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by

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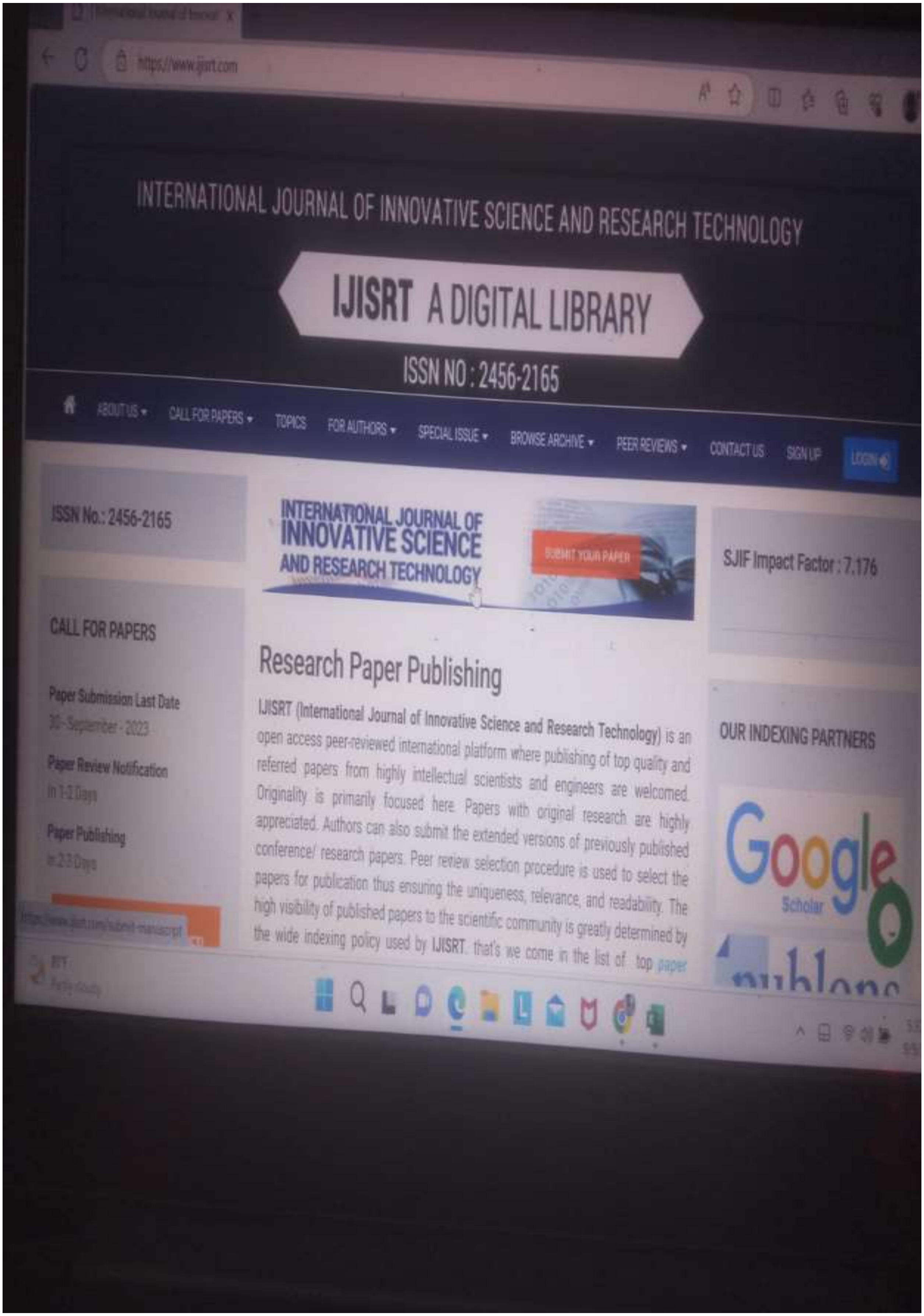
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Process Analysis of High Speed Steel Cutting Calculation (HSS) with S45 C Material on Universal Machine Tool

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Abstract:-Cutting tool is the tools lathe. Cutting process tool HSS With Cast Iron Material Universal Lathe which is commonly found at Analysis cutting Process by some aspects numely Cutting force , Cutting Speed, Cutting Powe r, Cutting Indication Power , Temperature Zone 1 and Temperatur Zone 2. Purpose of this Study was to determine how big the cutting Speed , Cutting Power, electromotor Power, Temperatur Zone 1 and Temperatur Zone 2 that drives the chisel cutting HSS in the Process of turning Cast Iron Material .Cutting force obtained from image analysis relationship between the recommended Component Cuting Force with plane of the cut and Cutting Speed obtained from image analysis of relationships between the recommended Cutting Speed Feed rate.

