(TECHNICAL DATA)

STRENGTH OF BOLTS, SCREW PLUGS, AND DOWEL PINS

(TECHNICAL DATA) COMPARISON OF DIE STEEL BY MANUFACTURERS HARDNESS OF MAJOR STEEL PRODUCTS AND CORRESPONDING TOOLS

■Bolt strength

1) When a bolt takes the tensile load

Pt=
$$\sigma$$
t×As····· (1)
= π d² σ t/4···(2)

Pt : Axial tensile load [kgf]

σ b: the bolts yield stress [kgf/mm²] σ t : the bolts allowable stress [kgf/mm²]

 $(\sigma t = \sigma b/\text{safety factor } \alpha)$ As: Effective bolt area [mm²] $As = \pi \, d^2/4$

d : Bolts effective diameter (shaft diameter) [mm]

 \blacksquare Unwin safety factor α based on tensile strength

Material	Static load	Repeat	Impact load	
Material	Static Ivau	Pulsating	Reversed	IIIIpaci Ivau
Steel	3	5	8	12
Cast iron	4	6	10	15
Copper, soft metals	5	5	9	15

Standard strength: The yield strength for ductile materials

(Example) The correct size is required for a socket head cap screw to take a repeat load (pulsating) with P= 200 kgf. (The materials of a socket head cap screw are: SCM435, 38~43HRC, strength category of 12.9.)

Using formula (1)

As=Pt/ σ t =200/22.4=8.9 [mm²]

The bolt with an effective area larger than this is required, and a 14.2 mm² M5 would be selected Although, if we take into consideration the endurance strength, looking at the strength category of 12.9, we would choice the M6 with an allowable load of 213kgf.

2) For stripper bolts which recieve the impact load, the size is decided by the fatigue strength. (Likewise for a load of 200kgf, the stripper bolt would be SCM435, 33~38HRC, with a strength category of 10.9.)

In the table to the right, the allowable load for a load over 200kgf for a strength category of 10.9 is as M8 at 318 (kgf). Therefore, the MSB10 would be selected, with a screw diameter of 10mm like the M8. Please use dowel pins also to take the shearing load.

The yield stress for a strength category of 12.9 is σ b=112 [kgf/mm²] The allowable stress $\sigma t = \sigma$ b/safety factor (safety factor of 5 from the above table) =112/5 $=22.4 [kgf/mm^2]$

The bolt endurance strength (For screws, the endurance strength is 2 million times use.)

	Effective		Strength	category			
Bolt size	bolt area	12	2.9	10.9			
DOIT SIZE	As			Fatigue strength *			
	mm ²	kgf/mm ²	kgf	kgf/mm ²	kgf		
M 4	8.78	13.1	114	9.1	79		
M 5	14.2	11.3	160	7.8	111		
M 6	20.1	10.6	213	7.4	149		
M 8	36.6	8.9	326	8.7	318		
M10	58	7.4	429	7.3	423		
M12	84.3	6.7	565	6.5	548		
M14	115	6.1	702	6	690		
M16	157	5.8	911	5.7	895		
M20	245	5.2	1274	5.1	1250		
M24	353	4.7	1659	4.7	1659		

Fatigue strength * is an edited excerpt taken from "the measured values of the endurance limit for small screws, bolts, and meter screws for nuts" (Yamamoto)

■Screw plug strength

Allowable load P is required for screw plug MSW30 to recieve an impact load. (The MSW30 : S45C, the tensile strength σ b of 34 \sim 43HRC is 65kgf / mm²)

When the root diameter section of the MSW is ruptured due to shearing strain,

the allowance load $P = \tau t \times A$ $=3.9\times1074$ =4188.6[kgf] Shear area A=root diameter $d_1 \times \pi \times L$ (root diameter d₁≒M-P) $A = (M-P) \pi L = (30-1.5) \pi \times 12$ =1074[mm²]Yield stressi=0.9itensile strength σ b=0.9i65=58.2 =46.6Allowable shear stress τ t=shear stress/safety factor 12 $=46.6/12=3.9[kgf/mm^2]$

When the tap is made of soft material.

an allowable shear is required from the root diameter of the female screw.

Root diameter di

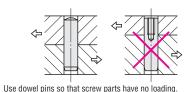
■ Dowel pin strength

The correct size for a dowel pin is required in order for it to hold repeated shear load (pulsating) of 800kfg. (Material of the dowel pin is SUJ2, hardness of 58HRC~.)

