

Mandelli Sistemi SpA

Lavorazione dei Materiali Tenaci

Stefano Musletti





Who we are

BI-MUpiù



€400M Euro Turnover (Riello Family Company)

Holding of different Companies active in different markets: Energy, Automation, Safety



Private Equity Company, supports growing companies providing capital and managerial competence



Machine Tools Division
€65M Euro Turnover



Where we are

BI-MUpiù

MANDELLI FACTORY Piacenza – Italy



- Overall Area: 20.300 sqm
- Covered Area: 19.000 sqm

RIELLO FACTORY Minerbe (Verona) – Italy

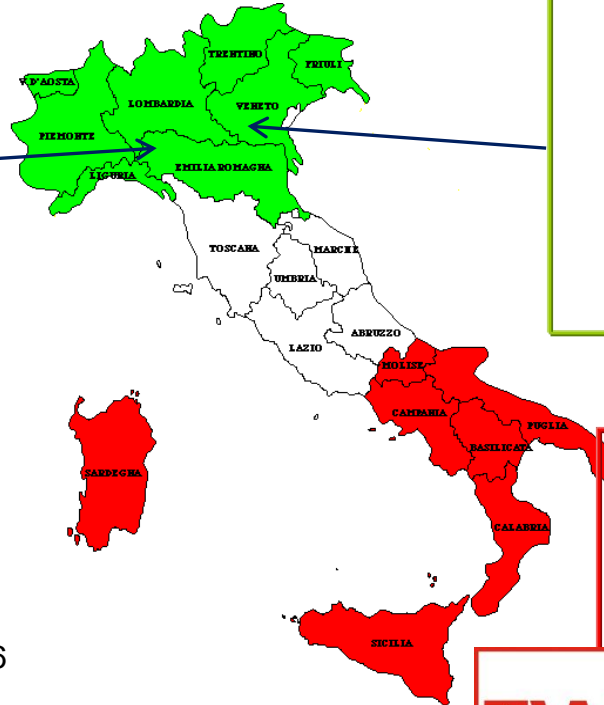


- Overall area: 50.000 sqm
- Covered area: 10.500 sqm

TRI-WAY FACTORY Windsor – Ontario Canada



- Overall Area : 9.325 sqm
- Covered Area : 3.393 sqm



TW

Sales & Service Direct Office

BENELUX - Mandelli Benelux NV/SA

Kerkplein 25 - 1930 Zaventem

USA - GRS USA

407 E Fort Street, Detroit, Michigan, Suite 504, 48226

P.R. CHINA - Riello Sistemi (Shanghai) Trade Co., Ltd

Room 503, 518 Anyuan road, Putuo, Shanghai 200040

What we do



High Quality / High Performance

- Horizontal Machining Centers
- Flexible Manufacturing Systems

Focused on

5-Axes and **Multitasking** for
