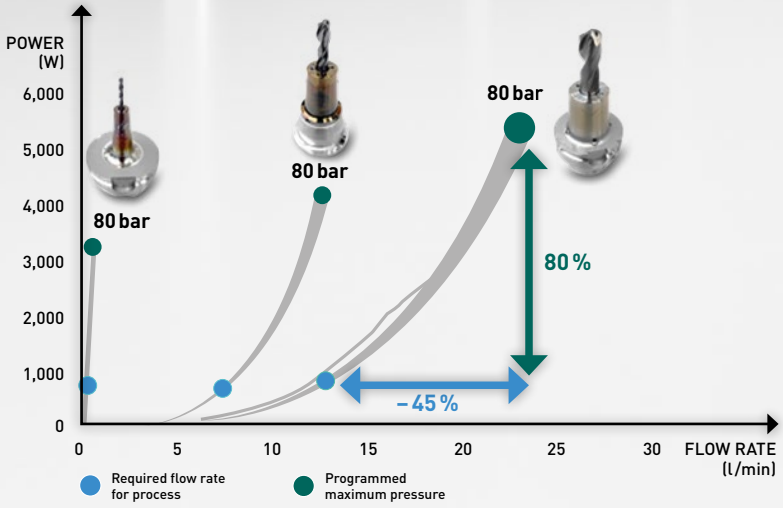
DMG MORI **GREEN**MODE

Adaptive Coolant Flow – Pure efficiency due to innovative process cooling

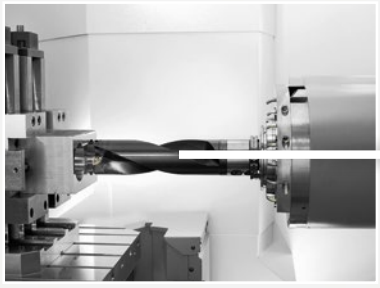
Process cooling with powerful pumps supports productive machining. However, up to 25 % of the energy consumption in the process is attributable to the coolant supply. With Adaptive Coolant Flow by DMG MORI, only as much coolant is added to the process as is actually required.

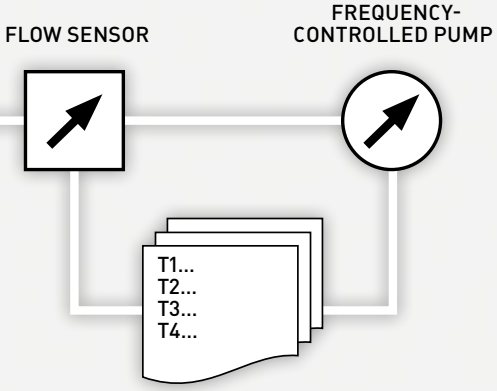
Approach of Adaptive Coolant Flow

+ Maximum pumping capacity not required for many processes
+ Exponential increase in pump power consumption with increasing flow rate
+ Patented technology by DMG MORI



Intelligent control and simple operation





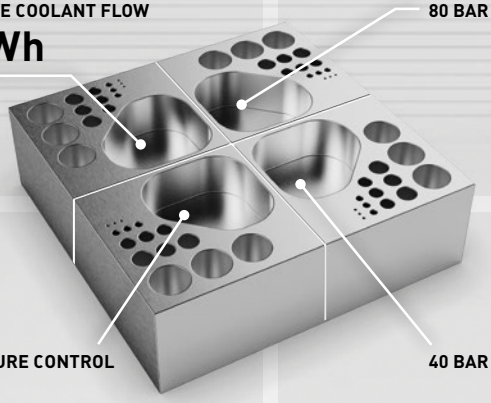
BENEFITS OF ADAPTIVE COOLANT FLOW

+ Tool-specific coolant supply
+ Technology cycle to determine the appropriate volume flow
+ Control of the volume flow during the process
+ Rapid availabilty and switch-off of cooling lubricant supply
+ Energy demand of pump reduced by up to 90 %

Energy savings in machining

ACF – ADAPTIVE COOLANT FLOW
0.66 kWh
–20%*

80 BAR PRESSURE CONTROL
0.83 kWh



–5%*
60 BAR PRESSURE CONTROL
0.79 kWh

–12%*
40 BAR PRESSURE CONTROL
0.73 kWh

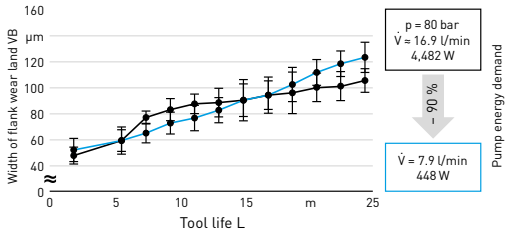
*Energy savings compared to 80 bar

Energy demand for machining the shown workpiece on a DMU 65 FDS monoBLOCK.

