



Autodesk[®] PowerMill[®] Robot

Tool & Spindle calibration

Autodesk® PowerMill® 2018

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Why to calibrate a spindle?

Robots need to be taught about tools in order to know the tool tip location.

During the teaching procedure, the robot determines where the tool tip center point is, in relation to its 6th axis workplane (in the case where the spindle is mounted on the robot).

This procedure must be repeated for each tool. This means that each tool will contain errors due to the inaccuracy of the teaching process.

Teaching the same tool twice will not give the same result. This is because the process is very visual, so the user will always introduce “human errors”.

Any errors incurred during the teaching stage will be dramatically amplified and will reduce machining accuracy.

The spindle calibration procedure has several key benefits:

- **It helps to improve machining accuracy**
- **It reduces setup times**
- **It removes the need to physically teach each tool**

With this functionality, the robot is closer in behavior to a CNC machine.



Objectives

The objective of the spindle calibration procedure is to:

1. Define the spindle center point (XYZ)
2. Define the spindle direction (IJK)

Spindle reference plane

Spindle center point
(tool attach point)

Spindle direction (tool axis)



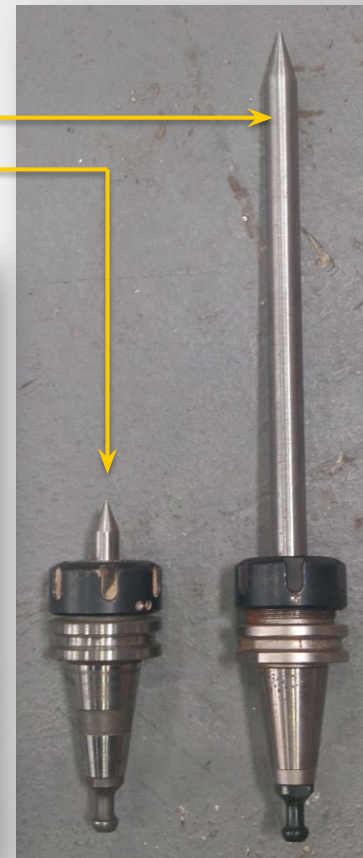
Requirements to perform a spindle calibration

1. PowerMill Robot with the robot simulation loaded

2. Three probes / spikes

- One long probe (spike)
- One short probe (spike)
- A third spike (used for teaching)

3. A tool measuring device



Step 1: Create a new spindle calibration

From the tool calibration form, create a new spindle calibration.

The spindle calibration data are stored into the RobConfig file of the robot.



Tool calibration

Spindle calibration

Select tool to load its length

Tool length: mm Tool number:

Tool information

X	Y	Z	
<input type="text"/>	<input type="text"/>	<input type="text"/>	
R1	R2	R3	
<input type="text"/>	<input type="text"/>	<input type="text"/>	
Q1	Q2	Q3	Q4
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Tool Base

Spindle calibration

Short probe

Length

X	Y	Z	
<input type="text"/>	<input type="text"/>	<input type="text"/>	
Teach 1 <input checked="" type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Teach 2 <input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Teach 3 <input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Average measure	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

Long probe

Length

X	Y	Z	
<input type="text"/>	<input type="text"/>	<input type="text"/>	
Teach 1 <input checked="" type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Teach 2 <input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Teach 3 <input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Average measure	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

Tool workplane orientation

Define X axis Define Y axis XY YZ ZX Reverse

Tool workplane Y axis direction (in the robot 6th axis workplane)

Other I J K

Head attach point definition

```
<head_attach_point PART="head" X="0.0" Y="0.0" Z="0.0" I="0.0" J="0.0" K="0.0" U="0.0" V="0.0" W="0.0" />
```

Name:

Spindle information

Tool axis vector	I	J	K
	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="1"/>
Tool workplane X axis vector	X	Y	Z
	<input type="text" value="1"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Tool attach point	X	Y	Z
	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