AEROSPACE - ENERGY industries

Spark 2015-2018

Precision
Machinery
30%

People & Parts
Mobility 6%

Energy 13%

Aerospace 51%

THE VALUE
OF PERFORMANCE

POWER
AGILITY
VERSATILITY
ENDURANCE

 **mandelli**
HORIZONTAL MACHINING CENTERS

BI-MUpiù

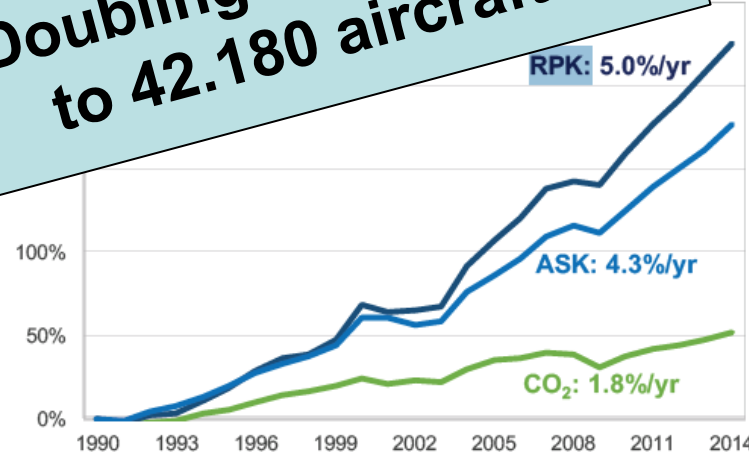




Trends in Aerospace Market in the next 20 years

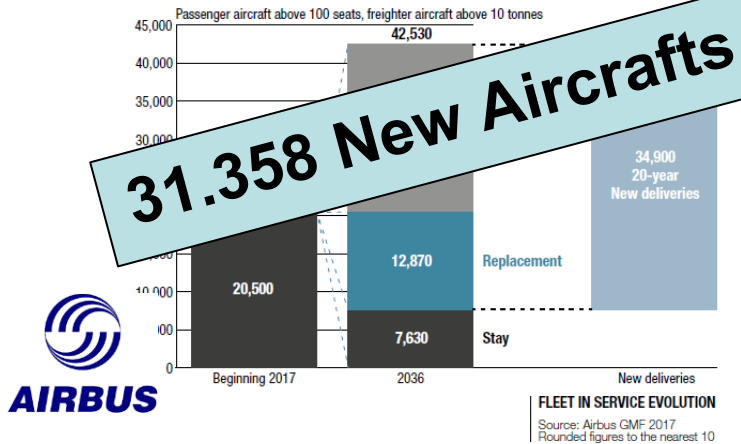


Doubling Global Fleet to 42.180 aircrafts



Revenue Passenger Kilometer
Available Seat Kilometer

31.358 New Aircrafts

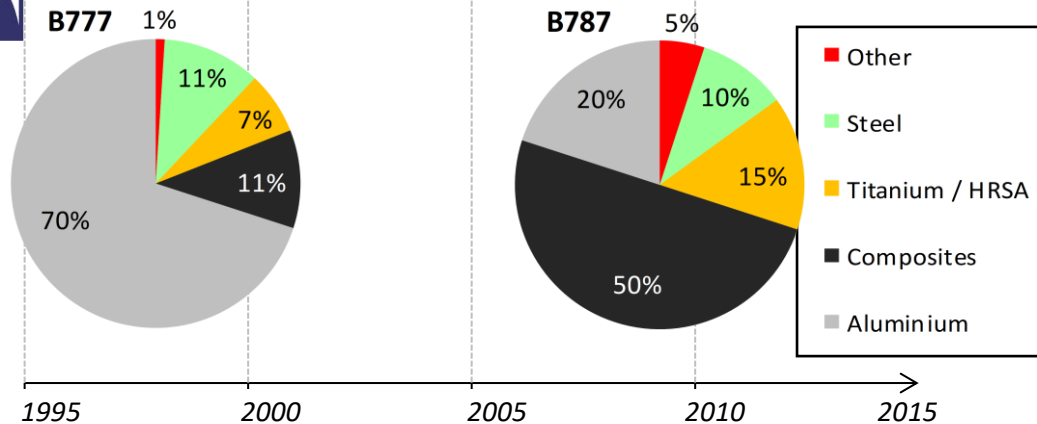


GOAL: CO₂ emission and fuel cost reduction

- High efficiency engines
- New wings design
- Light & strong materials



Trends in Aerospace Materials



- Decrement for:
- Aluminium up to 20%

- Increment for:
- Composites: up to 52%
- Titanium / HRSA: up to 15%



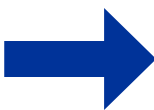
Titanium Alloy

Ti-6Al-4V	Ti-10V-2Fe-3Al	Ti-5Al-5Mo-5V-3Cr
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HRSA

Inconel 718	Inconel 706	Waspaloy
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- Low thermal conductivity
- Low elastic module
- High chemical reactivity with tools coating



