ADVANTiGE TM

J&M retention knobs evaluation

MAKINO
TITANIUM PROCESS DEVELOPMENT
Nov 2012

Objective

Identify possible differences between standard retention knobs and High Torque retention knobs manufactured by J&M

SETUP

Machine

- a81M-5XR sn900
- Spindle nose — No. 50 Taper
- Tooling — CAT V-flange
- Draw bar force — 29.4kN (6610 lb)
- Spindle torque — 1009 Nm(740 ft.lb)

SETUP

Retention knobs

- Retention knob 1
- Standard J&M 31647 sn 07/08-003344
- High Torque J&M 31647HT sn 10/12-000804
- Retention knob 2

a) **Retention knob 1**

a) **J&M standard**

a) **J&M High torque**

a) **Retention knob 2**

SETUP

Tool holders/Tool

- **Holder 1** Kennametal CV50BB400600 ATI 5230VS12-MB5732
- **Holder 2** Kennametal CV50BB400600 ATI 7745V0D06-A100Z09R
- **Holder 3** Erickson C-125339 Sandvik R390-032A32-17L
- **Holder 4** Kennametal CV50BB400600 Seco R220.69-00050-044-12.5AN

Holder/Tool 1

Holder/Tool 2

Holder/Tool 3

Holder/Tool 4

SETUP

Instruments

- Stanley proto torque wrench J6014C — retention knob tightening control
- J&M Taper shank test fixture — holder axial displacement measurement
- KISTLER dynamometer 9255B — cutting forces measurement
- Metal Max unit — tap testing

Torque wrench

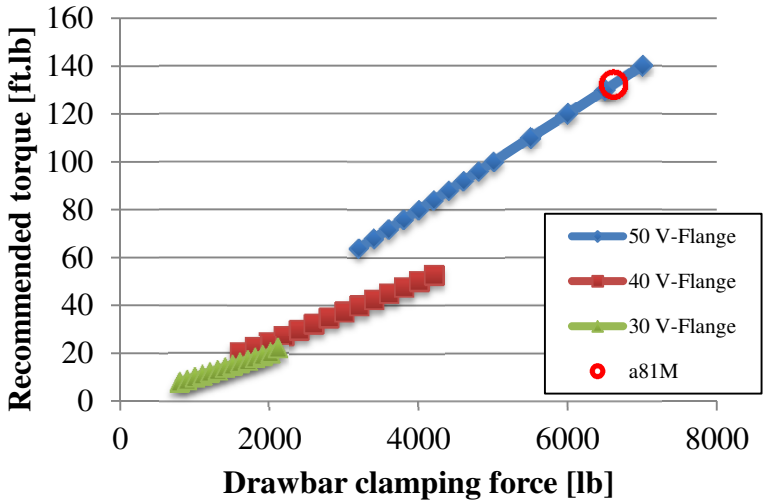
J&M test fixture

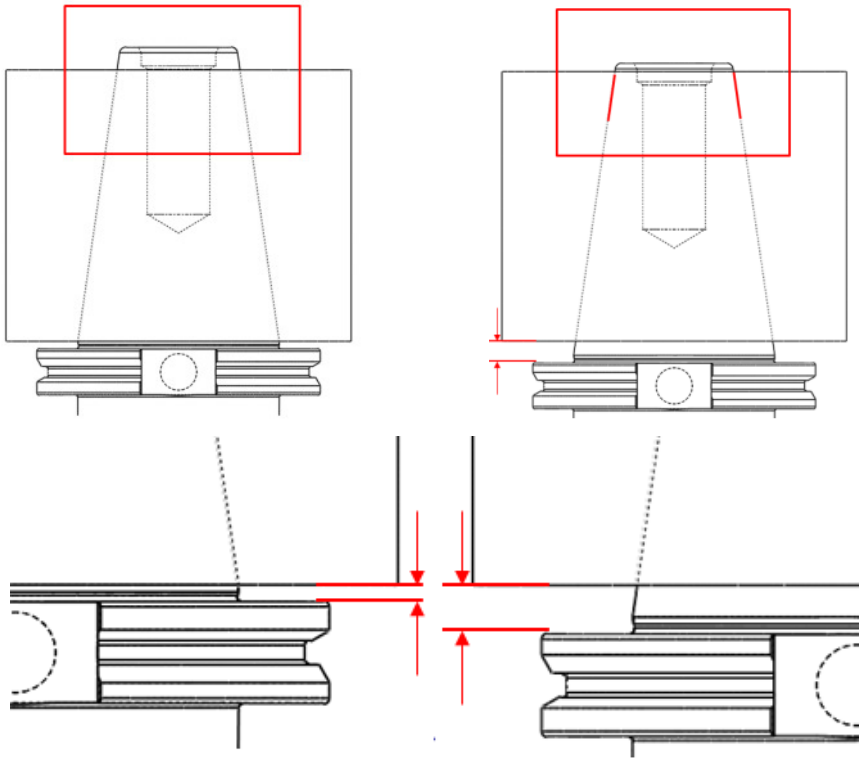
Dynamometer

Metal Max

INTRODUCTION

J&M claims that when a standard retention knob is tightened, it causes radial expansion of the holder taper along the thread area, highlighted with the red lines inside the red square in the Figure. Such expansion would create an anticipated contact between the holder and the test fixture taper which could be detected as an increment of the distance between the holder flange and the test fixture reference surface.