Override spindle information

Notes

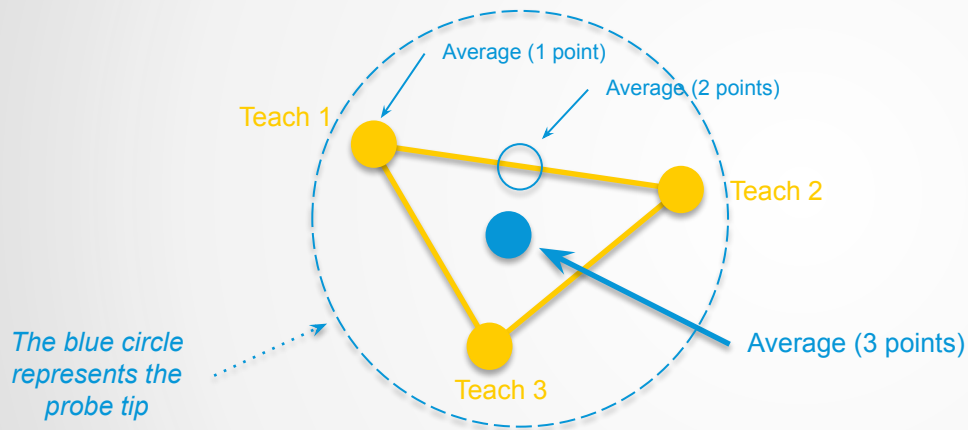
Use this spindle calibration by default

Step 2: Teach short probe

(Example based on a robot holding the spindle...)

The short probe must be taught as it would be for any other tool that the user wishes to use with the robot (usually using a “4 or 5 points method”). The values we are looking at are the coordinates (XYZ) of the tip of the probe.

Teaching is required at least once but more times will give better accuracy. This is because PowerMill Robot will use their average. The three ‘teach’ method is the best...



Once taught, the robot can display the X, Y and Z coordinates of the probe tip, in relation to the 6th axis workplane (flange) of the robot *.

These coordinates will be used by the spindle calibration form.


** If the part is held by the robot (the spindle is on the table), the X,Y and Z coordinates of the probe tip teach are displayed, on the teach pendant, in relation to the robot world workplane.*



Step 2: Teach short probe. Measure 1/3

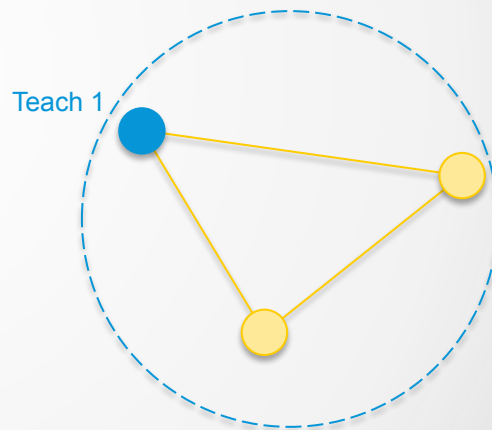
The first 'teach' gives the values below:

Short probe



Length	<input type="text" value="0"/>		
	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-229.341	-0.93	84.655
Teach 2 <input type="checkbox"/>	0	0	0
Teach 3 <input type="checkbox"/>	0	0	0
Average measure	-229.341	-0.93	84.655


Average error (mm): not determined



Step 2: Teach short probe. Measure 2/3

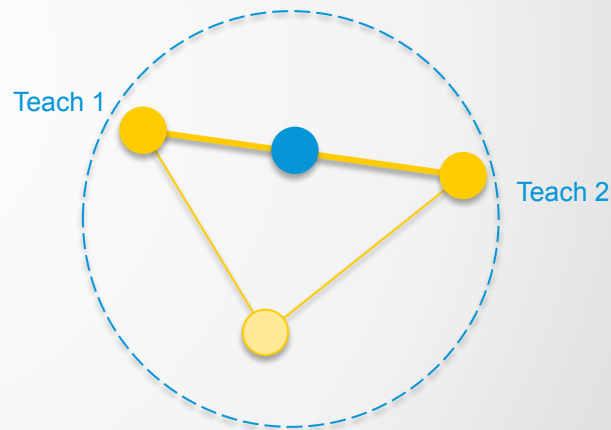
And for the second 'teach':