- Expensive materials
- Difficult to cut materials

**Heavy Duty 5X
MCs to fight
vibrations**



What is Chatter

BI-MUpiù

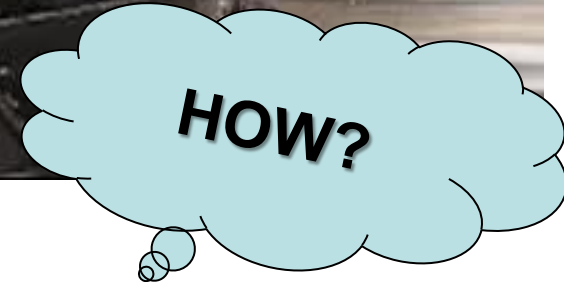
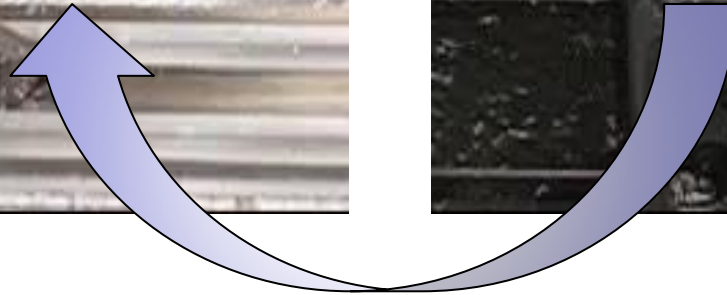


...depends on everything...
...upset the frequency...
...you think you solved it and it is back again...



No Chatter

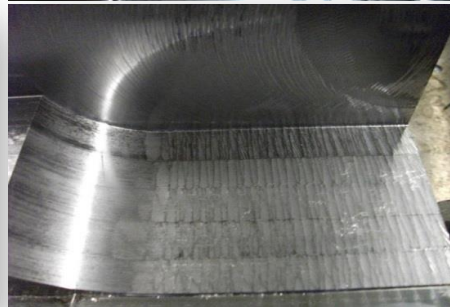
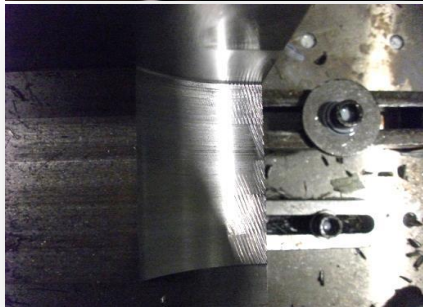
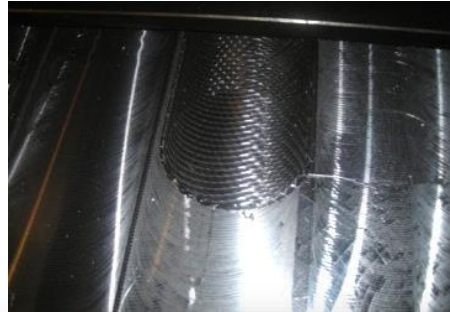
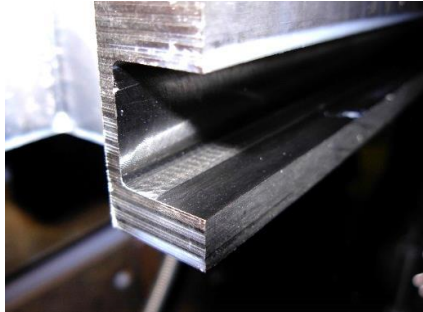
Chatter



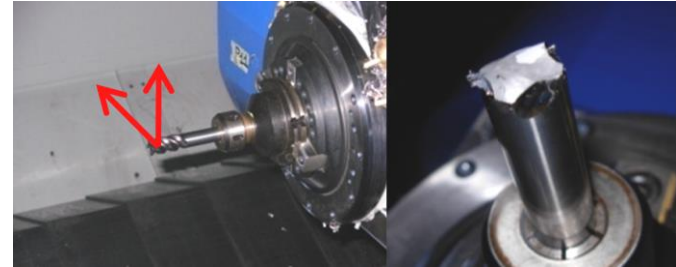


Damages caused by Chatter

Undesired marks left on the workpiece due to machine vibrations during machining:
SCRAP due the unacceptable surface quality