TEST FIXTURE USAGE

1. Test fixture collocation

2. Dial micro indicators calibration

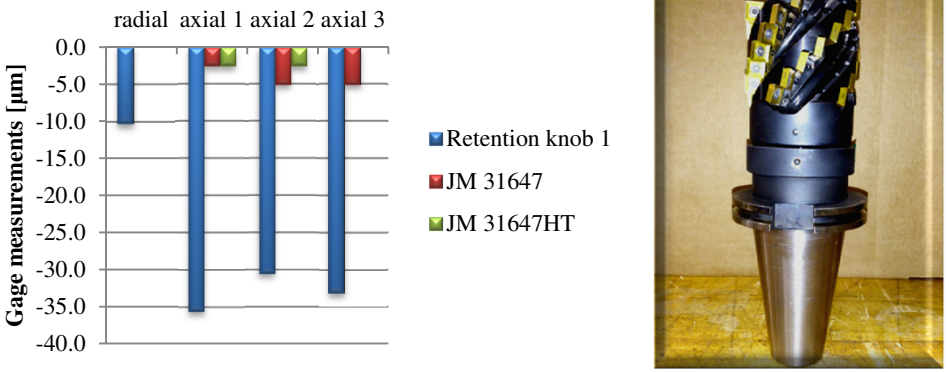
3.Collocation after tightening

4. Dial micro indicators reading

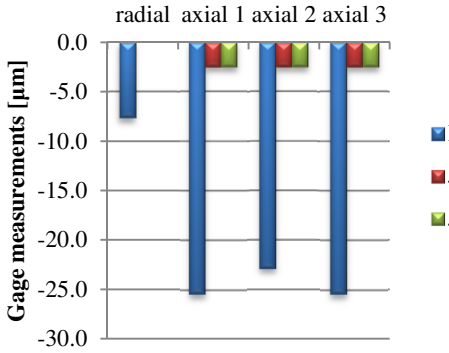
TAPER DEFORMATION RESULTS

Taper deformation J&M gauge

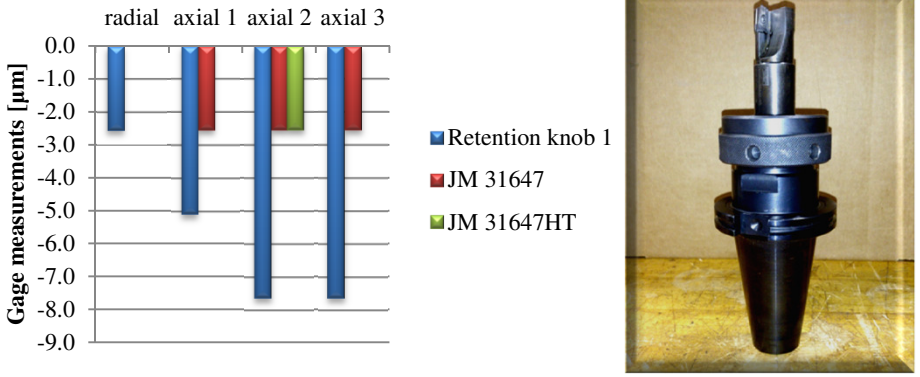
Holder 1/ Tool Kennametal CV50BB400600/ ATI 5230VS12-MB5732



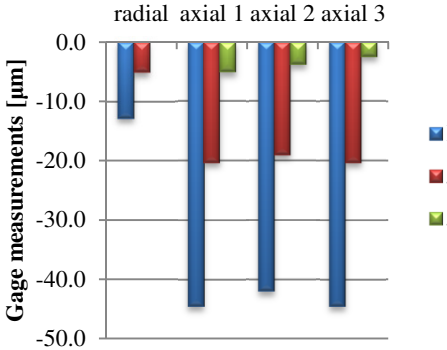
Holder 2/ Tool Kennametal CV50BB400600/ ATI 7745V0D06-A100Z09R



Holder 3/ Tool Erickson C-125339/ Sandvik R390-032A32-17L



Holder 4/ Tool Kennametal CV50BB400600/ Seco R220.69-00050-044-12.5AN



NOTE: If a color bar does not appear is because the reading was 0.

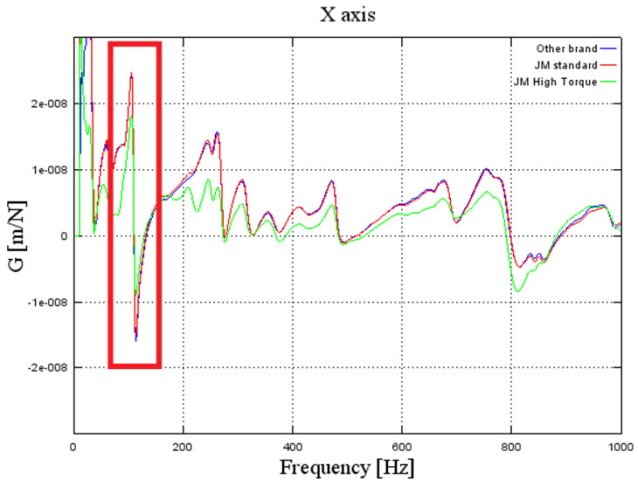
132 ft.lb torque tightening

Observations

Using the test fixture is evident that the high torque retention knob designed by J&M produces a smaller deformation over the holder taper compared with a standard design by the same brand and the other brands tested. The values of deformation are variable depending on the holder tested, note the results from Holder 3 much lower than the others. For the three samples used in this stage the differences in axial displacement measured go from 5 to 30 μm.

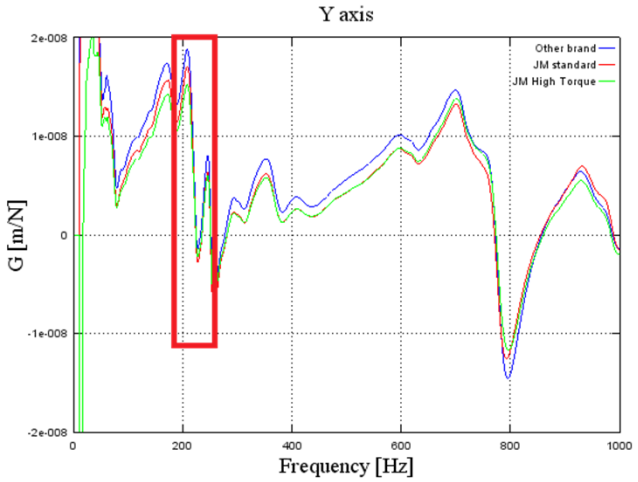
TAP TESTING

Holder 1



	Frequency	Modal Stiffness	Damping ratio
	ωn [Hz]	k [N/m]	
RK 1	109.56	2.78 E08	0.0383
JM ST	109.75	2.88 E08	0.0365
JM HT	109.75	3.90 E08	0.0365

