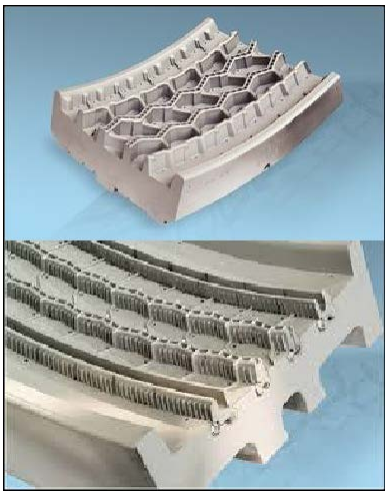
Test Report Summary – Slot Milling

Colibri's TJS 30K-HSK-100 Jet Spindle model

Test Date	March, 2016
Country	Germany
Industry	Die & Mold
Application	Slot Milling / 5-axis Milling Center
Material Group	-
Material No.	Alu AW5083 or ST 52-3

Test Data	Actual	Jet Spindle
Cutting Tool	Fraise M5782140 R1D2.0	
Diameter (mm)	2	2
No. of Flutes	2	2
Overhang	100	120
Cutting Speed Vc (m/min)	69	188
Spindle Speed (rpm)	10,982	29,921
Depth of Cut ap (mm)	0.2	0.2
Width of Cut ae (mm)	0.5	0.5
Feed Per Tooth fz (mm/t)	0.082	0.042
Table Feed (mm/min)	350	750
Feed / Revolution - fn [mm/rev]	1,797	2,495
Surface Quality	Good	Good
Metal Removal Rate	0.6	0.14
Machining Length (mm)	2,160,000	2,160,000
Operation Rough / Finish	Rough / Finish	Rough / Finish



Results	Actual	Jet Spindle
Cutting Time (hrs.)	402.4	290
Cost Reduction Machine Time	-	27.1%

Test Report Summary – Shoulder Milling

Colibri's TJS 30K-HSK-A63 Jet Spindle model

Test Date	March, 2015
Country	Germany
Industry	Aerospace
Application	Shoulder Milling
Material Group	-
Material No.	DIN Aluminum

Test Data	Actual	Test
Cutting Tool	VHM D1mm	
Diameter (mm)	1	1
No. of Flutes	3	3
Overhang	100	100
Cutting Speed (m/min)	57	126
Spindle Speed (rpm)	18,144	40,107
Depth of Cut (mm)	0.3	0.3
Width of Cut (mm)	0.75	0.75
Feed Per Tooth (mm/t)	0.005	0.005
Table Feed (mm/min)	272	602
No. of Passes	107	107
Chip Type	Fragments	Fragments
Surface Quality	Good	Good
Metal removal Rate	0.6	0.14

Time/Cost Evaluation	Actual	Test
Cutting Time (hrs.)	0.5	0.2
Cost Savings Per Part	-	45%

Test Report Summary – Profile Milling

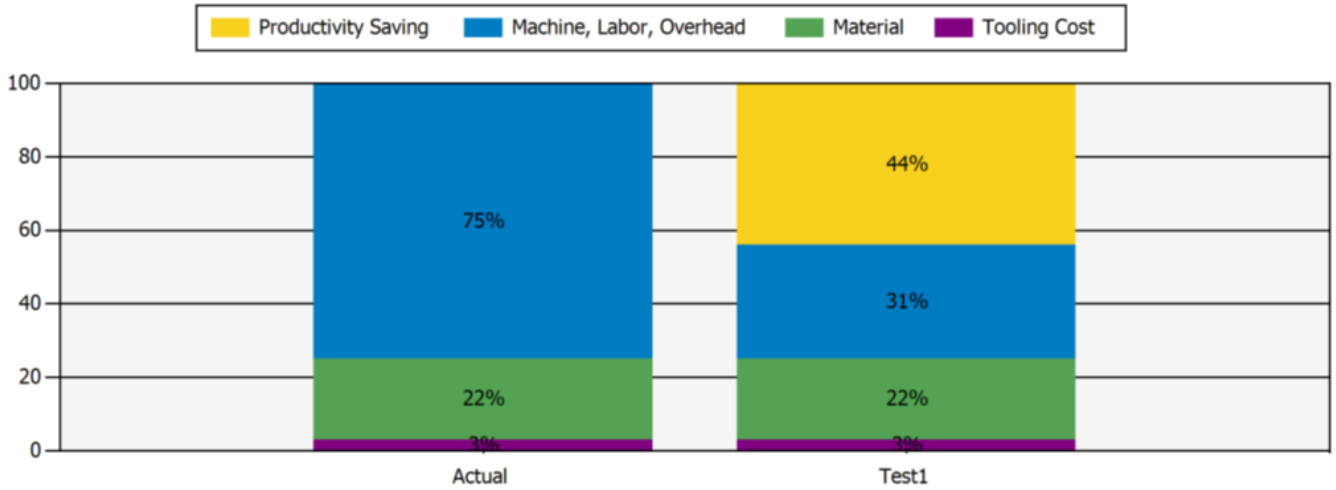
Colibri's TJS 20K-DIN69871-40 Jet Spindle model