Tool breakage



Inserts breakage



Bearings damaging

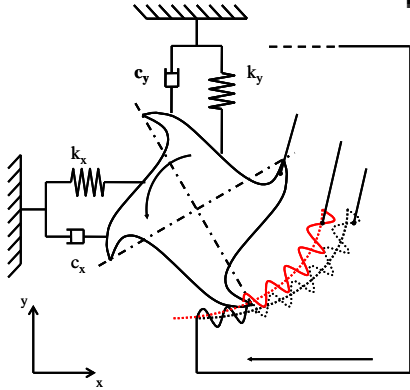




Machine Dynamics + Cutting process + Delay

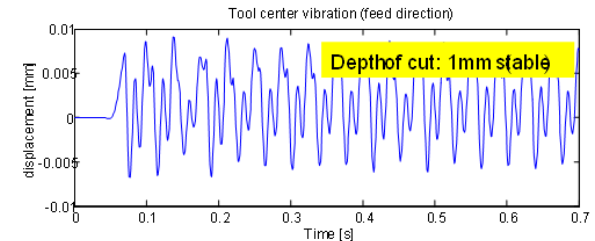
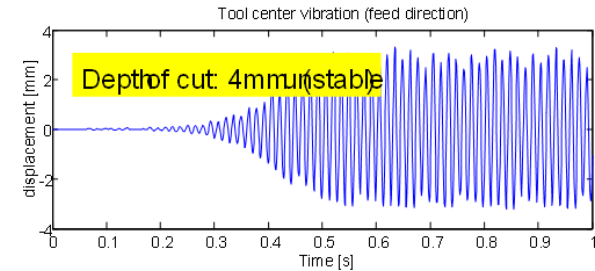
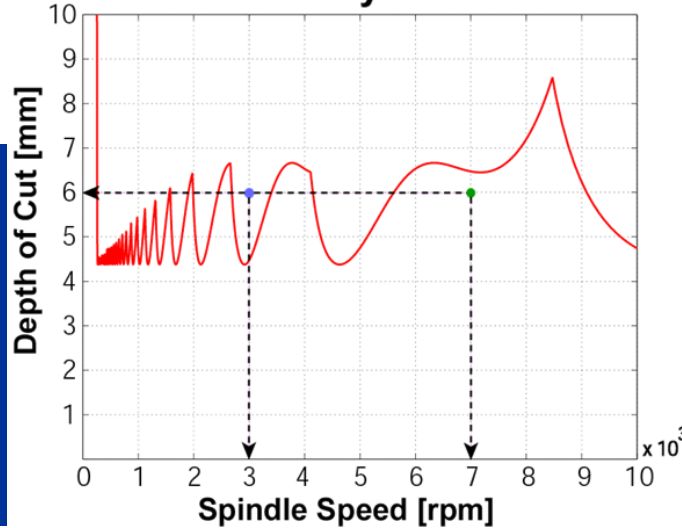
$$\{F\}e^{i\omega_c t} = \frac{1}{2} aK_t [1 - e^{i\omega_c \tau}] A_0 [G(i\omega_c t)] \{F\}e^{i\omega_c t}$$

DDE
(Differential Delayed Equation)



$$\{F\}e^{i\omega_c t} = \frac{1}{2} aK_t [1 - e^{i\omega_c \tau}] A_0 [G(i\omega_c t)] \{F\}e^{i\omega_c t}$$

Stability Lobes



- Also with continuous cut (turn, drill)
- Machine & cutting process model (FRF, tool, cutter, fixture, parameters, material)
- Even with low forces, vibration can become high diverging