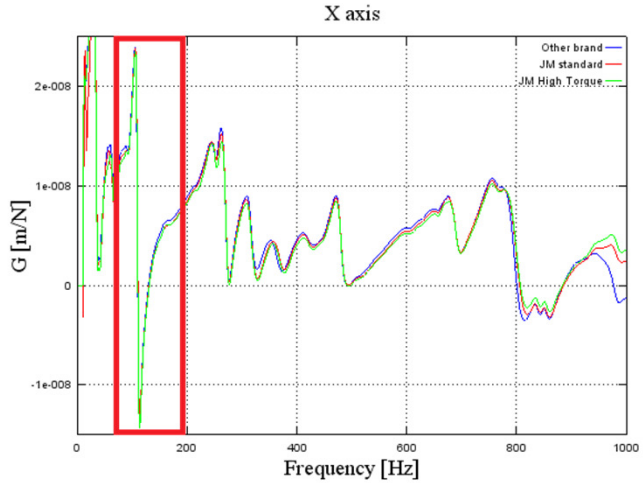
A improvement of the modal stiffness can be appreciated according to the table for the X-axis with J&M standard 4% higher modal stiffness than Retention Knob 1 and J&M high torque 40% better modal stiffness than Retention Knob 1.



	Frequency	Modal Stiffness	Damping ratio
	ωn [Hz]	k [N/m]	
RK1	218.23	3.13 E08	0.0445
JM ST	218.23	3.44 E08	0.0445
JM HT	218.04	3.78 E08	0.0454

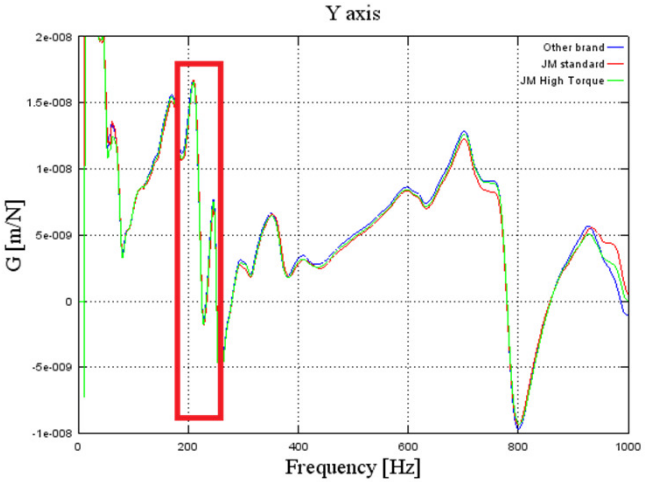
The improvement of the modal stiffness according to the table for the Y-axis with J&M standard 10% higher modal stiffness than Retention Knob 1 and J&M high torque 21% better modal stiffness than Retention Knob 1 .

Holder 2



	Frequency ωn [Hz]	Modal Stiffness k [N/m]	Damping ratio
RK1	109.56	2.84 E08	0.0383
JM ST	109.75	2.97 E08	0.0365
JM HT	109.75	3.02 E08	0.0365

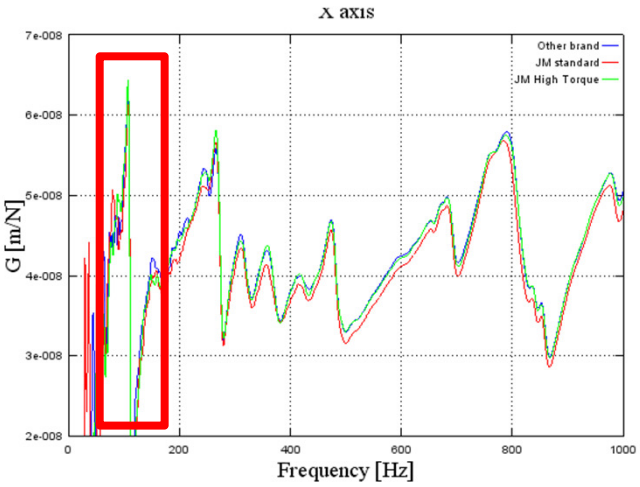
The improvement for the modal stiffness values was less significant than Holder 1. The X-axis showed 5% improvement when the J&M standard retention knob was used and 6% improvement for the J&M high torque retention knob in comparison with Retention Knob 1.

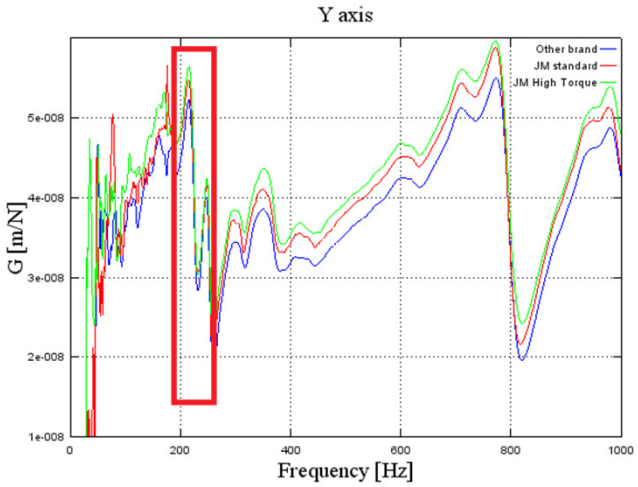


	Frequency ωn [Hz]	Modal Stiffness k [N/m]	Damping ratio
RK1	218.41	3.60 E08	0.0436
JM ST	219.15	3.73 E08	0.0427
JM HT	218.59	3.70 E08	0.0427

The improvement was only 4% using the J&M standard retention knob and 3% with the J&M high torque retention knob in comparison with Retention Knob 1.