Test Date	July, 2015
Country	Australia
Industry	Die & Mold
Application	Profile Milling
Material Group	21 - Aluminum wrought alloy
Material No.	-

Test Data	Actual	Test
Cutting Tool	Iscar: EC 020-B07-2C03 IC08	
Diameter (mm)	2	2
No. of Flutes	2	2
Cutting Speed (m/min)	94	220
Spindle Speed (rpm)	14,961	35,014
Depth of Cut (mm)	0.5	0.5
Width of Cut (mm)	0.8	0.8
Feed Per Tooth (mm/t)	0.0167	0.0167
Table Feed (mm/min)	500	1,169
Parts Per Cutter	300	300
Avg. Chip Thickness	0.01	0.01
Surface Quality	Excellent	Excellent
Metal removal Rate	0.2	0.47

Time/Cost Evaluation	Actual	Test
Cutting Time (hrs.)	61.6	26.3
Cost Savings Per Part	-	56.9%

Productivity Saving



Test Report Summary – Profile Milling

Colibri's TJS 20K-DIN69871-40 Jet Spindle model

Test Date	Oct, 2015
Country	Austria
Industry	Mechanical Engineering/Job Shops
Application	Profile Milling
Material Group	Casting
Material No.	DIN GGG-60

Test Data	Actual	Test
Cutting Tool	VHM SONDERFRÇSER P233	
Diameter (mm)	2.3	2.3
No. of Flutes	2	2
Overhang (mm)	120	120
Cutting Speed (m/min)	123	303
Spindle Speed (rpm)	17,023	41,934
Depth of Cut (mm)	1.3	1.3
Width of Cut (mm)	1.3	1.3
Feed Per Tooth (mm/t)	0.028	0.028
Table Feed (mm/min)	953	2,348
Metal removal Rate	1.61	3.97

Time/Cost Evaluation	Actual	Test
Cutting Time (hrs.)	36.6	15.9
Cost Savings Per Part	-	56.7%

Test Report Summary – Milling (3 tests)

Colibri's TJS 30K-ER32-R Jet Spindle model

Test Date	October 2014
Country	Czech Rep.
Industry	Automotive
Application	Milling
Material Group	Headlight Mold
Material No.	1.2343, 46HRC

Solid Carbide End Mill	Cutting Conditions	Original	HSM Jet Spindle
1 EB-A2-020-030/04C4M45 IC903	Cutting speed:	56	188 m/min
	Revolutions:	9,000 RPM	30,000 RPM
	Depth of cut:	0,1 mm	0,1 mm
	Width of cut:	0,1 mm	0,1 mm
	Feed per tooth:	0,02 mm/tooth	0,02 mm/tooth
	Table feed:	360 mm/min	1 200 mm/min
	Overhang:	4 x D	4 x D
	Time machining:	175 min	55 min
2 EB-A2-010-015/03C4M45 IC903	Cutting speed:	28	125 -140
	Revolutions:	9,000 RPM	40,000 – 45,000
	Depth of cut:	0,05	0,05
	Width of cut:	0,05	0,05
	Feed per tooth:	0.014	0.014
	Table feed:	252	1,120 -1,260
	Overhang:	3 x D	3 x D
	Time machining:	1,670	350
3 EB-A2-005-007/02C4M45 IC903	Cutting speed:	14	75
	Revolutions:	9,000 RPM	48,000
	Depth of cut:	0,02	0,02
	Width of cut:	0,02	0,02
	Feed per tooth:	0.008	0.008
	Table feed:	144	768
	Overhang: 4 x D	4 x D	4 x D
	Time machining:	1,110	210

