### **Vertical Milling**

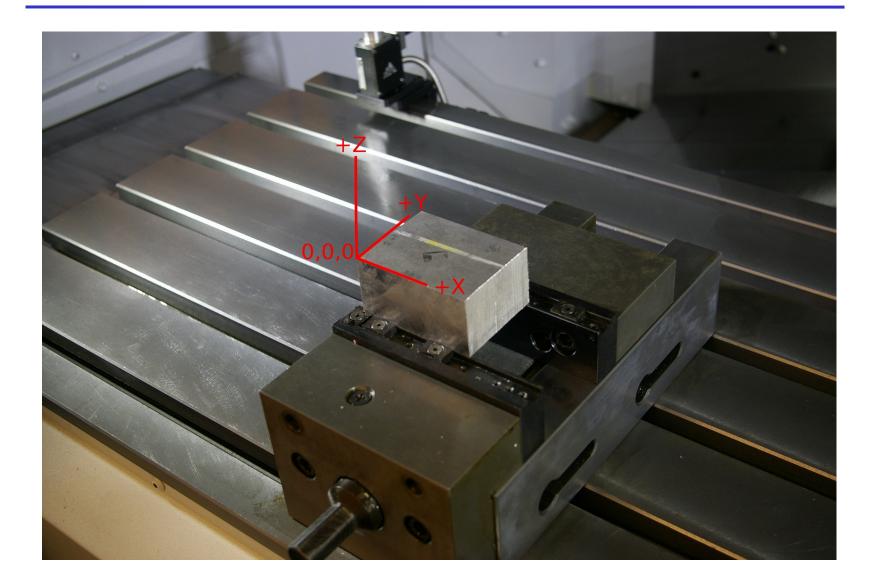




# **Doing Vertical Milling**

- Select stock
  - material, dimension
- Select workholding
  - usually vise or strap clamps
- Select tools & create toolpath
  - Esprit, Fusion360, Inventor HSM or hand-edited
    G-code for CNC, by hand for manual
- Set work and tool offsets (for CNC)
- Determine feeds, speeds, and cutting depth
  - CAM tools help with this for CNC (Esprit, HSM Works, Fusion360)

# **Coordinate System**



# **Work Offsets**

- G54-G59
- Different offsets will be identified for different vise jaw corners.
- If Z0 is top of stock, measure from table and subtract 600.0mm.
- Work probe should be available soon.



#### Offsets



# **Setting Work Offset**

										050		PAGE:1		NIT:mm, deg	REF
~	COMMON	000	~	G54	252	v	G55 -408	000	v	G56 -375	702	X		-0.003	REF.
Å		000	×	-261	A REAL PROPERTY AND INCOME.					-302		Ŷ		-0.003	
1		000	7	-447			-228 -466			-430					
C		000	2		000			000			000	Z		-0.014	
B		000	C		000			000			000	C		0.000	
D	0	000	0		000	D	0	000	D		000	В		0.000	
							250			050		00 T	2.01		
			~	G57	0.2.2	~	G58		~		0.4.4	SP. TO			2
			X Y	-440				000				COORD	1.		G54
			7	-299			-356		Z	-221	205				
			C	-362	000			000	-		000				
			B		000	-		000			000				
			D	0	000	D	0	000	D	0.	000				
2	1 2000	1	KOFAK	REGISTER	1		TATE	Inpi	it Ui	ata:	1	1 ~	Data	1	1
<	100L OFFSET	o o	FSET	TOOLS			T-LIFE MANAGE			OPERAT.	MEAS	JURE	ING	+ INPUT	>
	and the second se	The state of the state	and a second proceeding		and a subscription		a care proposed in the second second	A share of the second second							CALCULATION OF