Holder 3





	Frequency ωn [Hz]	Modal Stiffness k [N/m]	Damping ratio
RK1	110.88	1.26 E08	0.0327
JM ST	111.44	1.37 E08	0.0308
JM HT	110.88	1.23 E08	0.0327

The J&M retention knobs showed a different behavior compared with the previous two assemblies. This case showed the lower level of deformation.
The J&M standard retention knob showed 8% improvement of the modal stiffness but the J&M high torque showed a 3% decrease of the modal stiffness, both compared with Retention Knob 1.

	Frequency ωn [Hz]	Modal Stiffness k [N/m]	Damping ratio
RK1	223.50	1.35 E08	0.0367
JM ST	223.33	1.21 E08	0.0393
JM HT	223.88	1.26 E08	0.0366

The results for the Y-axis according to Table indicate than in both J&M retention knobs there is a fall in the modal stiffness in comparison with Retention Knob 1. 11% decrease for the J&M standard and 7% for the J&M high torque.

Observations

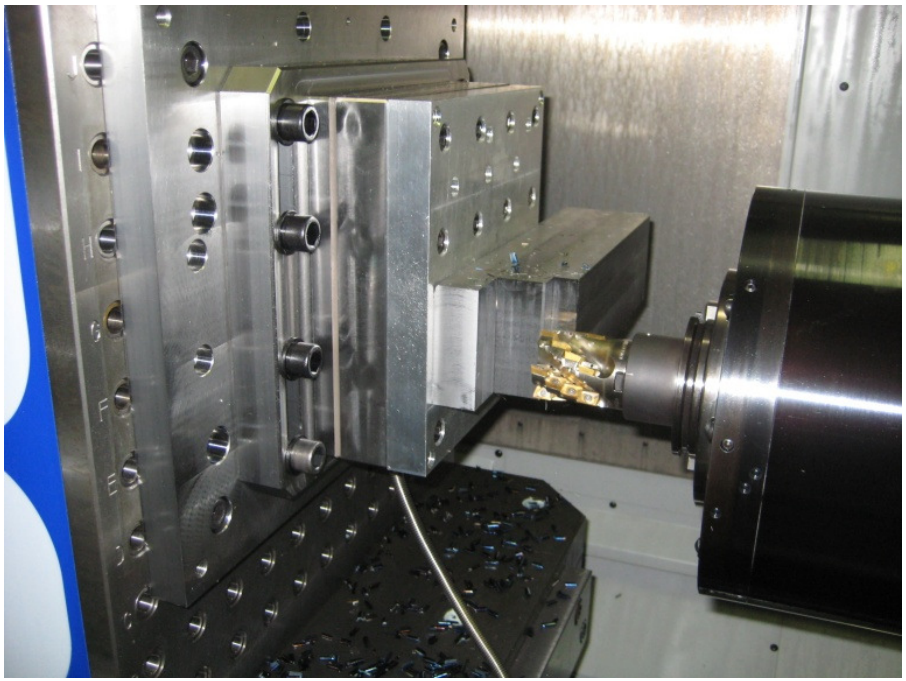
The evaluation of the modal stiffness estimated from the results of tap testing indicates that :

- There is no considerable difference between J&M standard and Retention Knob 1, the modal stiffness difference relies within 10% for axial displacements difference between 10 and 30µm.

- There is a considerable difference between J&M high torque and both Retention Knob 1 and J&M standard for the modal stiffness (40% X-axis and 21% Y-axis), when the axial displacement difference measured with the test fixture is greater than 30µm.

DYNAMIC LOAD

SETUP and Cutting Conditions



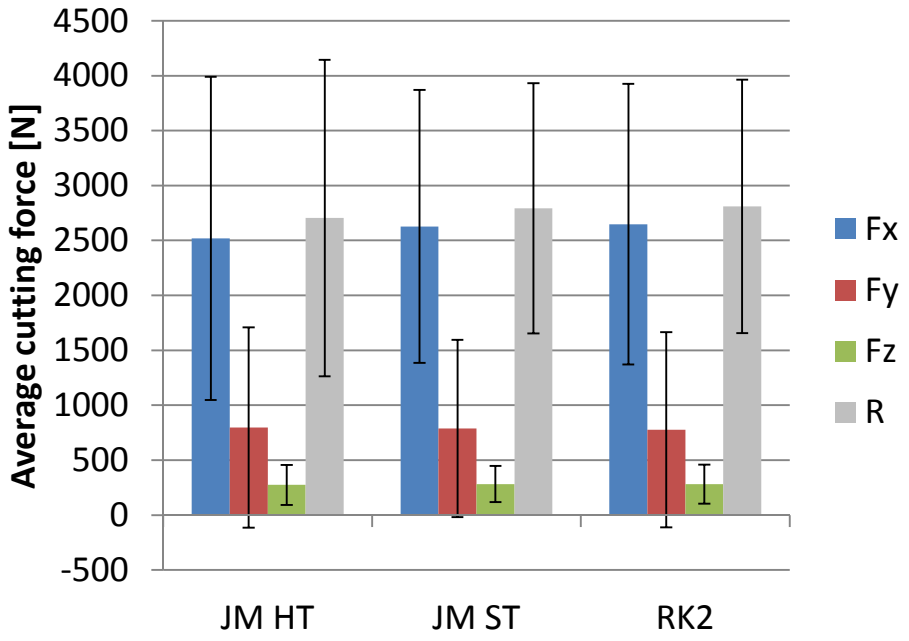
Material**: Carbon steel AISI 1050**

	Cutting speed m/min	Axial immersion mm	Radial immersion mm / %D	Feed per tooth mm/tooth
Set 1	100	20	20 / 40	0.1
Set 2	100	35	20 / 40	0.1
Set 3	200	40	20 / 40	0.1

	ft/min	in	in / %D	in/tooth
Set 1	328.08	0.787	0.787 / 20	0.0039
Set 2	328.08	1.378	0.787 / 20	0.0039
Set 3	656.17	1.575	0.787 / 20	0.0039

hypothesis: improve in stiffness derived from a better contact area between the holder and the spindle tapers would be reflected as a reduction of the average force value and/or a reduction in the cutting force variation.