Keywords:-Cutting Force, Cutting Speed, Cutting Power, Electromotor Power, Temperatur Zone 1,Temperature Zone 2.

I. INTRODUCTION

In the process of cutting, cutting tool moves relatively to workpiece and separates part of workpiece material, commonly called by chips. Part of cutting tool feeds into the workpiece material called by cutting element of the cutting tool. Turning process is the machining process to produce parts of engine which is generally cylindrical. The basic principle of machining process outer and inner surface is cylindrical such as shafts, holes /drill, threaded and tapered. In the machining, the function of axis is to transmit power and circle, based on the function axis is designed to be strong in accepting the load. The axis has shaft strength and hardness so the material used is made of carbon steel S 45 C. Generally the process of making the axis is done in the lathe, using cutting tools on a rotating workpiece. Cutting tools is the most critical part of a machining process. Material, parameter and geometry of cutting tool and cutting style will determine a machining process and affect the power of cutting tools. In a machining process cutting tool always changes. Cutting tool is a production component which can be wear and the price is relatively expensive. Cutting tool will be wear after being used for cutting. More wear, the cutting tool will be in critical condition. If it uses continuously the cutting tool wear will be faster, and someday cutting edge will be broken at all. The broken should be avoided to cutting tool, machine tool, workpiece because it can endanger to the operator, and also affect on the geometric and quality of production. Basically the wear will determine the limits of cutting cut power. The selection inappropriate type of cutting tool, workpiece material and cutting conditions can affect the strength of the cutting tool. Therefore it is important to know the type of cutting tool, workpiece material and cutting conditions (cutting speed, depth of cut and feeding movement) on the cutting tool wear. Cutting speed can’t be chosen randomly, if the cutting speed is low, it will take time a long to do it. If the speed is too high cutting tool will lose hardness (because of heating), cutting tool is wear very fast and tool life is short. It must be replaced with the new ones. Therefore cutting speed and depth of cut should be determined based on the character of workpiece. The strength and rigidity of the machine tool and workpiece are very important to reduce deformation caused by forces when cutting occurs. Bending occurs in the workpiece or other engine parts will reduce the accuracy of product. In the turning process, there is a cutting force such as radial force (the force on the depth of cut), tangesial force (force in cutting speed), and the longitudinal force (force funerals). Many factors affects the cutting forces like depth of cut, feed rate and the cutting speed, working forces can also be determined by empirical formulation such as specific cutting force. Specific cutting force (ks) is a numbers of force or energy required to move a unit volume of metal called specific cutting force or specific cutting energy. The relationship specific cutting energy with a workpiece material and tensile strength can be shown in table 1.

Work Materials	σb (Kg/mm^2)	*K* s	Work Materials	BHN	*K* s
Steel	30-40	132	Cast iron	140-160	81
	40-50	145		160-180	86
	50-60	157		180-200	92
	60-70	170		200-220	98
	70-80	191		220-240	104
	80-90	200		240-260	108
	90-100	225			
	100-110	240			
	110-120	260			

(Fundamentals of Tool Design:Syamsir A.Muin,page.66)(11)

Table 1: Specific Cutting Force

From Table 1 above we can show the correlation between work piece material, the tensile strength (σb) and specific cutting force (Ks). Tensile strength (σb) is close relation to carbon steel. Carbon steel is given every symbol which relate directly to the standard, heating performance and tensile strength as shown in Table 2 carbon steel for machine construction and steel rod is cold defines to the shaft.

Standar and type	symbol	Treatment Hot	Tensile strength (Kg/mm^2)	Information
Carbon steel construction machinery (JIS G 4501)	S30C	Penormalan	48	
	S35C	,,	52	
	S40C	,,	55	
	S45C	,,	58	
	S50C	,,	62	
	S55C	,,	66	
Stainless steel rods	S 35 C-D		55	Pulled cold, digrinding, in-lathe, or connect between these things
	S 45 C-D		60	
	S 55 C-D		72	

Fundamentals of Planning and Election of Machine Elements: Sularo, p.3

Table 2: Carbon Steel for Machine Contruction and Defines Steel Rod to The Exis.(2)

The shape and size of the cutting cross affect the specific cutting force (ks), as well as the main cutting force Fz. A Specific cutting g style will decrease by increasing in cutting cross (see chart 10.1). The price of Ks will also be affected by the comparison of depth of cut, a, to feeding S.