Short probe



	Length	X	Y	Z
Teach 1	<input checked="" type="checkbox"/>	-229.341	-0.93	84.655
Teach 2	<input checked="" type="checkbox"/>	-229.653	-1.216	85.117
Teach 3	<input type="checkbox"/>	0	0	0
Average measure		-229.497	-1.073	84.886


Average error (mm): 0.313



Step 2: Teach short probe. Measure 3/3

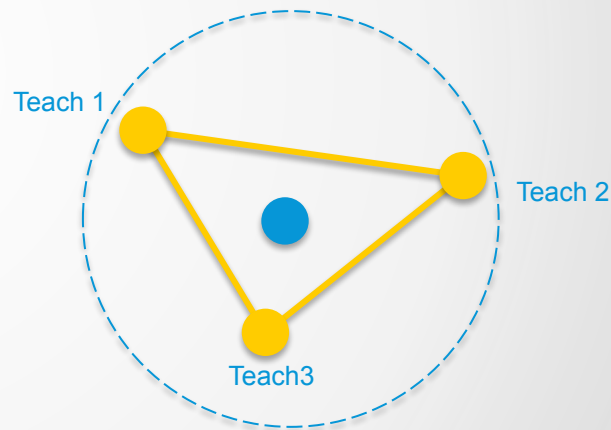
Finally for the third 'teach':

Short probe



	Length	X	Y	Z
Teach 1	<input type="checkbox"/>	-229.341	-0.93	84.655
Teach 2	<input checked="" type="checkbox"/>	-229.653	-1.216	85.117
Teach 3	<input checked="" type="checkbox"/>	-230.047	-1.411	85.093
Average measure		-229.68	-1.186	84.955


Average error (mm): 0.38



Step 3: Measure short probe length

The short probe length is then measured with the tool measuring device. The value can then be entered into the calibration form:

Short probe



Length

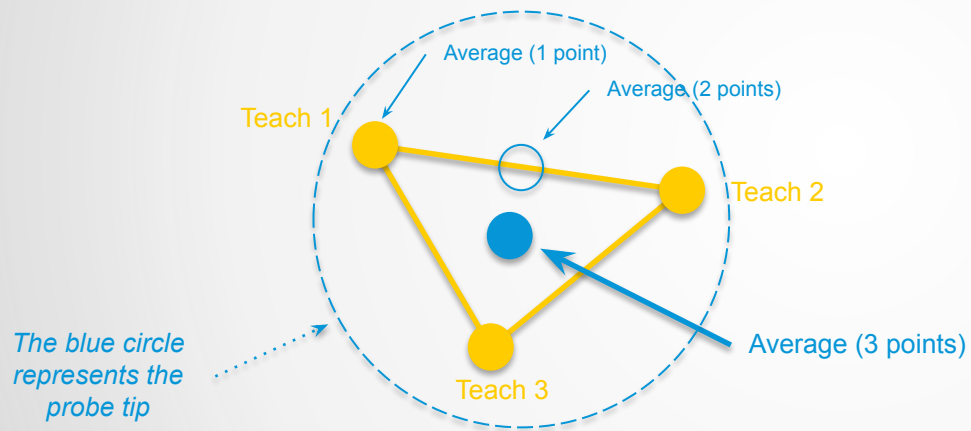
	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-229.341	-0.93	84.655
Teach 2 <input checked="" type="checkbox"/>	-229.653	-1.216	85.117
Teach 3 <input checked="" type="checkbox"/>	-230.047	-1.411	85.093
Average measure	-229.68	-1.186	84.955

Average error (mm): 0.38



Step 4: Measure long probe


The short probe method is repeated with the long probe...