Results (3 tests)

- All three endmills endured complete machining without any problems.
- In this case there is no load of the spindle and milling tool can work at optimized conditions.
- The customer can use only 9. 000 RPM during current machining.
- The cutting speed is reduced to only 56 to 14 m/min at diameter 0,5 mm.
- The result is, that time machining is 5 times longer than with using of SpinJet device. It leads to worse surface quality and low extreme conditions for tools. The broken tools also will be a result of the low conditions.

Estimated saved time is together about 39 hours per one mould. ***ROI after 2 machined molds.***
Other saving probably will be occured in the consumption of tools thanks to the optimized cutting conditions.

Test Report Summary – Face Milling

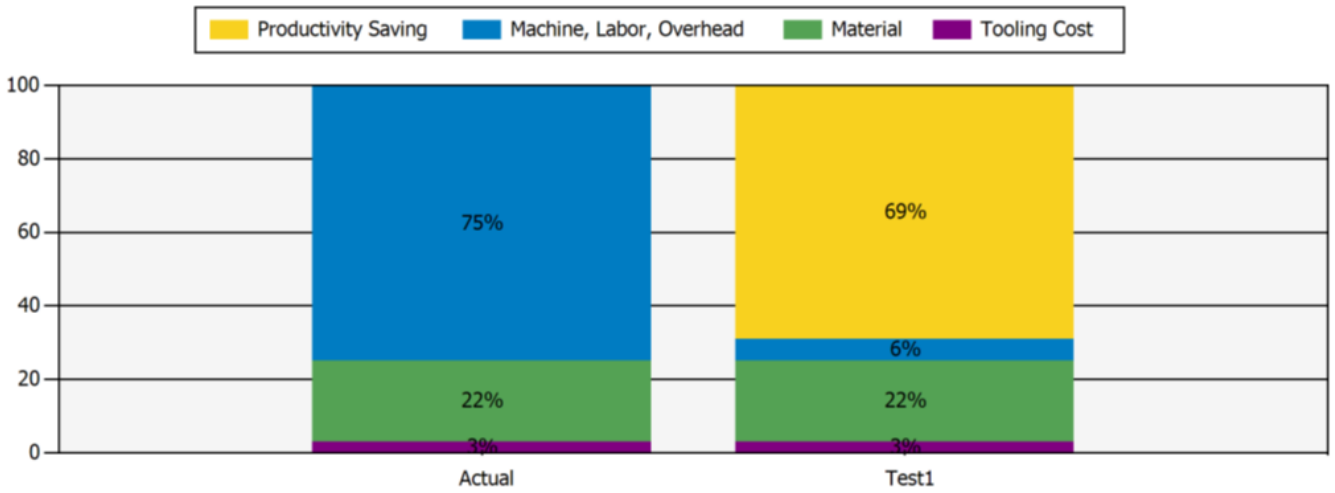
Colibri's TJS 30K-ST20-R Jet Spindle model

Test Date	Oct, 2015
Country	Australia
Industry	Energy Sector
Application	Face Milling
Material Group	Low alloy steel and cast steel
Material No.	AISI/SAE 1045

Test Data	Actual	Test
Cutting Tool	Iscar: EB040A07-2C04	
Spindle Type	Machine Spindle	TJS 30K-ST20-R
Diameter (mm)	4	4
No. of Flutes	2	2
Overhang (mm)	20	20
Cutting Speed (m/min)	38	440
Spindle Speed (rpm)	3,024	35,014
Depth of Cut (mm)	0.1	0.1
Width of Cut (mm)	0.5	0.5
Feed Per Tooth (mm/t)	0.033	0.0286
Table Feed (mm/min)	200	2,003
Parts Per Cutter	12	12
Surface Quality	Good	Good
Metal removal Rate	0.01	0.1