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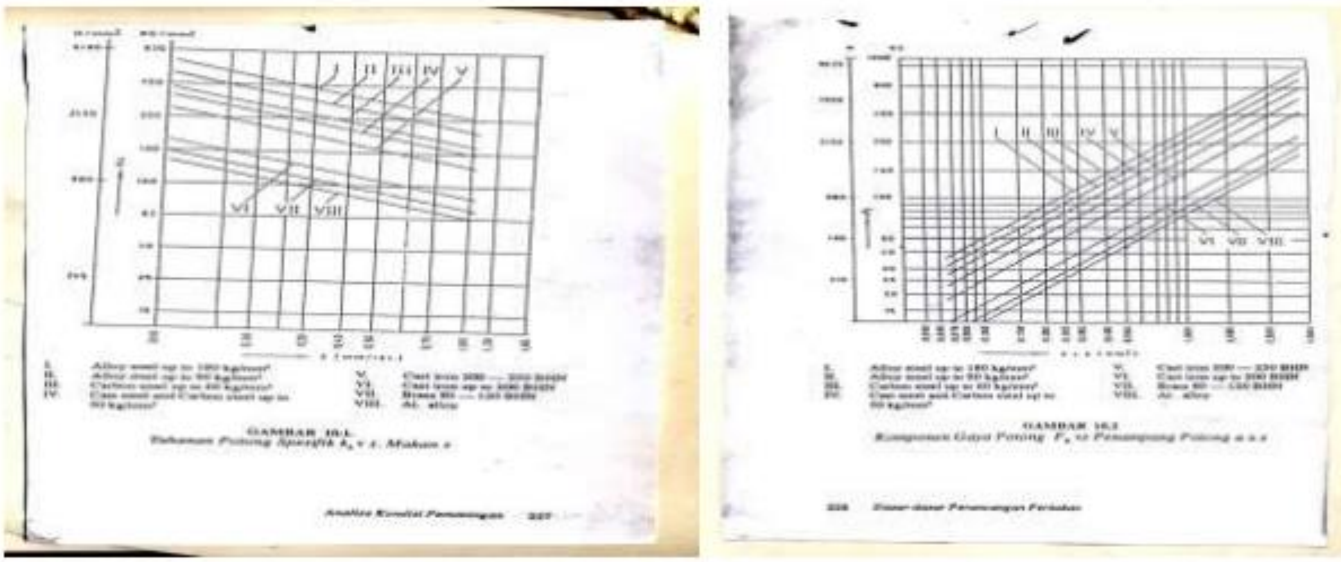
II. RESEARCH METHODS

The implementation of this research will be conducted to purchase cast iron material and cutting tool carbide in selling place in Medan. And the implementation will be carried out in production process laboratory at STT Harapan Medan. It will be done in December 2016 until the end of February 2017.



The process of making object test

Cast iron which is larger than 3 x 140 mm and 20 mm diameter, cut into 3 parts. Then making process object test by using machine tools (milling, shaping, and drilling machine) to get shape and size object test is done by cold work, so it can be considered no changes in microstructure, deformation, plastic or residual stress (residual stress cause by the manufacturing process). Then 3 part of cutting tool is also geared up with grinder machine one by one. The next the biased of cutting tool is cut in turning machine. Then it is installed by using a wrench, after that workpiece is installed by using dial indicator. Then turning machine is turned on by cutting the workpiece, try to move automatically and turn on for 1 hour or 60 seconds. In turning process we observe automatically how the condition of workpiece in turning process, whether cutting tool still have function or not, if it is not, we replace with the new sharpened cutting tool. Then we analyze several times to change cutting tool for 1 hour and how the condition of the axis whether it is smooth or rough, next we do the second test materials such as the first job by rotation and the same speed as the first job but different time that is 4 hours or 240 minutes. And the third job as the first job with different time that is of 8 hours or 480 minutes.

Cutting speed affects little cutting forces. In cutting speeds below 75 m/ minutes, the cutting forces will come down with increasing rise and then a constant cutting speed if the speed is above 75 m/ minutes. It is the reason why the carbide tool has a constant cutting force unaffected by the cutting speed. The correlation between cutting speed and feeding S for tool life of 60 minutes, 240 minutes and 480 minutes as shown in in Table 3 are shown the relationship between cutting speed and tool life for some types of materials and cutting tool conditions. This table will be shown the types of cutting tool used for cutting. They use HSS material or carbides. Selecting types of tool signature use a predetermined number. Then selecting of workpiece materials used in sequences number based on depth of cut condition or feeding. And next it can be known the rotation.