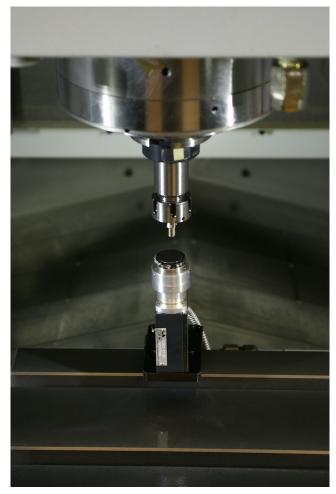
# **Tool Offsets**

- Enter tool data in offset table
- Put tool in spindle
- Indicate tool number in TOOL REGISTRATION screen

W		:47:25	TOOL	OFFSET			12:	47:41	
		PREE:1/T UNIT:nm, dog	TOOL	UFFSEI				DACE . 1 /17	UNIT:mm, deg
COMMENT		Exet. Pot		TL No	CO	MMENT		FAGE: 1717	UNII:mm, deg
	STANDE 1 DOCT		SP. 1						
ENDAILL									
			No.	TL LEN. OFFS	ET (H)   TL	RAD. OFFSET	(D) COMMENT		MACHINE REF
	COMMENT.	POT 1 CONVENT							-0.003
	COMMENT		1	110.000	0.000	6.000	0.000 C.DRILL	v	-0.003
			2	136.000	0.000		0.000 ENDMILL	1	
			3	0.000	0.000	0.000	0.000	L	-0.014
		24 0000	4		0.000	0.000	0.000	C	0.000
		and the second se	5		0.000	0.000	0.000	В	0,000
			6				0.000	000001	
			7					COORDI.	G5
		29 0000	And the second se						
		29 0000							
210 (00000		30 0000							
			12		0.000	0.000	0.000		
	COMMENT POI 1 11 10000 12 10000 13 10000 14 10000 15 10000 15 10000 16 10000 17 10000 19 10000 19 10000 19 10000 19 10000	Point      T      COMMENT      Point      T      COMMENT        COMMENT      Point      T      COMMENT      00029        COMMENT      Point      T      COMMENT      00029        COMMENT      Point      T      COMMENT      00029        11      10000      12      00000      14        15      00000      15      00000      15        16      00000      12      00000      13      00000      13	SERIE      SERIE      0007        SERIE      0009      1      0009        SERIE      0000      1      0000        11<0000	SERVICE      SERVICE 1      00.09      I      SP. 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OFFSET (D) WEAR      COMMENT        11      110.000      0.000      0.000      COMMENT        12      10000      22      0000      0.000      0.000      0.000      0.000      ENDMILL        13      10000      0.000      0.000      0.000      0.000      0.000      ENDMILL        13      10000      0.000      0.000      0.000      0.000      0.000      ENDMILL        13      10000      0.000      0.000      0.000      0.000      ENDMILL        14      10000      0.000      0.000      0.000      0.000      0.000        15      0000      25      0000      10      0.000      0.000      0.000        15      0000      27      0000      29      0000      0.000      0.000      0.000        19      19      0000      29      0000      10      0.000      0.000      0.000        19      0000      1000</td><td>No.      TL LEN. OFFSET (H)      TL RAD. OFFSET (D)      COMMENT      X        1      110.000      0.000      0.000      0.000      0.000      N////////////////////////////////////</td></td<>	No.      TL LEN. OFFSET (H)      TL RAD. OFFSET        SENSION 2      0000      1      0002 ENDMILL        COMMENT      POT      1      COMMENT      POT      1      0000 ENDMILL        COMMENT      POT      1      COMMENT      POT      POT      COMMENT      POT      POT      COMMENT      POT      POT	No.      SP. TOOL      OOO2 ENDMILL        No.      TL LEN. OFFSET (H) GEOM      TL RAD. 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### **Tool Offsets**

• Run program O0002, move tool close to sensor, press START again.