Step 4: Teach long probe. Measure 1/3

The first 'teach' gives the values below:

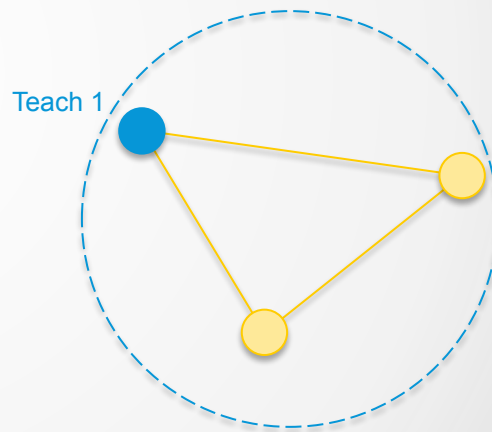
Long probe



Length 0

	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-315.126	-2.316	85.357
Teach 2 <input type="checkbox"/>	0	0	0
Teach 3 <input type="checkbox"/>	0	0	0
Average measure	-315.126	-2.316	85.357


Average error (mm): not determined



Step 4: Teach long probe. Measure 2/3

And for the second 'teach':

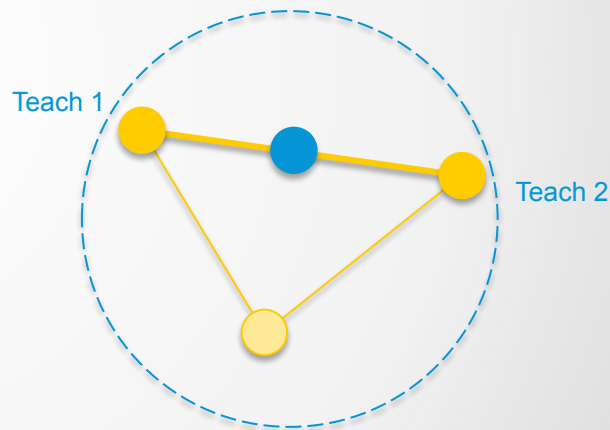
Long probe



Length 0

	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-315.126	-2.316	85.357
Teach 2 <input checked="" type="checkbox"/>	-315.089	-3.174	85.536
Teach 3 <input type="checkbox"/>	0	0	0
Average measure	-315.107	-2.745	85.446


Average error (mm): 0.439



Step 4: Teach long probe. Measure 3/3

Finally for the third 'teach':

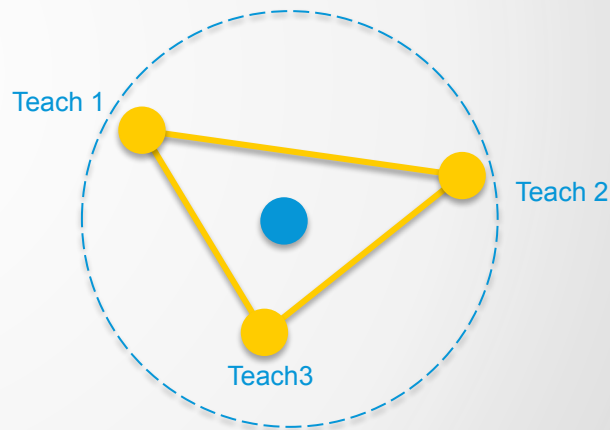
Long probe



Length 0

	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-315.126	-2.316	85.357
Teach 2 <input checked="" type="checkbox"/>	-315.089	-3.174	85.536
Teach 3 <input checked="" type="checkbox"/>	-315.565	-2.124	84.368
Average measure	-315.26	-2.538	85.087


Average error (mm): 0.685



Step 5: Measure long probe length

Optionally, the long probe length can be measured with the tool measuring device. The value can then be entered into the calibration form:

Long probe



Length <input checked="" type="checkbox"/>	222.915			
	X	Y	Z	
Teach 1 <input checked="" type="checkbox"/>	-315.126	-2.316	85.357	
Teach 2 <input checked="" type="checkbox"/>	-315.089	-3.174	85.536	
Teach 3 <input checked="" type="checkbox"/>	-315.565	-2.124	84.368	
Average measure	-315.26	-2.538	85.087	

Average error (mm): 0.685

If this is not used, the “Length” field must remain unchecked!