Time/Cost Evaluation	Actual	Test
Cutting Time (hrs.)	148.4	14.8
Cost Savings Per Part	-	89.5%

Productivity Savings



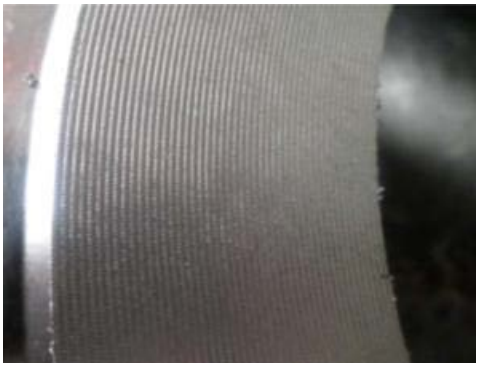
Tungaloy Premium Test Report – Groove Milling

Colibri's TJS20K-ER32-R Jet Spindle model

Test Date	DEC-2015
Country	France
Industry	Energy Sector
Application	Groove Milling: Pump casing flange
Material Group	CI + Chrome, Duplex SS
Material No.	HRC < 45HRC

Test Data	Actual	Test
Cutting Tool	Ball Nose End Mill	
Spindle Type	Machine Spindle	TJS 30K-ST20-R
Diameter (mm)	3	3
Cutting Speed (m/min)	33 (108 sfm)	188 (617 sfm)
Spindle Speed (rpm)	3,500	20,000
Feed Per Tooth (mm/t)	0.26 (0.01 ipt)	0.15 (0.006 ipt)
Table Feed (mm/min)	1,820 (71.65 ipm)	6,000 (232.22 ipm)

Time/Cost Evaluation	Actual	Test
Cutting Time (hrs.)	25	8
Machining Time Savings Per Part	-	68%



Groove milling on the flange of pump casings required a small-diameter tool. The machine's max RPM was not enough for the desirable Vc, which reduces tool life and also deteriorates the machined surface quality. Short cycle time was also required.

The SPINJET increased productivity, prolonged tool life and improved surface quality.

Test Report Summary – Drilling

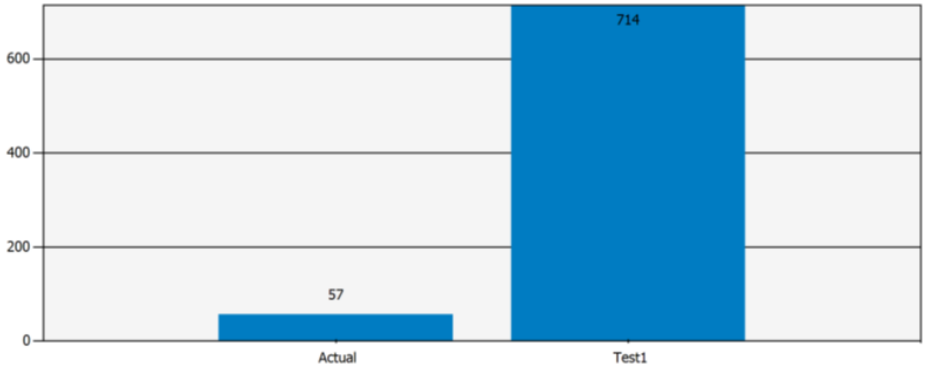
Colibri's TJS 20K-ER32-R Jet Spindle model

Test Date	Nov, 2015
Country	France
Industry	General machining
Application	Drilling
Material Group	Low alloy steel and cast steel
Material No.	S300PB