SET 1



Force magnitude

- J&M HT showed 5% Fx reduction in comparison with RK2
- J&M HT and J&M standard showed same value only 1% difference.

Spindle load

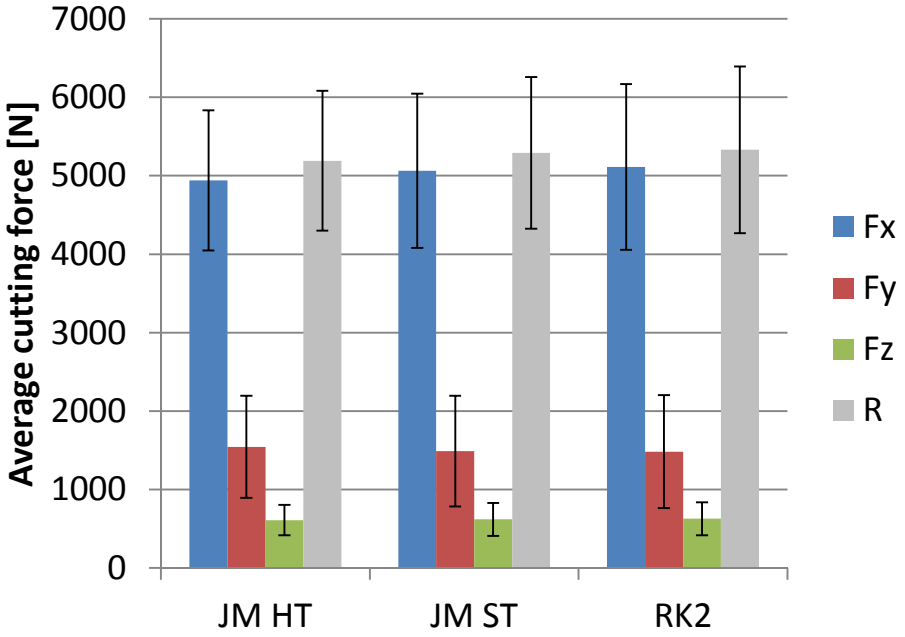
- Spindle load with J&M HT is 6% lower (relative) than RK2
- Spindle load with J&M ST is 1% lower (relative) than RK2

Force variation

- J&M HT showed 15% more variation than RK2
- J&M ST showed 3% less variation than RK2

	Fx [N]			Fy [N]			Fz [N]			Spindle Load
JM HT	**2519**	±	1472	**797**	±	912	**275**	±	182	5.24
JM ST	**2628**	±	1241	**789**	±	807	**283**	±	165	5.52
RK 2	**2648**	±	1278	**778**	±	889	**281**	±	178	5.57

SET 2



Force magnitude

- J&M HT showed 3% Fx reduction in comparison with RK2
- J&M ST and RK2 showed same value only 1% difference.

Spindle load

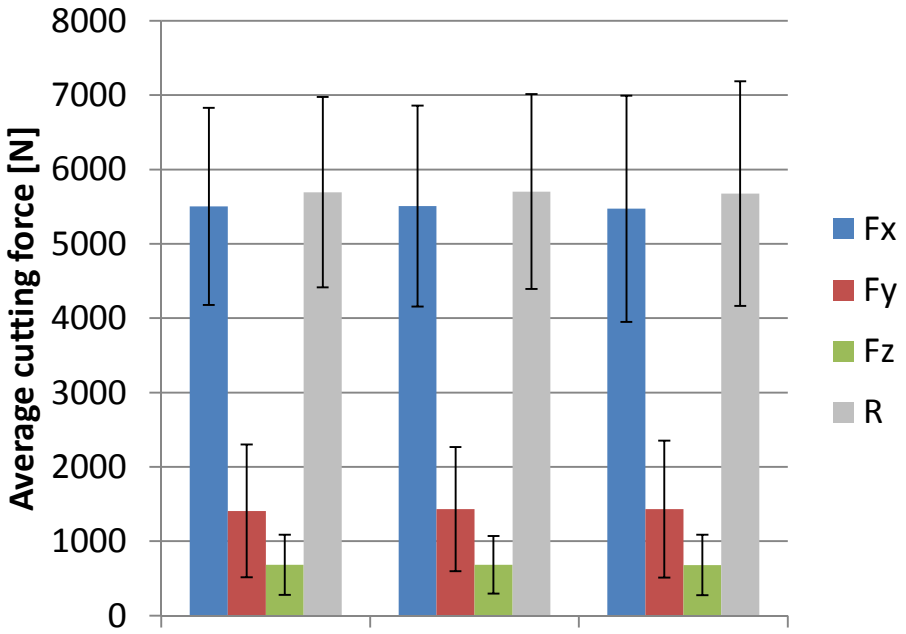
- Spindle load with J&M HT is 3% lower (relative) than RK2
- Spindle load with J&M ST same as RK2

Force variation

- J&M HT showed 16% less variation than RK2
- J&M ST showed 7% less variation than RK2

	Fx [N]			Fy [N]			Fz [N]			Spindle Load
JM HT	**4940**	±	892	**1545**	±	651	**610**	±	194	9.97
JM ST	**5063**	±	984	**1490**	±	707	**620**	±	210	10.26
RK2	**5110**	±	1056	**1483**	±	720	**628**	±	211	10.31

SET 3



Force magnitude
- J&M HT Fx same as RK2
- J&M ST Fx same as RK2

Spindle load
- Spindle load with J&M HT is 11% lower (relative) than RK2
- Spindle load with J&M ST is 10% lower (relative) than RK2

Force variation
- J&M HT showed 13% less variation than RK2
- J&M ST showed 11% less variation than RK2

	Fx [N]			Fy [N]			Fz [N]			Spindle Load
JM HT	**5505**	±	1326	**1407**	±	893	**693**	±	404	18.39
JM	**5507**	±	1351	**1432**	±	834	**683**	±	389	18.55
RK2	**5473**	±	1522	**1432**	±	922	**681**	±	406	20.58

Observations

For the range of cutting force tested 2.5, 5 and 5.5kN:

- The average cutting force does not show significant difference for the retention knobs used, J&M and Retention Knob 2.