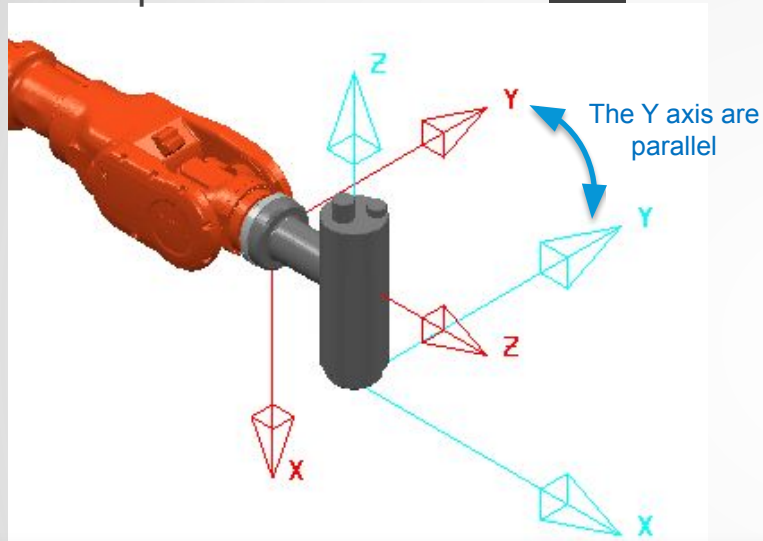
Length 0

Reference surface




Step 6: Define tool workplane orientation

It is necessary to define the X or Y axis direction of the required tool workplane, in reference to the 6th axis workplane of the robot. *Note: The orientation of the 6th axis workplane varies between robot manufacturers!*



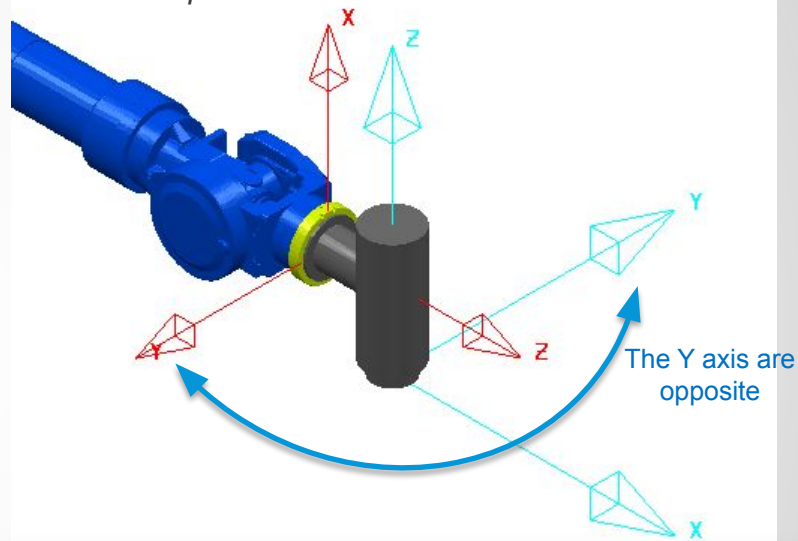
Tool workplane orientation

 Define X axis Define Y axis XY YZ ZX Reverse


Tool workplane Y axis direction (in the robot 6th axis workplane)

Other	I	J	K
<input type="radio"/>	0	1	0

This is generally used for KUKA, ABB, COMAU...



Tool workplane orientation

 Define X axis Define Y axis XY YZ Reverse

Tool workplane Y axis direction (in the robot 6th axis workplane)

Other	I	J	K
<input type="radio"/>	0	-1	0

This is generally used for FANUC, MOTOMAN...

Spindle information...