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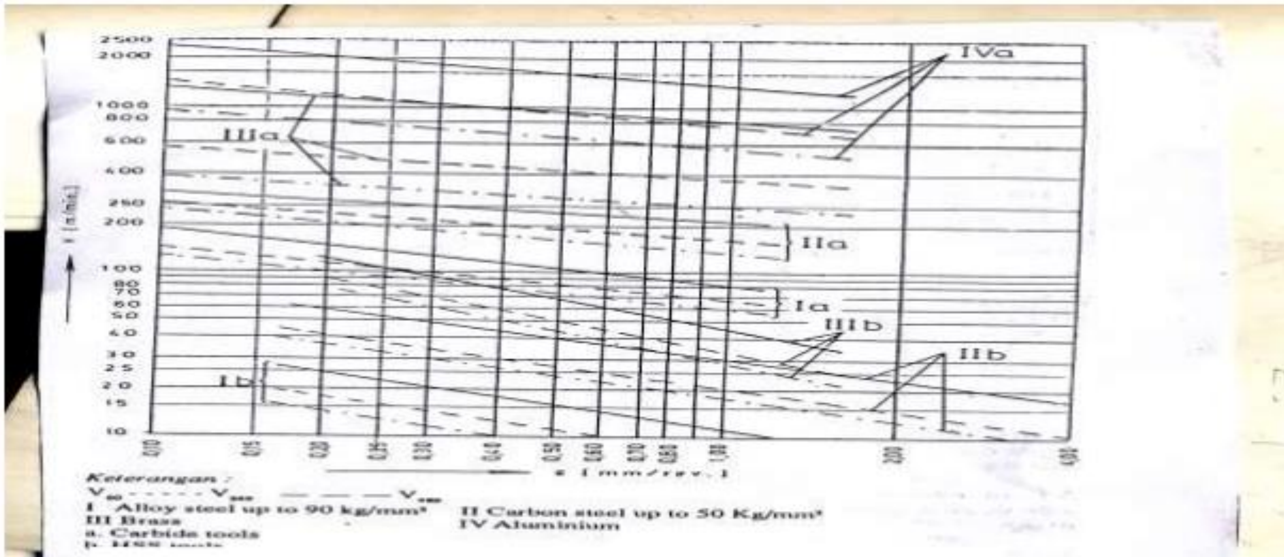


(Fundamentals of Tool Design:Syamsir A.Muin,page.231)(11)