PATENTED TECHNOLOGY FOR STABLE COOLANT FLOW

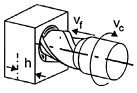
+ Controlled volume flow for constant coolant supply at the tool tip
+ Extensive studies show no increase in tool wear with reduced coolant flow[3]

Effect on tool wear in drilling

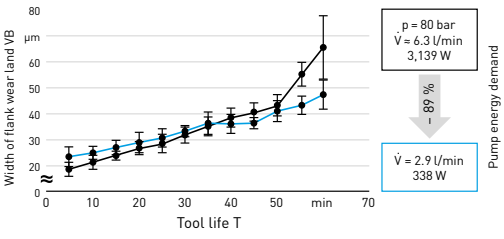


Process parameters:
Cutting speed: v_c = 50 m/min
Feed: f_z = 0.1 mm
Bore depth: h = 25.5 mm

Material:
AISI 316
Tool:
Tungsten carbide drill
(ø = 8.5 mm, IKZ)

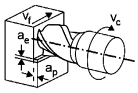


Effect on tool wear in milling



Process parameters:
Cutting speed: v_c = 70 m/min
Feed: f_z = 0.08 mm
Width of cut: a_e = 5 mm
Depth of cut: a_p = 5 mm

Material:
AISI 316
Tool:
Tungsten carbide end mill
(ø = 10 mm)



[3]Denkena, Berend, et al. "Energy efficient supply of cutting fluids in machining by utilizing flow rate control." CIRP Annals (2023).

DMG MORI **GREEN**MODE

*zero-sludge*COOLANT
Coolant system without accumulation of sediments

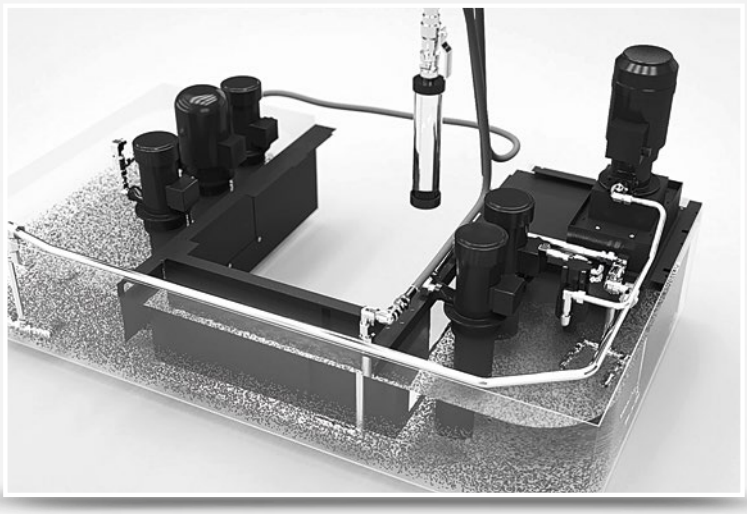
The production and disposal of cooling lubricants are associated with high CO_2 emissions.

With *zero-sludge*COOLANT, the operating time of cooling lubricants can be increased – especially in applications with the finest chips and particles.

Here is the video about *zero-sludge*COOLANT Technology:
tinyurl.com/c5htjajk

SEDIMENTS IN THE COOLANT TANK – A CHALLENGE

+ Finest chips and sediments can accumulate in the coolant tank
+ Accumulations can be observed particularly in machining of castings and during grinding
+ Cleaning the tank is time-consuming
+ The sediments degrade the quality of the cooling lubricant, so that it has to be replaced more frequently



Operating principle

Several coolant nozzles are arranged in such a way that they whirl up the cooling lubricant and up to 99 %[4] of the sediment can be filtered.

[4]Test result with test sediment sludge. The collection amount may vary depending on the type of material.

