TORNO

ORIGEN DE SISTEMA DE REFERENCIA
80 mm delante la base de la mordaza y linea central

Coordenadas en programas

X0 **Z0**

Offset para herramienta **T0101 para el uso con G50**

X162.775 **Z110.024** CU 1/3/00

159.5 110.024 CU 23/6/00

CAP

Centro de Automatización de Procesos

Torno - "offsets" de herramientas

Origen en control:

80 mm atrás de pie de mordaza

W-Shift X Z

T0101	X	Z	R	T	zero X	zero Z	fecha	operario
refrentar	0.000	0.000	0.4		162.775	110.024	01/03/00	CU
	0,000	0,000	0,4		157,500	110.024	02/10/00	JJ
T0202	X	Z	R	T	zero X	zero Z	fecha	operario
cilindrar izquierda	16.433	-0,277	0.4		146,342	110,301	01/03/00	CU
	13,652	-0,27	0,4					JJ
T0303	X	Z	R	T	zero X	zero Z	fecha	operario
cilindrar simétrico	-0,325	-10,346	0.4		163,100	120,370	01/03/00	CU
	7,849	-10,622	0,4					JJ
T0404	X	Z	R	T	zero X	zero Z	fecha	operario
broca, D11.5 (max 45)	-6,705	45,616					30/05/00	CU
	-8,281	45,580						JJ
T0505	X	Z	R	T	zero X	zero Z	fecha	operario
rosca exterior	0,385	-4,877			162,390	114,901	01/03/00	CU
	-1,200	-5,210						JJ
T0606	X	Z	R	T	zero X	zero Z	fecha	operario
buril interior, Dmin 12	-19,925	45,349	0.4				01/03/00	CU
	-22,495	45,357	0,4					JJ
T0707	X	Z	R	T	zero X	zero Z	fecha	operario
perforar/cortar, derecha	-0,502	-6,522					01/03/00	CU
	11,662	-3,649						JJ
T0808	X	Z	R	T	zero X	zero Z	fecha	operario
rosca interior, Dmin	-19,649	44,310					08/03/00	CU
	-22,192	44,529						JJ

CU 30/05/00

T0709	X	Z	R	T	zero X	zero Z	fecha	operario
perforar/cortar, izquierda	-0,502	-4,372					08/03/00	CU

T0410	X	Z	R		zero X	zero Z	fecha	operario
broca D12.5 (max 52)	-5,882	62,786					30/05/00	CU

T0411	X	Z	R		zero X	zero Z	fecha	operario
broca D13 (max 54)	-5,495	64,274					30/05/00	CU

T0412	X	Z	R		zero X	zero Z	fecha	operario
mandril Dxx (max xx)								
Spot Drill D6	-5.305	76.140						CU 8/6/00

T0413	X	Z	R		zero X	zero Z	fecha	operario
mandril Dxx (max xx)								

Txx14	X	Z	R		zero X	zero Z	fecha	operario

Txx15	X	Z	R		zero X	zero Z	fecha	operario

Txx16	X	Z	R		zero X	zero Z	fecha	operario

CU 30/05/00

Lista de los comandos del torno

Códigos G - Torno

G-Code.	Group.	Function.
G00	1	Positioning (Rapid Traverse)
G01	1	Linear Interpolation (Feed)
G02	1	Circular Interpolation CW
G03	1	Circular Interpolation CCW
G04	0	Dwell
G10	0	Offset Value Setting By Program
G20	6	Inch Data Input
G21	6	Metric Data Input
G22	9	Stored Stroke Check On
G23	9	Stored Stroke Check Off
G27	0	Reference Point Return Check
G28	0	Reference Point Return
G29	0	Return From Reference Point
G30	0	Return To 2nd Reference Point
G31	0	Skip Function
G32	1	Thread Cutting
G34	1	Variable Lead Thread Cutting
G36	0	Automatic Tool Compensation X
G37	0	Automatic Tool Compensation Z
G40	7	Tool Nose Radius Compensation Cancel
G41	7	Tool Nose Radius Compensation Left
G42	7	Tool Nose Radius Compensation Right
G50	0	Work Co-ord. Change/Max. Spindle Speed setting

G65	0	Macro Call
G66	12	Macro Modal Call
G67	12	Macro Modal Call Cancel
G70	4	Finishing Cycle
G71	4	Stock Removal in Turning
G72	0	Stock Removal in Facing
G73	0	Pattern Repeating
G74	0	Peck Drilling in Z Axis
G75	0	Grooving in X Axis
G76	0	Thread Cutting Cycil
G90	1	Cutting Cycle A
G92	1	Thread Cutting Cycle
G94	1	Cutting Cycle B
G96	2	Constant Surface Speed Control
G97	2	Constant Surface Speed Control Cancel
G98	11	Feed Per Minute
G99	11	Feed Per Revolution

G codes of group 0 represent those non modular and are effective to the designated block.