A Complex Phenomenon

Material mechanics

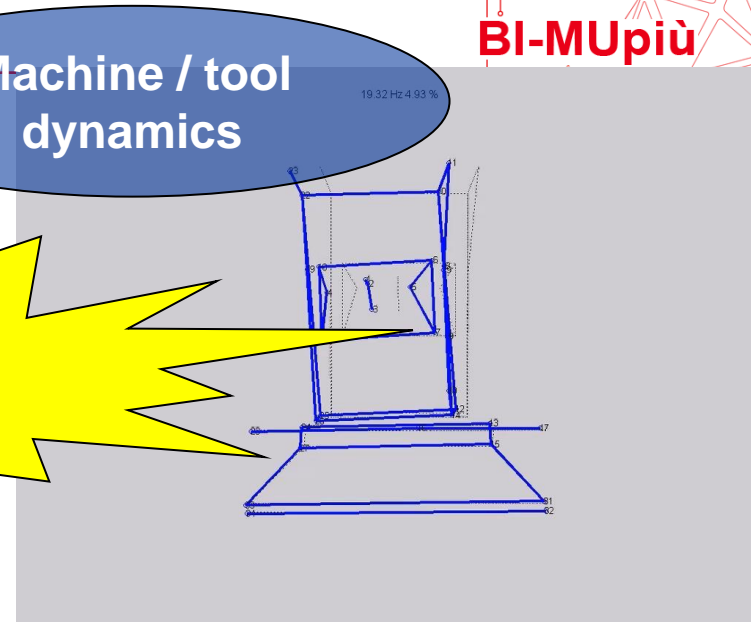
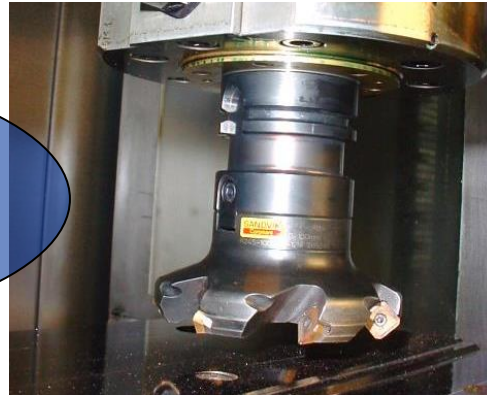
Machine / tool dynamics

All the aspects are relevant!!!!

Tool geometry, fixture & Cutting parameters

- Complex equations and calculations
- A lot of influencing factors, difficult to estimate


WHAT WE CAN DO?

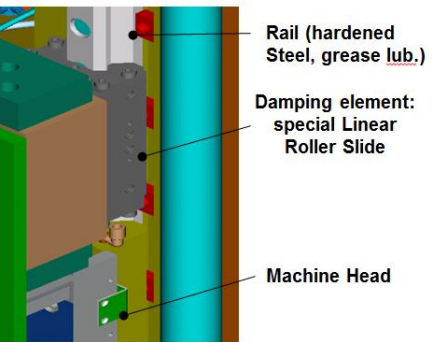
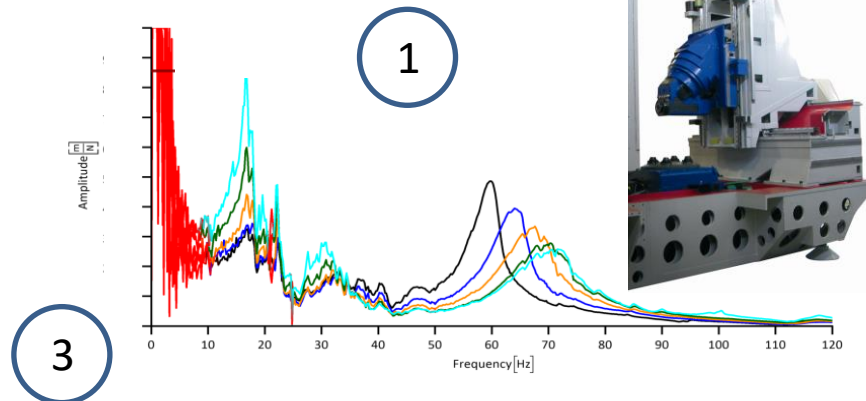