Analisa Kondisi Pemotongan 231

No.	Pahat: Material	Pahat: Shape	Bahan benda kerja	Kondisi potong: Depth	Kondisi potong: Feed	Potong fluida	$VT^n = C$: n	$VT^n = C$: C
1	High Carbon steel	8, 14, 6, 6, 6, 15, 3/64	Yellow brass (0.60 Cu, 0.40 Zn, 0.85 Ni, 0.056 Pb)	0.050	0.0255	Dry	0.081	242
2				0.100	0.0127	Dry	0.096	299
3	High carbon steel	8, 14, 6, 6, 6, 15, 3/64	Bronze (0.90 Cu, 0.10 Sn)	0.050	0.0255	Dry	0.086	190
4				0.100	0.0127	Dry	0.111	232
5	HSS-18-4-1	8, 14, 6, 6, 6, 15, 3/64	Cast iron 160 Bhn	0.050	0.0255	Dry	0.101	172
6			Cast iron, Nickel, 164 Bhn	0.050	0.0255	Dry	0.111	186
7			Cast iron, Ni-Cr, 207 Bhn	0.050	0.0255	Dry	0.088	102
8	HSS-18-4-1	8, 14, 6, 6, 6, 0, 0	Steel, SAE B1113 C.D.	0.050	0.0127	Dry	0.08	260
9			Steel, SAE B1112 C.D.	0.050	0.0127	Dry	0.105	225
10			Steel, SAE B1120 C.D.	0.050	0.0127	Dry	0.100	270
11			Steel, SAE B1120+Pb C.D.	0.050	0.0127	Dry	0.060	290
12			Steel, SAE 1035 C.D.	0.050	0.0127	Dry	0.110	130
13			Steel, SAE 1035+Pb C.D.	0.050	0.0127	Dry	0.110	147
14	HSS-18-4-1	8, 14, 6, 6, 6, 15, 3/64	Steel, SAE 1045 C.D.	0.100	0.0127	Dry	0.110	192
15		8, 22, 6, 6, 6, 15, 3/64	Steel, SAE 2340 185 Bhn	0.100	0.0125	Dry	0.147	143
16		8, 14, 6, 6, 6, 15, 3/64	Steel, SAE 2345 198 Bhn	0.050	0.0255	Dry	0.105	126
17		8, 14, 6, 6, 6, 15, 3/64	Steel, SAE 3140 190 Bhn	0.100	0.0125	Dry	0.160	178
18	HSS-18-4-1	8, 14, 6, 6, 6, 15, 3/64	Steel, SAE 4350 363 Bhn	0.0125	0.0127	Dry	0.080	161
19			Steel, SAE 4350 363 Bhn	0.0125	0.0255	Dry	0.125	146
20			Steel, SAE 4350 363 Bhn	0.0250	0.0255	Dry	0.125	95
21			Steel, SAE 4350 363 Bhn	0.100	0.0127	Dry	0.110	78
22			Steel, SAE 4350 363 Bhn	0.100	0.0255	Dry	0.110	46
23	HSS-18-4-1	8, 14, 6, 6, 6, 15, 3/64	Steel, SAE 4140 230 Bhn	0.050	0.0127	Dry	0.180	190
24			Steel, SAE 4140 271 Bhn	0.050	0.0127	Dry	0.180	159
25			Steel, SAE 6140 240 Bhn	0.050	0.0127	Dry	0.150	197
26	HSS-18-4-1	8, 22, 6, 6, 6, 15, 3/64	Monel metal 215 Bhn	0.100	0.0127	Dry	0.080	170
27				0.150	0.0255	Dry	0.074	127
28				0.100	0.0127	Em	[illegible]	185
29				0.100	0.0127	[illegible]	0.103	189
30	Stellite 2400	0, 0, 6, 6, 6, 0, 3/32	Steel, SAE 3240 annealed	0.187	0.031	Dry	0.190	215
31				0.125	0.031	Dry	0.190	240
32				0.062	0.031	Dry	0.190	270
33				0.031	0.031	Dry	0.190	310
34	Stellite No. 3	0, 0, 6, 6, 6, 0, 3/32	Cast iron 200 Bhn	0.062	0.031	Dry	0.150	205
35	Carbide (T 64)	6, 12, 5, 5, 10, 45	Steel, SAE 1040 annealed	0.062	0.025	Dry	0.156	800
36			Steel, SAE 1060 annealed	0.125	0.025	Dry	0.167	660
37			Steel, SAE 1060 annealed	0.187	0.025	Dry	0.167	615
38			Steel, SAE 1060 annealed	0.250	0.025	Dry	0.167	560
39			Steel, SAE 1060 annealed	0.062	0.021	Dry	0.167	880
40			Steel, SAE 1060 annealed	0.062	0.042	Dry	0.164	510
41			Steel, SAE 1060 annealed	0.062	0.062	Dry	0.162	400
42			Steel, SAE 2340 annealed	0.062	0.025	Dry	0.162	630

(Fundamentals of Tool Design: Syamsir A.Muin, p.74)

Table 3 The Relationship Between Cutting Speed and Tool Life for Types of Cutting Tool Conditions

Material Cutting Analysis (10)

$$Pc = \frac{Fc \times Vc}{4500}$$

Fc = Cutting Force (kg)

Pc=CuttingPower(Hp)

Vc = Cutting Speed (m/menit)

$$Pg = \frac{Pc}{\eta mk} + P\,idd$$

Pg = Elektromotor Power (Hp)

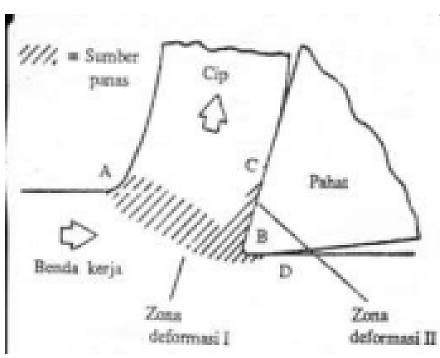
ηmk = Mekanis Effesienci (%)

Pidd = Indication Power (Hp)

$$\tan\theta = \frac{rc \times \cos\delta}{1 - rc \times \sin\delta}$$

rc = cutting ratio 0,3

δ = in this from tool signature.