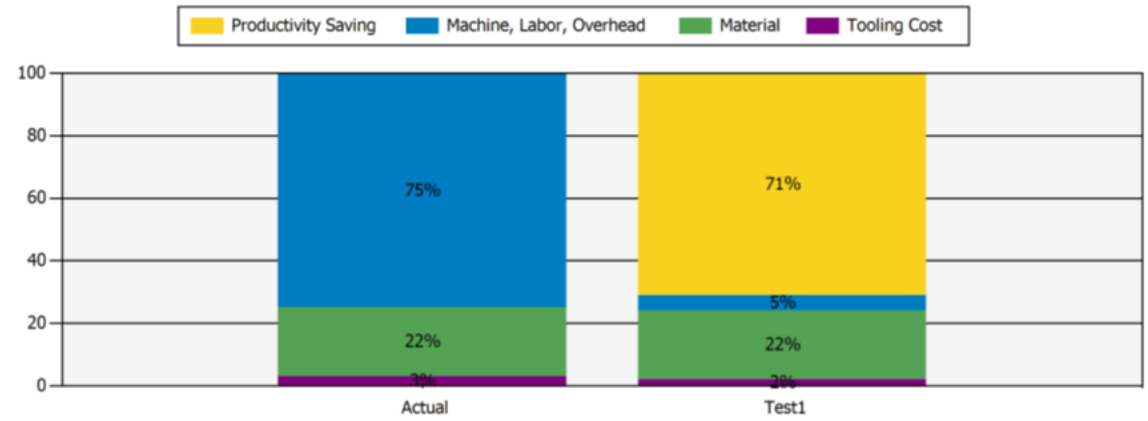
Test Data	Actual	Test
Cutting Tool	Iscar: SCD 010-004-030 AP4 903	
Spindle Type	Machine Spindle	TJS 20K-ER32-R
Hole depth (mm)	1	1
Spindle Speed (rpm)	17,030	36,924
Feed	0.04	0.0789
Table Feed (mm/min)	240	2,998
Holes Per Cutting Edge - New Corner	200	250
Primary Wear	Flank wear	Flank wear
Surface Quality	Good	Good
Chip type	Fragments	Fragments

Time/Cost Evaluation	Actual	Test
Cutting Time (hrs.)	17.4	1.4
Cost Savings Per Part	-	22.4%

Parts per Hour



Productivity Saving



Test Report Summary - Copy Milling

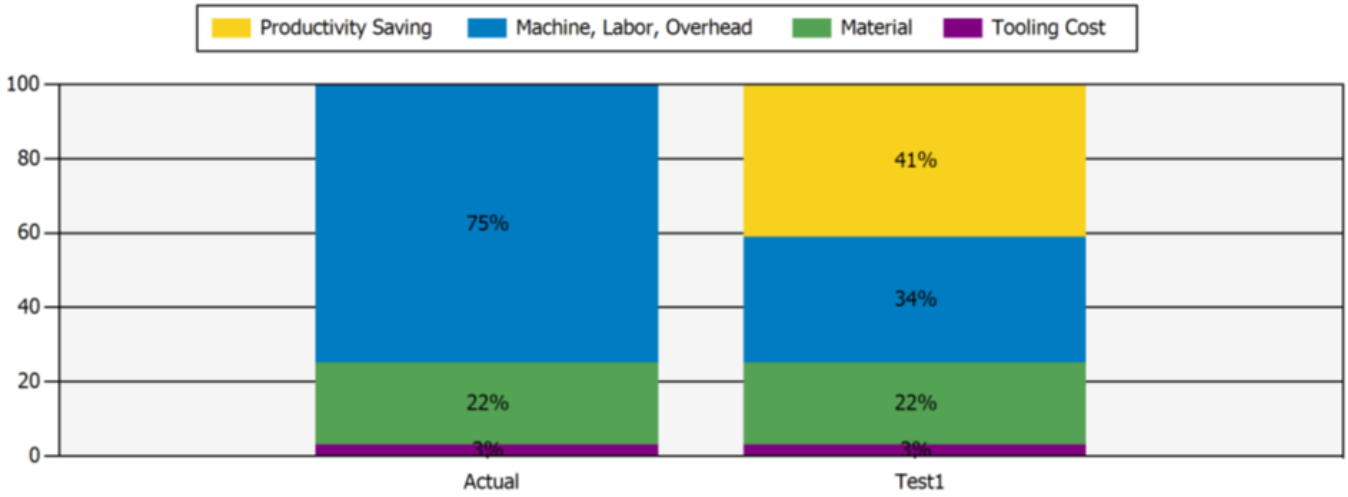
Colibri's TJS 20K-HSK A63 Jet Spindle model

