### MATERIAL REMOVAL

- Turning
  - work rotates, chip forming
- Milling
  - tool rotates, chip forming
- Grinding – tool rotates, work may rotate too, no chips



# CHIP FORMATION



#### **CHIP FORMATION**



# CHIP FORMATION



## FEEDS & SPEEDS

•We want to know three things:

•How fast should we turn the spindle?

•How fast should we move the workpiece into the tool (or tool into the workpiece)?

•Cutting rate -> dist/time (RPM \* cutter diam \* pi)

RPM = 12\*(SFM)/(pi\*D in inches) = 3.82\*SFM/D

Feed rate -> dist/time (rate of work motion \* # teeth)

IPM = T \* FPT \* RPM

•Chip load (Feed Per Tooth)- how much of a "bite"?

•Depth of cut

#### FEEDS & SPEEDS

#### COBALT HSS AND HSS END MILLS

Speed and Feed Data - Applications in Various Materials

					HEAT-RESISTANT NICKEL		HGH STRENGTH		HEAT RESISTANT					
	HEAT-RESISTANT		HEAT-RESISTANT		BASE ALLOY S, HIGH		STAINLESS STEELS, HIGH		FERRITIC BASE ALLOYS		MACHINE STEEL, HARD		BRASS, BRONZE, ALLOYED ALUMINUM, ABRASIVE PLASTICS	
MATERIAL	L COBALT BASE ALLOYS.		AUSTENITIC ALLOYS,		STRENGTH STAINLESS		TENSILE STEELS		MEDIUM STRENGTH		BRASS AND BRONZE,			
	HIGH TENSILE STEELS		HIGH TENSILE STEELS		STEELS, HGH		(40-60 C)		STAINLESS STEELS		ELECTROLYTIC COPPER			
	(50-55 C)		(46-50 C)		STRENGTH TITANIUM		MEDIUM STRENGTH		UNALLOYED TITANIUM		MILD STEEL FORGINGS			
					ALLOYS		TITANIUM ALLOYS		TOOL STEELS (30-40 C)		(20-30 C)		SPEED	
	SPEED		SPEED		SPEED		SPEED		SPEED		SPEED		100-200 SFM	FEED
	6-10 SFM	FEED	10-16 SFM	FEED	16-20 SFM	FEED	20-40 SFM	FEED	40-60 SFM	FEED	60-80 SFM	FEED		CHIP LEAD
DIA. OF		CHIP LOAD		CHIP LEAD		CHIP LEAD		CHIP LEAD		CHIP LEAD		CHIP LEAD	RPM	PER TOOTH
END MILLS	RPM	PER TOOTH	RPM	PER TOOTH	RPM	PER TOOTH	RPM	PER TOOTH	RPM	PER TOOTH	RPM	PER TOOTH	6111-12222	.00020005
1/16			-		-		1222-2444	.00020005	2444-3667	.0002005	3667-4888	.00020005	3056-6112	.00020005
3/32	-		-		611-815	.0002-0005	815-1629	.00020005	1629-2750	0002-005	2750-3259	.0002-0005	2037-4074	.0002001
1/8	-				456-611	0002-0005	611-1222	0002-0005	1222-1833	0002-005	1833-2440	0002-001	1528-3056	.0005002
3/16	-		204-306	0002-0005	306-407	0002-0005	407-815	0002-0005	815-1222	0002-005	1222-1625	0002-001	1222-2444	.0005002
1/4	76-153	0002-001	153-230	0002-001	229-306	0002+001	306-611	0002+001	611-917	0002+001	917-1222	0005-002	1019-2038	.0005003
5/16	61-122	0002-001	122,183	0002-001	183,244	0002-001	244-489	0002-001	/80.733	0002-001	733.078	0005-002	873-1746	.0005003
3/9	51-102	0002-001	102-100	0002-001	153,003	0002-001	203,407	0005-002	406-611	0005-002	611-815	001-002	/64-1528	.0005003
7/16	44.99	0005-001	99,130	0005-001	131-175	0005-002	175.340	0005-002	340.524	0005-002	524,609	001-003	611-1222	0005-004
1/2	20.72	0005-004	78.445	0005-001	445 452	0005-002	453.302	0005-002	302.450	000-002	450 614	001-002	555-1110	.0005004
1/4	38-76	.0005001	/6-115	.0005001	115-153	.0005002	153-306	.0005003	306-458	.001003	458-611	.001003	509-1018	.001006
9/16	34-68	.0005002	68-104	.0005002	104-136	.0005002	136-272	.0005003	2/2-412	.001003	412-543	.001004	469-938	.001006
6/8	31-61	.0005002	61-92	.0005002	92-122	.0005002	122-244	.001004	244-367	.001004	367-489	.001004	436-872	.001006
11/16	28-56	.0005002	56-84	.0005002	84-111	.0005002	111-222	.001004	222-337	.001004	337-444	.001004	407-814	.001006
3/4	26-51	.0005002	51-76	.0005002	76-102	.001004	102-203	.001004	203-306	.001004	306-407	.001004	382-764	.002 UP

•Example: 3/16 4 flute end mill, cutting 6061 alum.

•Speed = 100-200 SFM, FPT = .0002 - .001

•RPM = 3.82\*150/0.1875 = 3056 => 3000

•*IPM* = 4 \*.0006 \* 3000 = 7.2 => 7

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## WRONG FEEDS & SPEEDS

- Too fast feed broken tools, damaged work
- Too slow feed premature tool wear