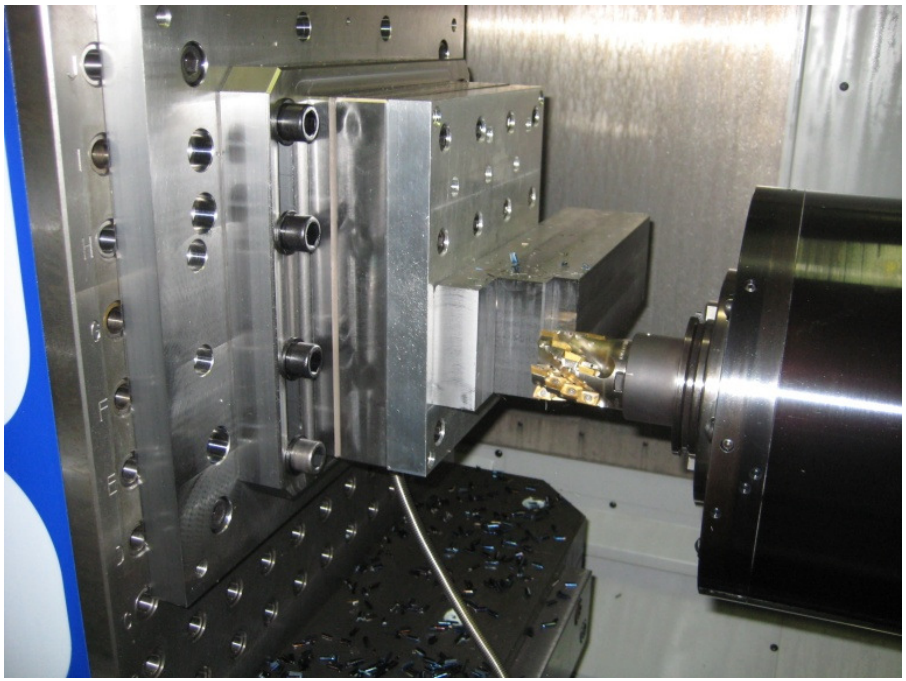
- The use of J&M HT retention knobs showed and improvement in cutting force variation in relation with Retention Knob 2. 15%, 16% and 13% for the 2.5, 5 and 5.5kN cases. However these comparison is made with max. and min. values for each revolution.

- The use of J&M ST retention knobs showed and improvement in cutting force variation in relation with Retention Knob 2. 3%, 7% and 11% for the 2.5, 5 and 5.5kN cases.

- The reduction of the cutting force variation has an effect over the spindle load which represents an improvement by using J&M HT retention knobs. Maximum 11% (relative) spindle load reduction.

FREQUENCY CONTENT

SETUP and Cutting Conditions



	Cutting speed m/min	Axial immersion mm	Radial immersion mm / %D	Feed per tooth mm/tooth
Set 1	100	20	20 / 40	0.1
Set 2	100	35	20 / 40	0.1
Set 3	200	40	20 / 40	0.1

	ft/min	in	in / %D	in/tooth
Set 1	328.08	0.787	0.787 / 20	0.0039
Set 2	328.08	1.378	0.787 / 20	0.0039
Set 3	656.17	1.575	0.787 / 20	0.0039

Material**: Carbon Steel AISI 1050**

Note: the dynamic load section presented results for variation based on the maximum and minimum values for each revolution of the tool (not completely reliable). Here, the frequency content analysis shows more accurate values since it considers the effect of each flute.

hypothesis: similarly to the force magnitude and variation analysis, an improvement in stiffness derived from a better contact area between the holder and the spindle tapers would be reflected as a reduction in the cutting force variation, which it will be read in the frequency content analysis as amplitude.

SET 1

	Fx dominant frequency [Hz]		Fy dominant frequency [Hz]		Resultant
	Frequency	Amplitude [N]	Frequency	Amplitude [N]	Amplitude [N]
JM HT	**52.98**	657	**52.98**	449	**513**
JM ST	**52.98**	659	**52.98**	477	**498**
RK2	**52.98**	667	**52.98**	486	**507**

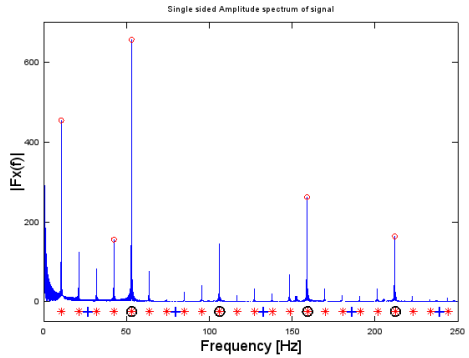
This set of cutting parameters was the most stable of all since the frequency with higher amplitude corresponds to the tooth pass frequency. The compared values are the correspondent to the Resultant force. The variation of the resultant amplitude between the three different retention knobs relies within 2% and is too close to enunciate any difference.