Solutions to Chatter



1. Machine Design to minimize dynamic compliance
2. Introduce Artificial Damping in the process
3. Provide our Customers with SLD for specific, critical operations
4. iPum@smartcut 

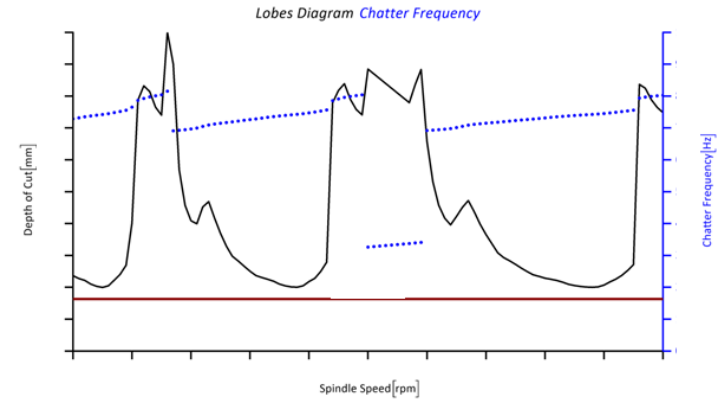


2

	HIRTH COUPLING	A-axis DAMPING ON	
Y-axis DAMPING ON	0.035 (- 83.8%)	0.007 (- 96.7%)	PP Y-axis oscillation [mm]
	97.36 (- 20.8%)	33.88 (- 72.5%)	PP spindle current [A]
	29.68 (- 19.6%)	9.49 (- 74.3%)	PP head vibration [m/s ²]
Y-axis DAMPING OFF	0.216	0.118 (- 45.4%)	PP Y-axis oscillation [mm]
	123	86.4 (- 29.8%)	PP spindle current [A]
	36.93	25.61 (- 30.7%)	PP head vibration [m/s ²]



3





Monitoring Sensors:
Sensors Data Acquisition

Numerical Control:
Profibus Data Acquisition

Control Unit:
Data Elaboration & Logging

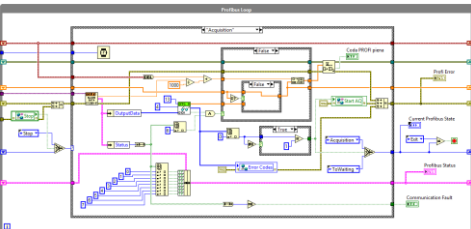
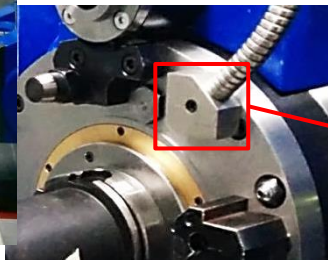
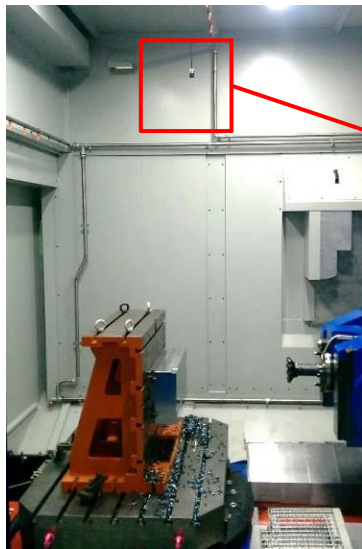
Control Unit:
Data Interpretation & Control Strategies

- Data Elaboration**
- Accelerations analysis
 - Noise analysis
 - Machine status signals analysis
 - Cutting forces estimation
 - Tool tip vibration estimation

- Control Strategies**
- Spindle Speed Variation activation
 - Spindle Speed Tuning activation