MDI *** *	*** ***	**   S0%	37 mm/mi O min	-1	000	10	<b>NOOO</b> OO
PROGRAM CHECK			COORDINA	TE 1/2			
				ABS. COORD	1.	REMATI	N.DIST REF
1 G324 2 %			Х	-790	. 903 X		0.000
			Y	-25	. 303 Y		0.000
			Z	-399	.914 Z		0.000
			c		. 000 C		0.000
			B		. 000 B		
				0	. 000 B		0.000
NODAL 1/2 Fied SP. SPD	0.00ACT.FEED	0.00	LOAD	METER 0	x	100%	200% #AX
SF- 5FU	DACT.S.SPD SPINDLE LOAD	0 . in -1	x	9			11
G G G G G G G G G G G G G G G G G G G	G91 G54 G80 G17	648 ( 667	149 Y Z	9 34			9 36
REPEATS SP.TOOL TL.NAME ENDMILL	2 NEXT TL 2 NAME	0	CB	0			0
H D GEOWETR	60	FORK COUNT					
LENGTH RADIUS	I ICAN	2566 / 9: CYCLE TIME	2 899	0			0
		000000 000	005				
>							
		BG SELECT		1	REGIST.	INPUT	RETRIEVE



#### Process

- Rigidity:
  - use shortest tool and tool holder
    - deflection of tool or work causes form error
  - keep workpiece firmly clamped and supported
  - avoid speed/feed/depth combos that chatter
- Heat:
  - use carbide tools when heat is a problem
  - keep chips cleared (liquid or air coolant)
    - hard chips get harder
    - soft chips stick to tool
  - don't go too fast OR too slow
- Chip load:
  - keep volume removed constant!
  - especially watch tool entry, exit, corners

## **Setting Feeds & Speeds**

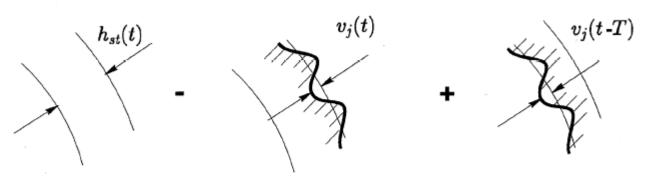
<u>Aluminum (6061, 2024, 7075)</u>						
SFM	Chipload Per Tooth					
2, 3, & 4 Flute	up to .125 dia.	<u>.125250 dia.</u>	.250500 dia.	<u>.500-1.0 dia.</u>		
300-500	.00080020	00150040	00200060	00300090		

Tool Steels <30 RC (4140, 4340, A2, D2, O1, S7, P2, H13)						
SFM	Chipload Per Tooth					
2, 3, & 4 Flute	up to .125 dia.	.125250 dia.	.250500 dia.	<u>.500-1.0 dia.</u>		
150-225	.00050010	00080020	00100030	00200040		

Carbon Steels <35 RC (A36, 1000's, 1100's, 1300's)					
SFM		Chipload	l Per Tooth		
2, 3, & 4 Flute	up to .125 dia.	.125250 dia.	.250500 dia.	.500-1.0 dia.	
175-250	.00060015	00100025	00150040	00200050	