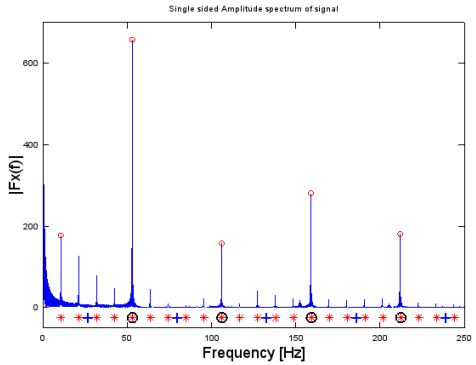
J&M HT

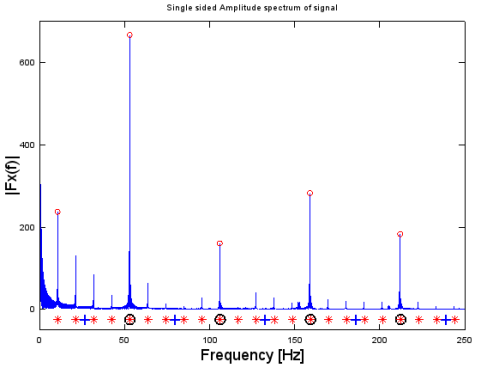
J&M ST

RK2

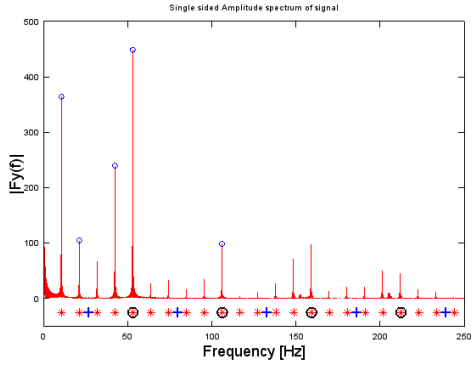
X -axis

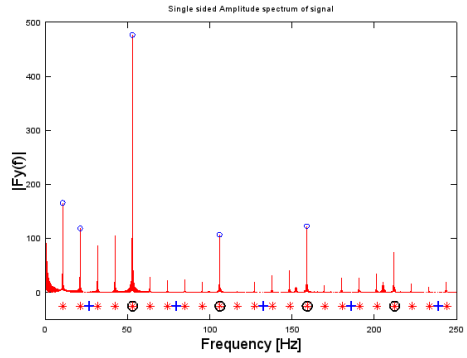


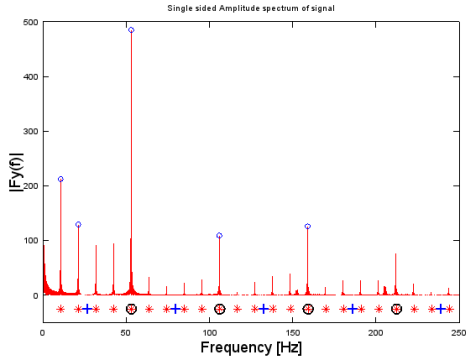




Y -axis







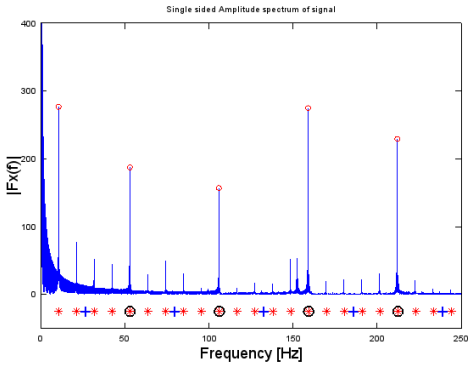
SET 2

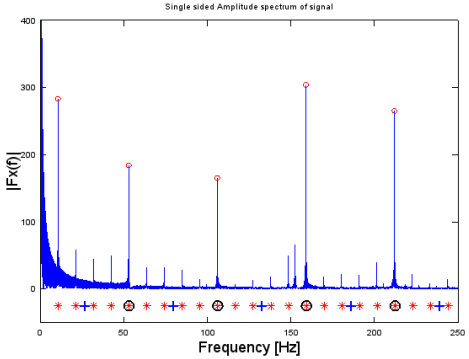
	Fx dominant frequency [Hz]		Fy dominant frequency [Hz]		Resultant
	Frequency	Amplitude [N]	Frequency	Amplitude [N]	Amplitude[N]
JM HT	**10.6**	268	**10.6**	292	**356**
JM ST	**10.6**	283	**10.6**	280	**400**
RK 2	**10.6**	290	**10.6**	279	**399**

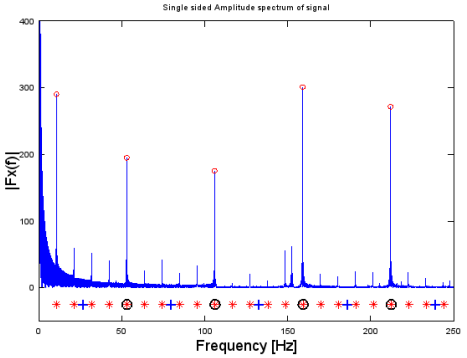
The magnitude of forces is enough to make a clear distinction between the retention knobs effect. Retention knob 2 and J&M standard do not exhibit difference for 5kN range of force however J&M high torque shows a reduction of the amplitude of 11%.