(**Fundamentals of Tool Design**:Syamsir A.Muin,page.151)

.Force Diagram in Cutting

$\theta + \beta - \delta = 45^0$

Tangencial Force (Ft)

Ft = Fc tan (β - δ)........... (Kg)

Scisories Force (Fs) Fs = Fc Cos θ – Ft Sin θ ....(Kg)

Normality in Scisorse Force (Fns)

Fns = Fc tan (β – δ + θ) = Fc tan 45⁰ ....(Kg)

Resultan Force (Fv) $Fv = \frac{Fs}{\cos(\beta - \delta + \theta)} = \frac{Fs}{\cos 45^0}$

Friction Force (Ff)

Ff = Fv Sin β ....(Kg)

Normal Force(Fn)

Fn=Ff / tan β

Friction Factore (η)

η = tanβ

The theoreticalrelationship between I and R tan Ø in comparison with experimental data as shown in chart 6.8. it can be seen that a theory I ignore the price of a high R tan Ø is high speed and feed.In theory assumes plane heat source, heat can only flow in the workpiece by conduction; in fact the heat produced covers a large zone, most of it goes into the workpiece. The effects of spreading heat become very important in

Maximum Temperature(Ø max)

Ø max = Ø m + Ø s + Ø0

Ø m = Temperature high up (⁰c)

Ø m = it can with know lf/lo dan Wo

Lo= Hotter long source Lo = lf / lo = $\frac{lf}{x\ rc}$ ao = ac /rc

ac

Wo = Konstanta 0,2

ρ = Materials Weight (kg/m3) Wemercan do this equation including to determine some requirements to workpiece, he produces an equation which states (part of Qs is conditioned on the workpiece) as a unique function of R tan Ø Ø = shear angle

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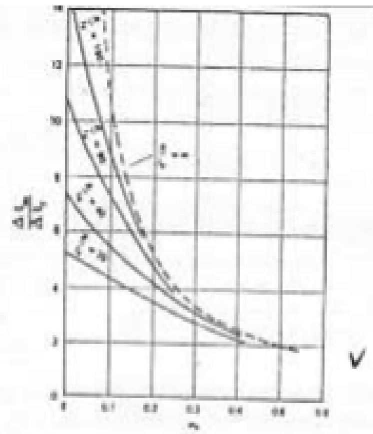
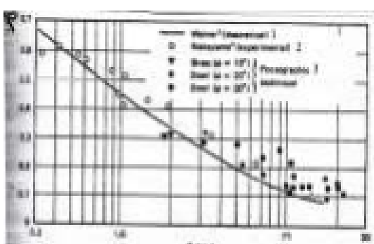
Ø = shear angle



GAMBAR 6.10.

Efek dari Lebar Zona Deformasi Ke-II Pada Suhu Chip (After Boothroyd). loo a_s = Panjang kontak pahat-cip, w_o a_s = lebar zona deformasi ke II



GAMBAR 6.8

Efek dari R tan ϕ Pada Bagian Gunting, Padanya Sebagian dari Panas Pada Zone Gunting Dihantarkan Pada Benda Kerja (After Boothroyd)

The theoreticalrelationship between I and R tan Ø in comparison with experimental data as shown in chart 6.8. it can be seen that a theory I ignore the price of a high R tan Ø is high speed and feed.In theory assumes plane heat source, heat can only flow in the workpiece by conduction; in fact the heat produced covers a large zone, most of it goes into the workpiece. The effects of spreading heat become very important in

Maximum Temperature(Ø max)

Ø max = Ø m + Ø s + Ø0

Ø m = high up (^{0}c)

Ø m = it can with know lf/lo dan W0

Lo= Hotter long source Lo = lf / lo =lf x rc ao = ac /rc

ac

Wo = Konstanta 0,2

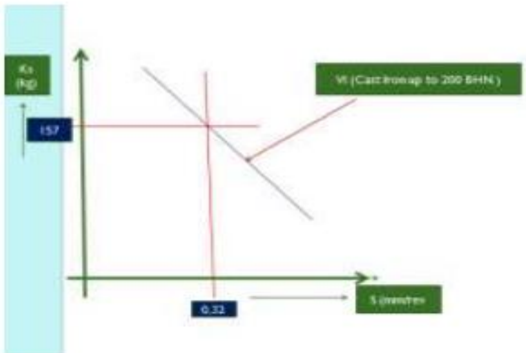
Ø0=HomeTemperature (27s/d30)^{0}C

In chart 6.10shows the effect of large variations in distribution of heat source which isn't uniform. if this curve is used, then Lo can be estimated from the wear on the tool face and wide from the heat source can be estimated from a

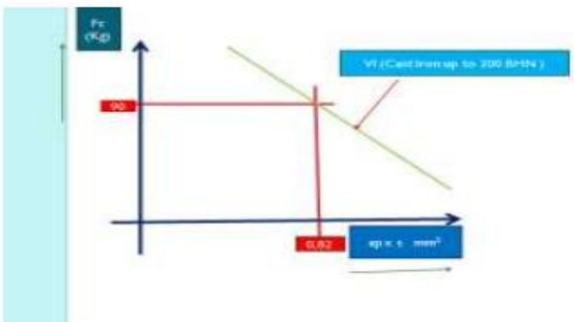
III. RESULT

1. Known : Carbon Steel S 45 C in JIS (Standar jepang) AISI 1045 or Steel SAE 1045 CD (Standar Amerika).Cutting Tool HSS 18-4-1 (Standar Amerika) T = 1 Hour