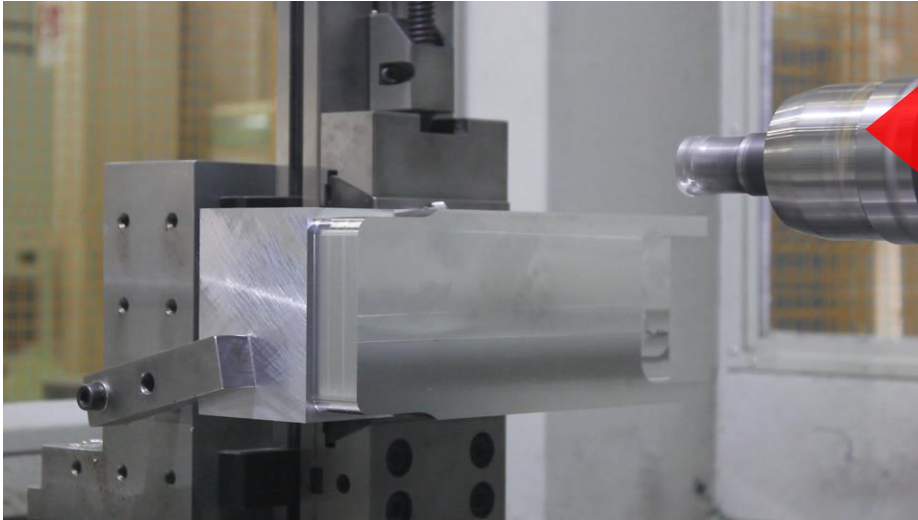
Hydrophone
total waterproof

3-Axes Accelerometer
the rigid cover ensures a protection against the metal chips and coolant