Spindle calibration

Short probe



Length 137.493

	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-229.341	-0.93	84.655
Teach 2 <input checked="" type="checkbox"/>	-229.653	-1.216	85.117
Teach 3 <input checked="" type="checkbox"/>	-230.047	-1.411	85.093
Average measure	-229.68	-1.186	84.955

Average error (mm): 0.38

Long probe

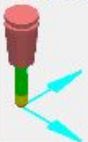


Length 222.915

	X	Y	Z
Teach 1 <input checked="" type="checkbox"/>	-315.126	-2.316	85.357
Teach 2 <input checked="" type="checkbox"/>	-315.089	-3.174	85.536
Teach 3 <input checked="" type="checkbox"/>	-315.565	-2.124	84.369
Average measure	-315.26	-2.538	85.087

Average error (mm): 0.685

Tool workplane orientation



Define X axis Define Y axis

XY YZ ZX Reverse

Tool workplane Y axis direction (in robot 6th axis workplane)

Other I J K

I	J	K
0	1	0

Name

My spindle calibration

Spindle information

	I	J	K
Tool axis vector	0.999874	0.0158	-0.001546
Tool workplane X axis vector	-0.001546	0	-0.999999

	X	Y	Z
Tool attach point	-92.289	0.985	84.743

Average error (mm): 0.084

Spindle direction (tool workplane)

Spindle center point

Notes

This is a spindle calibration sample...

Use this spindle calibration by default

Check

Save

Cancel

Create the "spindle workplane" measured for checking

Head attach point definition

```
<head_attach_point PART="head" X="1402.243" Y="0.985" Z="1942.289" I="-0.001546" J="0.0158" K="-0.999874" U="-0.999999" V="0" W="0.001546" />
```

Step 7: Measure cutting tool length

The cutting tool length is measured in the same way as the probes...



Reference surface

Tool information is displayed



Tool calibration [X]

Spindle calibration
My spindle calibration [v]

Select tool to load its length [v]

Tool length **149.746** mm Tool number 1

Tool information

	X	Y	Z
Tool tip coordinates	-242.016	-1.381	84.974
	Rz	Ry	Rx
Tool workplane orientation	-180	89.911	179.095

Q1 Q2 Q3 Q4

0.70653781	-0.00558201	0.70763119	0.00559065
------------	-------------	------------	------------

Tool Base

Copy to user parameters list [Close]

This information should go in the robot controller or in the robot program.
In this case the tool length was 149.746 mm

The coordinates are referring to the robot 6th axis workplane (flange) as the spindle is mounted on the robot (for this example)

Values are displayed in the robot manufacturer specific convention (Euler/Quaternion/...)

Tool length database

Tool length can be stored in the tool length database as described below:

Tool calibration

Spindle calibration
My spindle calibration

Select tool to load its length
1 - EM10 (178.15mm)

Tool length **178.15** mm Tool number 1

Tool information

	X	Y	Z
Tool tip coordinates	-270.416	-1.829	85.018
Tool workplane orientation	Rz	Ry	Rx
	-180	89.911	179.095

Q1	Q2	Q3	Q4
0.70653781	-0.00558201	0.70763119	0.00559065

Tool Base

Copy to user parameters list Close

Tool length database

Tool length database

N...	Name	Length
1	EM10	178.15
2	EM8	150.56
3		0
4		0
5		0
6		0
7		0
8		0
9		0
10		0
11		0
12		0

Save Cancel

Step 8: Update CAD & simulation

- For the most accurate simulation the .mtd file can be updated to reflect the 'actual' *head_attach_point* values, derived from the spindle calibration form.

- In some cases it may be advisable to adapt the CAD data of the robot simulation.

```
<head_attach_point PART="head" X="..." Y="..." Z="..." I="..." J="..." K="..." U="..." V="..." W="..."  
/>
```

Head attach point definition

```
<head_attach_point PART="head" X="1402.243" Y="0.985" Z="1942.289" I="-0.001546" J="0.0158" K="-0.999874" U="-0.999999"  
V="0" W="0.001546" />
```