DMG MORI **GREEN**MODE

AI Chip Removal
Avoid accumulations of chips and downtimes

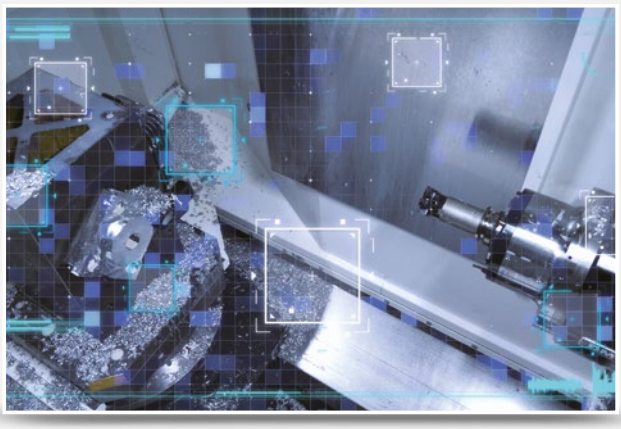
EXCLUSIVE TECHNOLOGY
BY DMG MORI

Accumulations of chips on the component or in the machine's working area lead to unwanted downtimes, especially in series production.

With the AI Chip Removal by DMG MORI, these downtimes can be avoided and non-productive times reduced compared to a conventional working space flushing.

Reduce non-productive times and use of coolant

+ Precise and efficient removal of chip accumulations
+ Up to 2 independently controllable coolant nozzles
+ Shorter non-productive times through targeted control of the flushing nozzles
+ Less coolant required



Automate with artificial intelligence

+ Optional extension with AI-based chip detection
+ Detection of chip accumulations using image recognition
+ Automatic programming of the working area flushing

The DMG MORI **Energy Consumption Test Cycle**

In order to evaluate the effects of new technologies on energy requirements, DMG MORI has established an internal standard for measuring the energy requirements of machine tools.

FEATURES OF THE DMG MORI ENERGY CONSUMPTION TEST CYCLE

+ Standardized measurement of electrical energy and compressed air
+ Measurement of operating states according to ISO 14955-3

Machine tool: DMU 65 FDS monoBLOCK

−36 %[5]

WITH **GREEN**MODE
32,190 kWh/a

−17,890 kWh/a

WITHOUT **GREEN**MODE
50,080 kWh/a

1. STANDBY	2. WARM UP	3. NC-READY	4. PROCESSING	5. EMERGENCY SHUTDOWN
Δ −45 %	Δ −16 %	Δ −11 %	Δ −38 %	Δ −81 %
Reference 7.7 kW	Reference 9.0 kW	Reference 7.7 kW	Reference 17.3 kW	Reference 3.5 kW
GREENMODE (ECO) 4.2 kW	**GREEN**MODE 7.6 kW	**GREEN**MODE 6.9 kW	**GREEN**MODE 10.8 kW	**GREEN**MODE (ECO+) 0.7 kW

Savings in operation – sample calculation

Machine running time: 4,000 hours/year (16 hours/day, 250 days/year)

Machine states	Standby	NC- ready	Machining
Ratio	30 %	20 %	50 %
Mean power demand without **GREEN**MODE	7.7 kW	7.7 kW	17.3 kW
Mean power demand with **GREEN**MODE	4.2 kW	6.9 kW	10.8 kW

CO_2-SAVING

6,798 kg/a

COST SAVING

3,578 €/a

[5]All values shown are based on internal investigations and experience from DMG MORI. Actual values may vary due to actual production conditions. Assumptions for annual energy demand: 250 working days/year, 2 shifts/day, 8 hours/shift, 30 % standby, 20 % NC ready, 50 % machining, CO_2 emission factor: 0.38 kg/kWh, electricity price: 0.20 €/kWh.

DMU 65 FDS monoBLOCK
with GREENMODE

SAVE
6,798 kg CO_2
AND
3,578 €
ANNUALLY

CORRESPONDS TO THE CO_2 ABSORPTION OF
226
TREES*

*Internal assumptions for the average annual CO_2 uptake of 30 kg per tree: beech, 30 m height, 80 years old, 38 cm trunk diameter at 1.3 m height (based, among others, on data from the The Bavarian State Institute of Forestry (LWF)).

Export Control: Machines and products from DMG MORI may be subject to export restrictions. Therefore, prior export control authorization from competent authorities may be required. To prevent the illegal diversion of the equipment to individuals or nations that threaten international security, every DMG MORI machine is equipped with an RMS function (Relocation Machine Security). The RMS automatically deactivates the machine when the machine is moved or disassembled. Such deactivation does not take place during regular operation or maintenance. If the equipment is so-disabled, it can only be re-activated by DMG MORI or some authorized representatives. Reactivation can be ordered via DMG MORI Service. If the machine is deactivated due to a substantial repair activity, this service is free of charge. DMG MORI may refuse to re-activate the machine if it determines that doing so would be an unauthorized export of technology or otherwise violate applicable export restrictions. DMG MORI shall have no obligation to re-activate such machine and shall have no liability as a result thereof.

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