Looking for cutting Force (Fc) can known in chart.2 Cutting Force Componen Fc vs depth of cut a x s



Looking for cutting speed (Vc) can known in chart 3. The correlation between cutting speed and feeding S for tool life of V60 , V240 ,V480. and material take in table 3.1 .cutting coefisien k where in σb = 50-60 with K = 157 kg/mm^2 . In Chart 3 from II.Carbon Steel up to 50kg/mm^2. With Cutting Tool HSS 18-4-1 can from no b.HSS tools

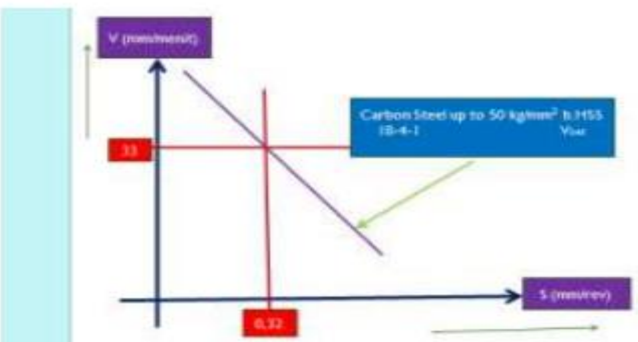


•Daya Potong (Pc)

$$Pc = \frac{Fc \times Vc}{4500} \rightarrow \frac{90\ kg \times 33\ m/menit}{4500} = 0,66\ HP$$

•Daya Elektromotor (Pg)

$$Pg = \frac{Pc}{ήmk} + P\ idd \rightarrow \frac{0,66}{0,8}\ HP + 0,25\ Hp = 1,075\ HP$$



Dari gambar diatas maka Kecepatan potong (Vc) didapat = 33 m/menit

•Komponen gaya –gaya (Ft , Fs ,Fns ,Fv ,Ff,Fn,η)

$$\tan \theta = \frac{rc \times \cos \delta}{1 - rc \times \sin \delta} \rightarrow \frac{0,3 \times \cos 8^0}{1 - 0,3 . \sin 8^0} = 0,31 \rightarrow \theta = 17,22^0$$

$$\theta + \beta - \delta = 45^0 \rightarrow 17,22^0 + \beta - 8^0 = 45 \rightarrow$$

$$\beta = 45^0 - 17,22^0 + 8 = 35,78^0$$

$$\beta = 35,78^0$$

. Gaya Tangensial (Ft)

$$Ft = Fc \tan (\beta - \delta) \rightarrow 90\ kg \times \tan (35,78^0 - 8^0) \rightarrow$$
$$Ft = 47,41\ kg$$

•Gaya Gunting (Fs)

$$Fs = Fc \cos \theta - Ft \sin \theta = 90\ kg \cos 17,22^0 - 47,71\ kg \sin 17,22^0$$

$$Fs = 85,96\ kg - 14,12\ kg = 71,84\ kg$$

•Gaya gesek (Ff)

$$Ff = Fv \sin \beta = 101,6\ kg \sin 35,78^0 \rightarrow Ff = 59,4\ kg$$

•Gaya normal (Fn)

$$Fn = \frac{Ff}{\tan \beta} = \frac{59,4\ kg}{\tan 35,78^0} = \frac{59,4\ kg}{0,72} \rightarrow Fn = 82,5\ kg$$

•Faktor gesek (η)

$$\eta = \tan \beta = \tan 35,78^0 \rightarrow \eta = 0,72$$

2

•Gaya normal pada bidang gunting (Fns)

Fns = Fc tan ($\beta - \delta + \theta$) = Fc tan 45^0 ➔
Fns = 90 kg x 1 = 90 kg

•Gaya Resultan (Fv)

$$Fv = \frac{Fs}{\cos(\beta-\delta+\theta)} = \frac{Fs}{\cos 45^0} = \frac{71{,}84\ kg}{0{,}7071} \rightarrow Fv = 101{,}6\ kg$$

Known example data no.1,known rc = 0,3 , Ff = 674 N , ρ = 7800 kg/m^3, K= 43 J/m^{0}C ,Cp = 0,473 kj/kg^{0}C ,B = 2,5 mm , Lf = 7,5 mm ,ώ0 = 0,24 , θ0 = 28 ^{0}C

Result Energi (Pm)
From no1 Vc can = 29 m/menit = 0,483 m/detik.
Fc = 90 kg = 882,6 Newton

Pm = Fc x Vc = 882,6 x 0,483 m/detik = 426.59 Nm/detik = 426.59 j/detik
Pm = 102.38 kal/detik = 0,102 kkal/detik.