G codes of different groups can be commanded to the same block indefinitly. If more than one G code from the same group are commanded, the later becomes effective.

M40	Parts catcher extend
M41	Parts catcher retract
M43	Swarf conveyor forward
M44	Swarf conveyor reverse
M45	Swarf conveyor stop
M48	lock % f eed and % sbeed at 100 %
M49	Cancel M48 (default)
M50	Wait for axis in position signal (canceis continuous path)
M51	Cancel M50 (default)
M52	Pull-out in threading = 90 degrees (default)
M53	Cancel M52
M54	Disable spindle fluctuation testing (def ault)
M56	Select internal chucking (from PLC edition "F")
M57	Select external chucking (from PLC edition "F")
M62	Auxiliary Output 1 On
M63	Auxiliary Output 2 On
M64	Auxiliary Output 1 Off
M65	Auxiliary Output 2 Off
M66*	Wait for Auxiliary Output 1 On Input
M67*	Wait for Auxiliary Output 2 On Input
M68	Only index with all axes at home position
M69	Index turret anywhere
M70	Mirror in X On
M76	Wait for Auxiliary Output 1 Off (from revision C)
M77	Wait for Auxiliary Output 2 Off (from revision C)
M80	Mirror in X Off
M98	Sub Program Call
M99	Sub Program End

M codes marked with an * are executed at the end of a block, ie, after axis movement.

```
% M66
M39
G99G97G40G21S2000
G28U0W0
M06T0101 M03
G00X32Z0
G01X-1F0.05
Z1
6← 628U0W0
M06T0303S2000                Ø2Ø2
G00X32Z2
G71U1R0.05
G71P1Q2U0.05W0.1F0.05
N1G00X0
G01Z0F0.05
G03X8Z-1.8R11.35F0.05
Pendiente G01X5Z-17F0.05
G03X12Z-20R5.19F0.05
G01Z-21F0.05
G03X28Z-27R10.32F0.05
X32
M06TØ0X0X
Pendiente G00X28Z-27
G01X12F0.05
G02X8Z-32R6.18F0.05
Pendiente G01X6Z-37F0.05
G03X12Z-39R4.59F0.05
G01Z-40.5F0.05
G03X18Z-42.5R3.66F0.05
G01Z-44F0.05
G03X24Z-45.5R2.55F0.05
G01Z-47.5F0.05
G01X10F0.05
Pendiente G01X8Z-54F0.05
G02X14Z-60R8.36F0.05
Pendiente G01X12Z-61F0.05
Pendiente G01X30Z-67F0.05
G01Z-70F0.05
N2X34
G70P1Q2
```

Códigos M – Torno

M00	Program Stop
M01*	Optional Stop
M02*	Prograrn Reset
M03	Spindle Forward (clockwise)
M04	Spindle Reverse (counter clockwise)
M05*	Spindle Stop
M06	Automatic Tool Change
M07	Coolant "B" On
M08	Coolant "A" On
M09*	Coolant Off
M10	Chuck Open
M11	Chuck Close
M13	Spindle Forward and Coolant On
M14	Spindle Reverse and Coolant On
M15	Program Input using MIN P (special function)
M16	Special Tool Call (tool call ignores turret)
M19	Spindle Orientation
M20	Spindle Index A
M21	Spindle Index 2A
M22	Spindle Index 3A
M23	Spindle Index 4A
M25	Quill Extend
M26	Quill Retract
M29	Select DNC mode
M30	Program Reset and Rewind
M31	Increment parts counter
M37	Door open to stop
M38	Door Open
M39	Door Close

Reassessing power factors

Certain published data promotes inaccuracy when calculating horsepower for turning operations

Dr. Edmund Isakov
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Edited by Thomas J. Grasson

Available power on turning equipment places limits on cut size. Thus it is important to calculate horsepower properly when developing specifications for new equipment or optimizing existing operations.