Test Date	Dec, 2015
Country	Germany
Industry	General machining
Application	Copy milling
Material Group	Aluminum - wrought alloy
Material No.	DIN AlZnMgCuO,5

Test Data	Actual	Test
Cutting Tool	Iscar: EC-A2 020-030/12C4M45903	
Spindle Type	Machine Spindle	TJS 20K-HSK A63
Diameter (mm)	2	2
No. of Flutes	2	2
Overhang (mm)	12	12
Cutting Speed (m/min)	107	232
Spindle Speed (rpm)	17,030	36,924
Depth of Cut (mm)	0.5	0.5
Width of Cut (mm)	1.5	1.5
Feed per Tooth (mm/t)	0.026	0.026
Table Feed (mm/min)	886	1,920
Surface Quality	Good	Good
Metal Removal Rate (cm3/min)	0.66	1.44

Time/Cost Evaluation	Actual	Test
Cutting Time/Part (sec)	1,084.1	500
Cost Savings Per Part	-	18.8%

Productivity Saving



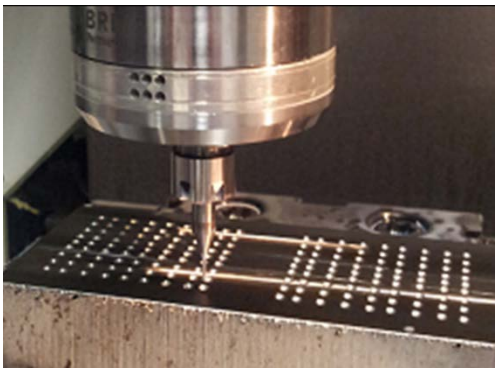
Test Report Summary – Thread Milling

Colibri's TJS 30K-ER32-R Jet Spindle model

Test Date	Jan, 2013
Country	Israel
Industry	General Industry
Application	Thread Milling
Material Group	Alloy Steel
Material No.	SAE 4340

Test Data	Actual	Test
Cutting Tool	D3T06015L062-I0.4 ISO TM VTH Vargus	
Diameter (mm)	1.55	1.55
No. of Teeth	3	3
Cutting Speed (m/min)	32	150
Spindle Speed (rpm)	6,572	32,000 / 30,800
Depth of Cut (mm)	5	5
Feed Per Tooth (mm/t)	0.014	0.014
Table Feed (mm/min)	276	1294
Failure - wear/breakage	Wear	Still good
Tool Life	81	280 (not final)
Surface Finish	Good	Very good

Time/Cost Evaluation	Actual	Test
Cutting Time (sec. per hole)	16.0	4.0
Cost Savings Per Part	-	75%



Test Report Summary – Engraving

Test Date	2014
Country	India
Industry	Die & Mold
Application	Engraving – Logo Punch
Material Group	Hardened Steel 65 HRC
Material No.	H13 65HRC

Test Data	Actual	Test
Cutting Tool	ECD-S2 040/90C04-50 TT9030 (90 Deg. Chamfering)	
Spindle Type	Machine S. – BT30	TJS 30K-ER32 R
Diameter (mm)	4	4
No. of Flutes	2	2
Cutting Speed (m/min)	17	66
Spindle Speed (rpm)	8,000	30,000
Depth of Cut (mm)	0.35	0.35
Width of Cut (mm)	0.70	0.70
Feed per Tooth (mm/t)	0.005	0.005
Table Feed (mm/min)	80	300
Surface Quality	Poor	Good
Metal Removal Rate (cm3/min)	0.66	1.44

Time/Cost Evaluation	Actual	Test
Cutting Time/Part (min.)	49	4
Productivity of Cycle Time	-	12 times faster