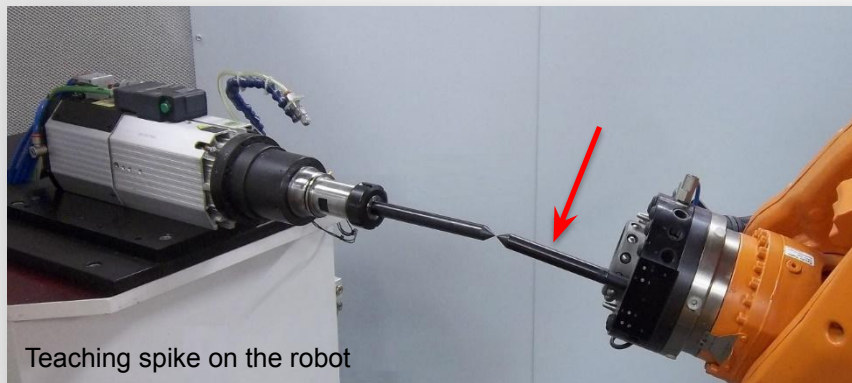


Autodesk[®] PowerMill[®] Robot

Part on robot / External static spindle

Part-on-robot / External static spindle

Step 1: Teach the spike on the robot like a standard tool, against a fixed spike (usually using a “4 or 5 points method”)



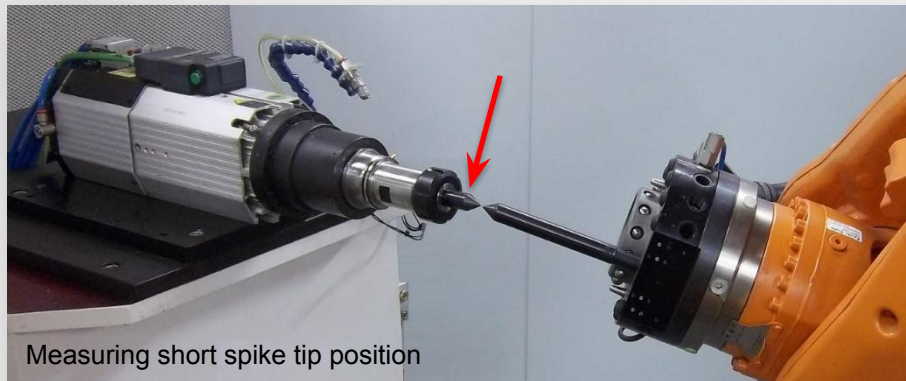
This will give the position of the robot spike tip from the robot flange (6th axis) workplane and allow to jog the robot around the robot spike tip.

The robot teach pendant can usually show the position of the tooltip from the robot world workplane and this is what we will use next.

Step 2: Switch the teach pendant display to show tooltip coordinate from **robot world workplane**

Part-on-robot / External static spindle

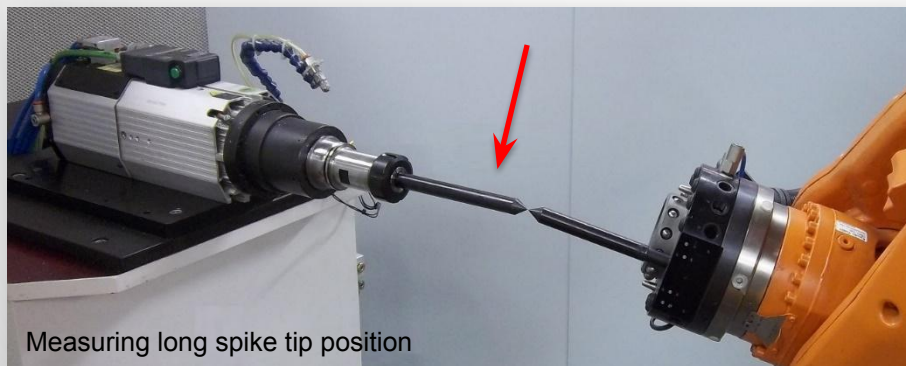
Step 3: Measure the short spike tip position



Moving the previously taught robot spike tip against the short probe tip will show, on the robot teach pendant, the position of the short spike tip from the robot world workplane.

These are the XYZ coordinates to use in the spindle calibration form.

Step 4: Measure the long spike tip position



The same as above needs to be done with the long probe... and the coordinate from the world workplane needs to be entered in the spindle calibration form.

The short and long spike as well as the cutting tools are measured in the usual way (as described earlier).



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