This raises concern about the accuracy of the *p* values used in calculating horsepower requirements since many of the published values are not precise enough for accurate calculations.

The *p* value, also known as power unit or *K* factor, is an experimentally determined constant and is equal to the horsepower required to cut a material at a rate of one in.^{3}/min. The unit of measure of *p* is hp/in.^{3}/min.

The common method of estimating horsepower in turning is based on metal removal rate (Q) and *p* for workpiece materials. Horsepower at the cutting tool (P_c) is found from: $P_c = Q \times p$

The metal removal rate is calculated by the formula:

$Q = 12 \times d \times f \times V_c$

where d is the depth of cut in inches; *f* is the feed rate in in./rev. (ipr); V_c is the cutting speed in sur-

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Actual *p* values based on test results

Workpiece			*p* values at machining conditions		
Material	Designation	Brinell hardness	General purpose	Finishing	Roughing
Carbon steel	AISI 1018	141	0.62	0.70	0.66
Carbon steel	AISI 1045	195	0.72	0.74	0.70
Alloy steel	AISI 4140	194	0.73	0.79	0.74
Alloy steel	AISI 4340	214	0.73	0.76	0.72
Alloy steel	AISI 4140	258	0.79	0.85	0.77
Alloy steel	AISI 4142	277	0.75	0.84	0.77
Alloy steel	AISI 4340	485	1.05	1.31	1.00
Tool steel	AISI H11	205	0.76	0.78	0.73
Stainless steel	AISI 316L	147	0.73	0.81	0.73
Stainless steel	AISI 410	243	0.74	0.81	0.71
Stainless steel	AISI 17-4PH	294	0.72	0.99	0.70
Gray cast iron	SAE G3000	195	0.47	0.53	0.48
Ductile cast iron	ASTM 65-45-12	165	0.51	0.58	0.55
Titanium alloy	AMS Ti-6Al-4V	287	0.62	0.64	0.62
Nickel alloy	Inconel 718	277	1.02	1.20	1.01
Aluminum alloy	AMS 2024	139	0.30	0.31	0.29

The formula for horsepower at the motor (P_m) is : $P_m = \dfrac{P_c}{E}$

where E = machine tool efficiency (typically, E = 0.70-0.90).

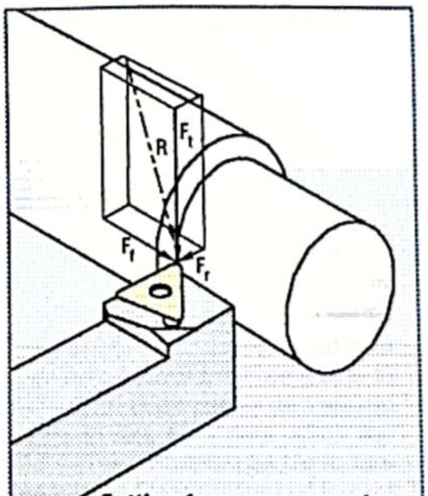
face ft/min. (sfm).

The p factors can be found in several handbook publications. However, different handbooks list different values for these power constants that vary by as much as 40 to 50% for the same material and Brinell hardness number. Aggravating this situation, p factors are based on using sharp tools only with no consideration given for type of cut, such as rough, finish, or general purpose.

While many in the metal cutting industry think of these handbooks as bibles of machining practices, the p factors vary so broadly that people find selecting the proper factor difficult. To correct this situation, special lab tests were conducted to determine actual power-constant values for machining common work materials at various cutting conditions.

A three-force component dynamometer helped measure tangential (F_t), feed (F_f), and radial (F_r) cutting forces. The measurements were the basis for developing an equation to calculate p factors using the cutting force values. From this equation, actual p value numbers were developed for various materials and machine processes categorized as general purpose, finishing, and roughing.

Verification of p values took place by calculating feed force and radial force based on tangential force and determining the accuracy between the calculated and measured forces.