J&M HT | J&M ST | RK2

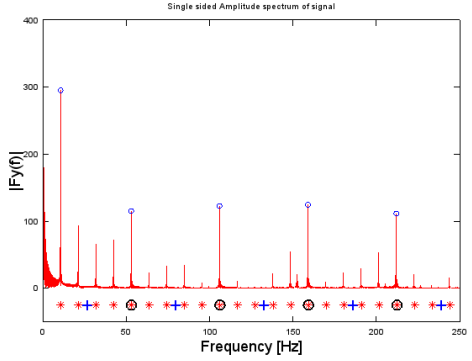
X -axis

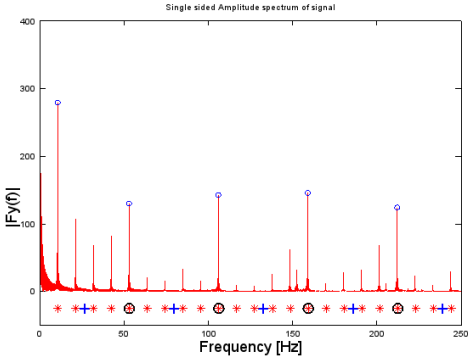


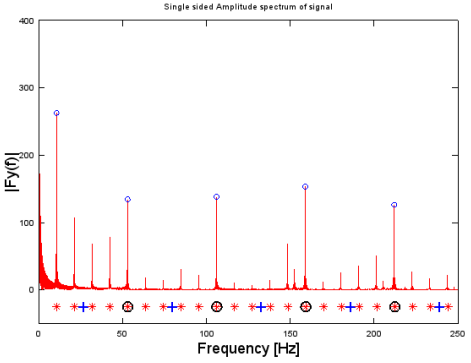




Y -axis



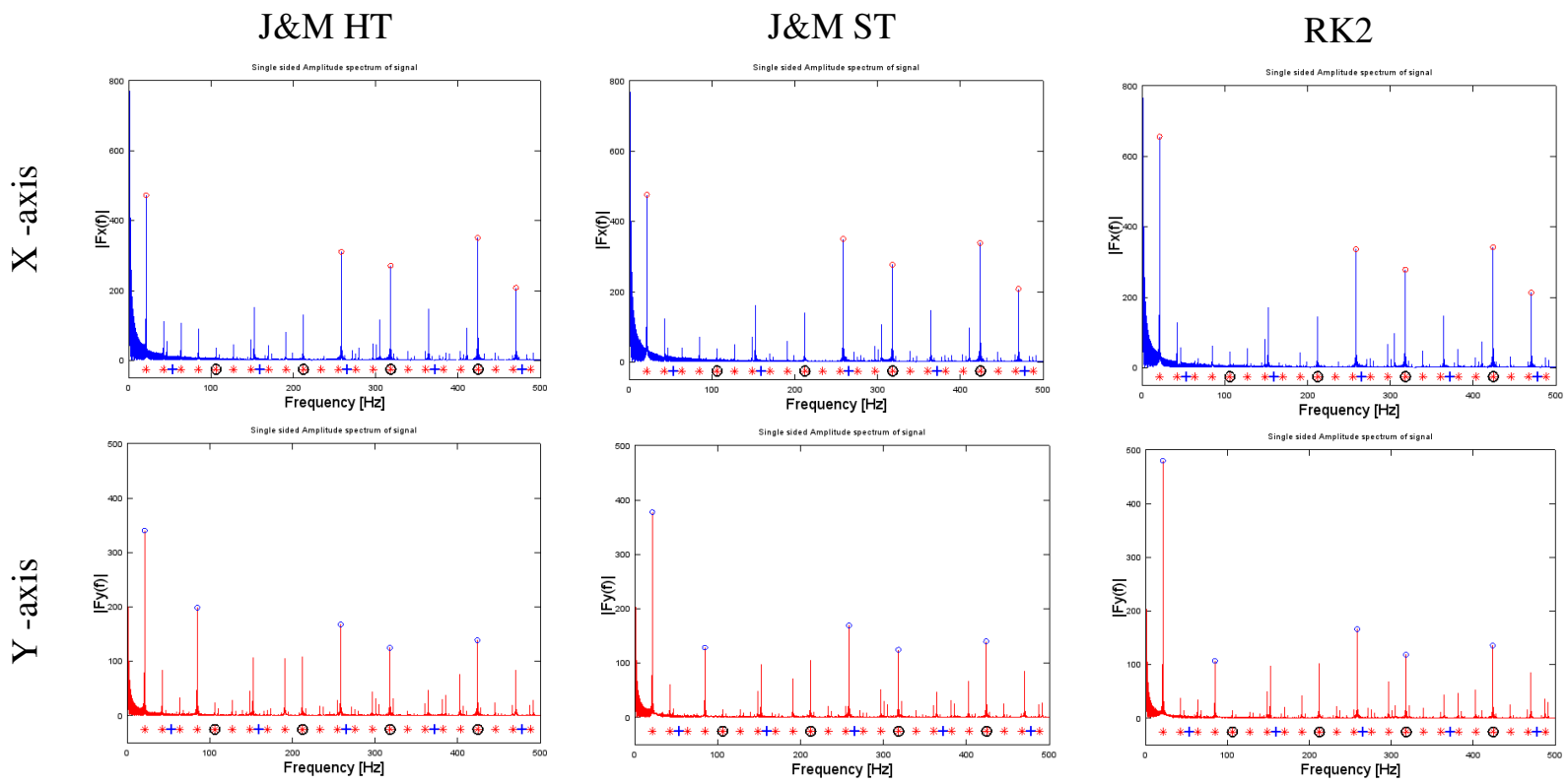




SET 3

	Fx dominant frequency [Hz]		Fy dominant frequency [Hz]		Resultant
	Frequency	Amplitude [N]	Frequency	Amplitude [N]	Amplitude [N]
JM HT	**21.19**	473	**21.19**	341	**474**
JM ST	**21.19**	476	**21.19**	378	**520**
RK2	**21.19**	656	**21.19**	482	**692**

For this set the effect of the high torque retention knob becomes more notorious. The J&M standard reduces the amplitude for the dominant frequency 25% respect to the Retention Knob 2 whereas the J&M high torque reduces it 30%.



Observations

For the range of cutting force tested 2.5, 5 and 5.5kN:

- The average cutting force does not show significant difference for the retention knobs used, J&M and Retention Knob 2.
- The use of J&M HT retention knobs showed a reduction in cutting force variation in relation with Retention Knob 2. 15%, 16% and 13% for the 2.5, 5 and 5.5kN cases.
- The use of J&M ST retention knobs showed a smaller reduction in cutting force variation in relation with Retention Knob 2. 3%, 7% and 11% for the 2.5, 5 and 5.5kN cases.
- The reduction of the cutting force variation has an effect over the spindle load which represents an improvement by using J&M HT retention knobs. Maximum 11% (relative) spindle load reduction.

GENERAL CONCLUSIONS

1) There are only significant benefits of J&M only if using the J&M High Torque knob.

2) The high torque knob seems to distort the holder less but could be as much as 5 to 30 microns axially.

3) Modal stiffness of the tool is affected if the axial displacement is large - around 30 microns or more.

4) Up to 3% less relative spindle load is possible in certain cutting force conditions (2500N or 562lbf) due to less variation in cutting forces (about 9%-16% less variation). For 5kN or 5.5kN the difference for spindle load is even greater at 11% relative in variation even if the force fluctuation variation is less.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