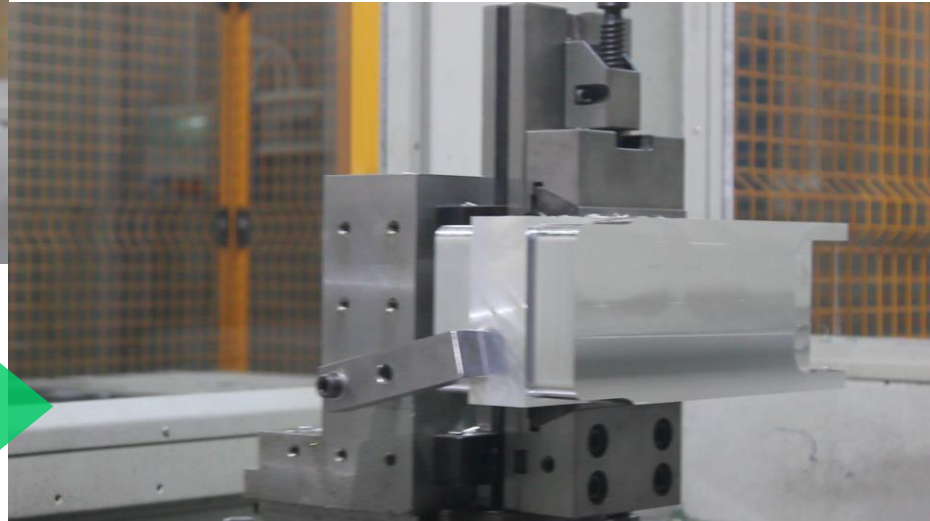


Smartcut in Action – Spindle Speed Tuning



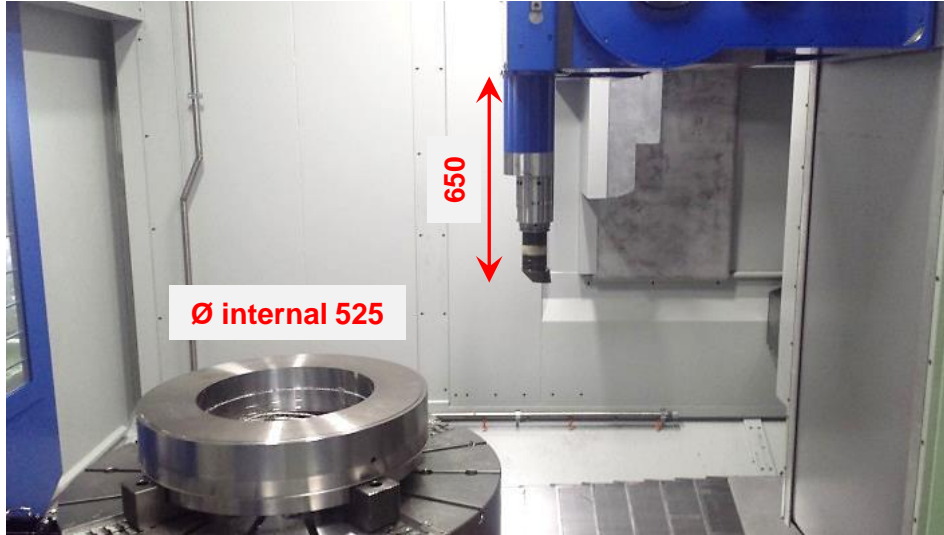
Slot milling without *iPum@-smartcut*
CHATTER: high vibration & high noise

Slot milling with *iPum@-smartcut*
STABLE CUTTING





Smartcut in Action – Spindle Speed Variation



Material: C40 Steel
Operation: Internal-turning

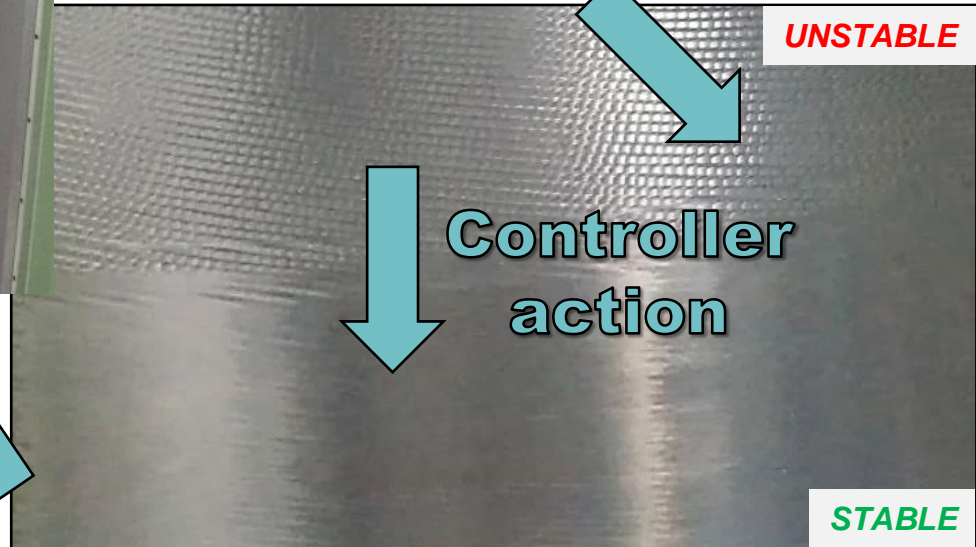
Depth of cut: 8 mm

Rotary table speed: 116 rpm

Tool feed: 58 mm/min

RVA: 0.2
RVF: 0.16

Rotary table speed max: 139 rpm
Rotary table speed min: 93 rpm





iPum@smartcut Advantages



- Extremely compact system: easy integration aboard the machine
- General purpose and high flexible solution: the smart system can work for several application with different tools, materials, cutting parameters and operations
- Self-selection of the most suitable machining strategy: optimized cutting parameters that allows chatter suppression ensuring the maximum productivity
- Energy saving solution: the spindle current consumption is optimized for the application
- The tool inserts and the machine components life are always protected thanks to the cutting forces estimation in real-time
- Quick closed loop feedback
- Preliminary tool learning cycles are not required
- The text was registered at the Italian patent office, the PCT extension will be required for the protection in the world

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