Cutting force components

F_t = Tangential force

F_f = Feed force

F_r = Radial force

R = Resultant cutting force

Calculating cutting force components

The cutting force components are tangential (F_t), feed (F_f), and radial (F_r). Calculation of tangential force is important because this force produces torque at the spindle and accounts for the greatest portion of the machining power. Tangential force can be calculated by the general equation:

$$F_t = \frac{33{,}000 \cdot P_c}{V_c}$$

where 33,000 = conversion factor; 1 hp = 33,000 ft lb/min.
Substitution for P_c and Q into the formula produces:
$F_t = 396{,}000 \times d \times f \times p$

Relationship between feed and tangential forces

AISI Steel	Hardness BHN	Feed *ipr*	Depth of Cut *in.*	Empirical Formula
1018, 316L,	140-200	0.008-0.010	0.060-0.300	$F_f = 0.581F_t - 18.3$
4140, 1045		0.012-0.020	0.060-0.300	$F_f = 0.458F_t - 6.6$
H11, 4340,	205-260	0.008-0.012	0.060-0.300	$F_f = 0.556F_t - 5.3$
410, 4140		0.015-0.020	0.060-0.300	$F_f = 0.477F_t + 7.3$

Feed forces calculated by the empirical formulas vary from measured values within ±10% in 82% of all data points and within ±15% in 99% of all data points.

Relationship between radial and tangential forces

AISI Steel	Hardness BHN	Feed *ipr*	Depth of Cut *in.*	Empirical Formula
1018, 316L,	140-200	0.010-0.020	0.060-0.150	$F_r = 0.145\,F_t + 32.0$
4140, 1045		0.010-0.020	0.180-0.300	$F_r = 0.182\,F_t - 9.3$
H11, 4340,	205-260	0.008-0.012	0.060-0.300	$F_r = 0.111\,F_t + 40.7$
410, 4140		0.015-0.020	0.060-0.300	$F_r = 0.143\,F_t + 48.7$

Radial forces calculated by the empirical formulas vary from measured values within ±10% in 74% of all data points and within ±15% in 93% of all data points.

Recorded and calculated cutting forces

Using the indicated machining conditions, the chart shows recorded and calculated cutting forces when turning 4140 alloy steel with a hardness of 258 BHN.

Cutting force components were measured with a Kistler dynamometer, type 9263. After collection, the data was converted into digital form and recorded. Cutting force components were calculated using the same machining conditions.

Cutting force components and horsepower consumption			
		Input data in the shaded cells only	
Machining Conditions and Calculations	**Symbol**	**Unit**	**Value**
Workpiece Material			
1. Diameter	D	in.	4.0
2. Hardness	BHN		258
3. Power constant	p	hp/in³/min	0.77
Machining Conditions			
1. Depth of cut	d	in.	0.200
2. Feed rate	f	ipr	0.020
3. Cutting speed	V_c	sfm	900
4. Spindle speed	n	rpm	859
5. Metal removal rate	Q	in³/min	43.2
Calculations of Cutting Forces			
1. Tangential force	F_t	lb	1219.7
2. Feed force	F_f	lb	589.1
3. Radial force	F_r	lb	223.1
4. Resultant force	R	lb	1372.8
Horsepower Calculation			
1. Horsepower at the cutting tool	HP_c	hp	33.3
2. Machine tool efficiency factor	E		0.80
3. Horsepower at the motor	HP_m	hp	41.6

Calculated feed forces varied from measured values within ±10% in 82% of all data points and within ±15% in 99% of all data points. Radial forces calculated by the formulas varied from measured values within ±10% in 74% of all data points and within ±15% in 93% of all data points.

Based on the accuracy of this data, the practical value of *p* fosters a high confidence factor and is a safe bet when estimating horsepower requirements for turning operations. ■

Machine Tool Efficiency Factors	
Type of Drive	**E**
Direct belt drive	0.90
Back gear drive	0.75
Geared head drive	0.70-0.80
Oil-Hydraulic drive	0.60-0.90

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Depth of cut, in.	Feed rate, ipr	p factor	Tangential force, lb		Feed force, lb		Radial force, lb	
			recorded	calculated	recorded	calculated	recorded	calculated
0.080	0.008	0.85	224.7	215.4	130.7	114.5	63.3	64.6
0.080	0.012	0.85	309.2	323.1	149.9	174.3	82.7	76.6
0.140	0.015	0.79	653.8	657.0	365.4	320.7	158.6	142.7
0.200	0.010	0.77	621.9	609.8	347.0	333.7	106.7	108.4
0.200	0.020	0.77	1179.5	1219.7	565.9	589.1	250.6	223.1