 http://www.custompartnet.com/ calculator/milling-speed-and-feed

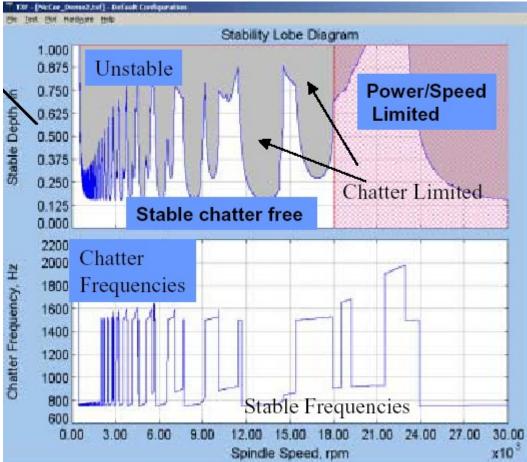
#### Vibration



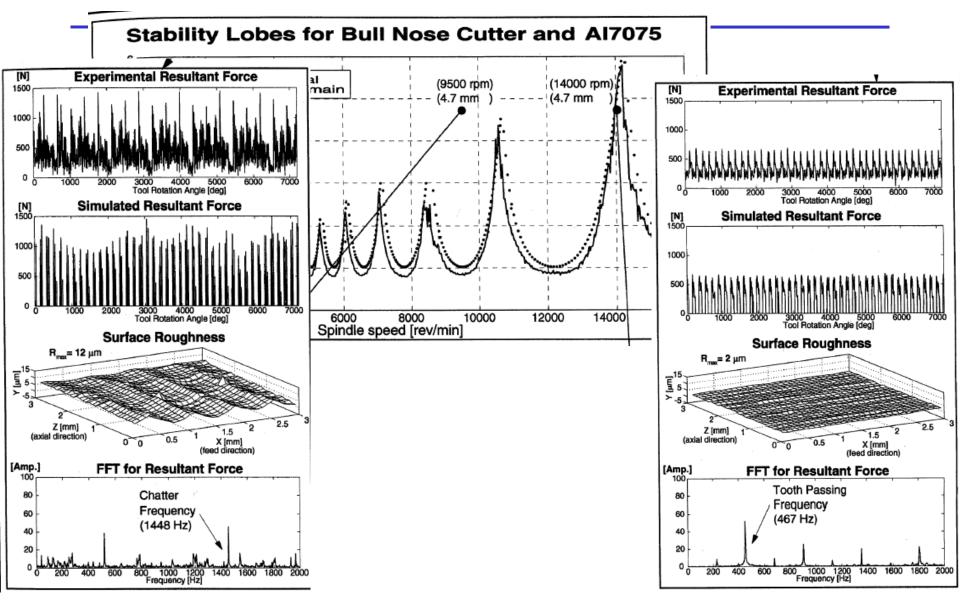
- Static chip thickness
- Vibration at present tooth period
- + Vibration at previous tooth period

# Vibration

- For Max Material Removal Rate:
  - Choose highest spindle RPM
  - Tune tool length to stay in a stable lobe at top spindle RPM



#### Vibration



# **Example Program**

9 <sub>0</sub>	(DRILL 6.35MM HOLES)					
00010 (SIMPLE EXAMPLE FOR NVX)						
(OP1- TOP SIDE)	G28 Z0					
(STOCK- 50MM X 40MM X 50MM)	T9 M6					
(G54 ZERO- LEFT FRONT TOP)	G43 H9					
G54	S2000 M3					
G00 G40 G90 G17 G21	M8					
(SPOT DRILL HOLES)	G0 X12.5 Y12.5 Z2.5					
T7 M6	G83 Z-2.5 Q2.5 R2.5 F250.0; (CANNED DRILL CYCLE)					
G43 H7	X12.5 Y25.0					
S2000 M3	X25.0 Y25.0					
M8	X25.0 Y12.5					
G0 X12.5 Y12.5 Z2.5						
G81 Z-2.5 R2.5 F250.0; (CANNED DRILL CYCLE)	G80 G0 Z2.5; (CANCEL CANNED CYCLE)					
X12.5 Y25.0						
X25.0 Y25.0	M9					
X25.0 Y12.5	M5					
G80 G0 Z2.5; (CANCEL CANNED CYCLE)						
M9	G28 Z0					
M5	M30					

# **G-Codes for Milling**

- G00 Rapid positioning
- G01 Linear interpolation (feeding)
- G02 CW Circular interpolation
- G03 CCW Circular interpolation
- G04 Dwell
- G21 Metric system
- G30 Return to reference point
- G40 Cancel tool radius compensation

# **G-Codes for Milling**

- G54-G59 Select work coord system
- G65 Macro call
- G81 Drill canned cycle
- G83 Peck drill canned cycle
- G84 Tapping canned cycle
- G90 Absolute coordinates
- G91 Incremental coordinates

### **M-Codes for Milling**

- M0 Program Stop
- M1 Opt. Program Stop
- M3 Start spindle (normal rotation)
- M4 Start spindle (reverse rotation)
- M5 Stop spindle
- M6 Tool change
- M8 Start coolant