Hotter in friction force (Pf)

Pf = Ff x V0 = Ff xVc x rc = 674 N x 0,483 m/detik x 0,3 = 97'66 Nm/detik
Pf = 97,66 j/detik = 23,44 kal/detik = 0,023 kkal/detik.

Htter in Scisorse force(Ps)

Ps = Pm – Pf = 0,102 kkal/detik – 0,023 kkal/detik = 0,079 kkal/detik
Ps = 0,079 kkal / detik.
Temperature up in zone I (θs)

$$R = \frac{\rho \times Cp \times V \times a}{k} = \frac{7800\ kg/m^3 \times 473\ J/kg^0C \times 0{,}483\ m/det \times 2{,}54.10^{-3}\ m}{43\ J/m^0C}$$

R = 105,26

$\tan\theta = \tan 17{,}22 = 0{,}3$ ➔ $R \tan\theta = 105{,}26 \times 0{,}3 = 31{,}57$

In chart.4 ,with R tan 31,57 didapat $\Gamma = 0$

Maka :

$$\theta s = \frac{(1-\Gamma) \times Ps}{\rho \times Cp \times a \times VxB} =$$

$$\frac{(1-0) \times 0.079 \text{ kkal/det}}{7800 \text{ kg/m}^3 \times 473 \text{j/kg}^0\text{C} \times 2{,}54.10^3 \text{m} \times 0.48 \text{ m/det} \times 2{,}5.10^{-3}\text{m}}$$

$$\theta s = \frac{330{,}694 \text{ J/det}}{11{,}24 \text{ J/det }^0\text{C}} = 29{,}42\ ^0\text{C}$$

Kenaikan temperature pada zone II (θf)

$$\theta f = \frac{Pf}{\rho \times Cp \times a \times V \times B} = \frac{0.023 \text{ kkal/det}}{7800 \text{ kg/m}^3 \times 473 \text{ j/kg}^0\text{C} \times 2{,}54.10^{-3} \times 0{,}48 \text{ m/det} \times 2{,}5.10^{-3}\text{m}}$$

$$\theta f = \frac{96{,}278 \text{ j/det}}{11{,}24 \text{ j/det }^0\text{C}} = 8{,}56\ ^0$$

Result From Matematic in finished with time work T= 1 Hour =60 minute and Cutting Force(Fc) = 90 Kg can be make in this down

	Vc (m/s)	Pc (Hp)	Pg (Hp)	Ft (Kg)	Fs (Kg)	Ff (Kg)	Fns (Kg)	Fv (Kg)	Pm (kal/s)	Pf (kal/s)	Ps (kal/s)	Θs ^{0}C	Θf ^{0}C
T=1 Hour Fc=90 kg	0,483	0,58	0,97	47,4	71,8	59,4	90	101,6	102	23	79	29,42	8,56

Result From Matematic in finished with live tool T= 1 hour =60 minute with V= 29 m/minute, T= 4 hour = 240 minute with V= 33 m/minutet ,T= 8 hour =480 minute with V = 48 m/minute Cutting Force (Fc) = 90 Kg can make table in this up

TIME WORKS	Vc (m/s)	Pc (Hp)	Pg (Hp)	Ft (Kg)	Fs (Kg)	Ff (Kg)	Fns (Kg)	Fv (Kg)	Pm (kal/s)	Pf (kal/s)	Ps (kal/s)	Θs ^{0}C	Θf ^{0}C
T=1 Hour Fc=90 kg	0,483	0,58	0,97	47,4	71,8	59,4	90	101,6	102	23	79	29,42	8,56
T=4 Hour Fc=90 kg	0,55	0,66	1,07	47,4	71,8	59,4	90	101,6	116	26	90	29,24	8,44
T=8 Hour Fc=90 kg	0,8	0,96	1,45	47,4	71,8	59,4	90	101,6	169	38	131	29,26	8,48

IV. CONCLUSION

1. Various types of cutting tool research can be applied to obtain the result of calculation analysis according to condition and industry.
2. To obtain accurate calculation result analysis, it is necessary ketelitiaan read the picture on the diagram under study.

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