P=A×
$$\tau$$

= π D² τ /4
D= $\sqrt{(4P)/(\pi \tau)}$
= $\sqrt{(4\times800)/(3.14\times19.2)}$
 $= 7.3$

The applicable yield stress of SUJ2 σ b=120[kgf/mm²] Allowable shear strength $\tau = \sigma$ b×0.8/safety factor α $=120\times0.8/5$ $=19.2[kgf/mm^2]$



A size of D8 or more is selected for a MS dowel pin. Also, the tools and stock etc can be reduced if the size of the dowel pin is consistently large.

Everything noted here are only examples of strengths. In actual practice, the hole pitch precision, the perpendicular angle of the hole, surface coarseness, circularity, the plate materials, parallelism, whether its tempered or not, the precision of the injection molding machine, production quantity tool wear, etc must be taken into consideration. Therefore these values should only be used as a guide. (These are not guaranteed figures.)

Comparison of die steel by manufacturers

Classification	Steel types re	Hardness		
CIASSIIICALION	JIS	AISI	DIN	in use HRC
	SC group			13
	SCM440 group			28
	SCM(revised)	P20 group		33
				40
Pre hardened steel	SUS group			33
	SUS group (free cutting) *Includes free cutting components			33
	SUS group			35
	SKD61 group (free cutting) *Includes free cutting components	H13 group	X40CrMoV51	40
	Precipitation hardened steel group (hee cutting) * Includes free cutting components	P21 group		40
	Precipitation hardened steel group	P21		40
	SKS93			55~62
	SKS3			55~62
	SKD61	H13	X40CrMoV51	50
	SKD1	D3	X210Cr12	58
Quench-and-temper	SKD11	D2		58
steel	SKD11 (revised) *8 Cr series	D2 group		60
	SKD12	A2		58
	SKH51	M2	S6-5-2	60
	SUS group			57
	SUS group			52
Aging-treated steel	Maraging steel			53
nymy-treated Steel	Non-magnetic steel			43

itachi Metals, Ltd.	Daido Steel Co., Ltd.	Uddeholm	Kobe Steel Co., Ltd.	Aichi Steel Works, Ltd.	Nippon Koshuha Steel Co., Ltd.	Sanyo Special Steel Co., Ltd.	NACHI
		UHB11	KTSM2A	AUK1	KPM1	PC55	
			KTSM21	A111744	L/DIAO	001400	
			KTSM3A KTSM31	AUK11	KPM2	PCM28	
HPM7		HOLDAX	KTSM3M		KPM25		
	PX5	IMPAX			KPM30		
(HPM2T)	GO40F	NIMAX					
HPM38	S-STAR	STAVAX			KSP1	QPD5	PROVA400
HPM77	G-STAR	RAMAX RoyAlloy					
PSL	NAK101	CORRAX			U630	QSH6	
FDAC	DH2F		KTSM41		KDA	QD6F	
HPM1	NAK55		KTSM40EF		KAP		
CENA1 (HPM50)	NAK80		KTSM40E		KAP2	PCM40	
YCS3	YK30			SK301	КЗМ	QK3M	SK3M
SGT	GOA	ARNE		SKS3	KS3	QKS3	SKS3
DAC	DHA1	ORVAR		SKD61	KDA	QD61	HDS61
CRD	DC1	SVERKER3		SKD1	KD1	QC1	CDS1
SLD	DC11			SKD11	KD11S	QC11	CDS11
(SLD8) HPM31	DC53 PD613	SLEIPNER	KAD181	AUD15	KD21	QCM8	MCR12
	DC12	RIGOR		SKD12	KD12	QC12	CDS12
YXM1	MH51				H51	QH51	SKH9
SUS440C		ELMAX	KAS440 (powder)		KSP2 KSP3	QCD5 SPC5 (powder)	FAXR2
HPM38 HPM38S	S-STAR	STAVAX			KSP1	QPD1 QPD5	PROVA400
YAG	MAS1C				KMS18-20	QM300	
HPM75							

Processing method		Equipment	Required tools
		General purpose mill- ing cutter NC milling cutter Machining center Drilling machine	Drills Reamers End mills Cutting tools
Cutting	Boring	Drill press Boring machine Jig borer	Drills Taps Reamers Cutting tools
	Machining cylinders	General purpose lathe NC lathe Turning center	Drills Reamers Taps Cutting tools
Grinding		Surface grinder Cylindrical grinder Jig grinder Profile grinder Forming grinder	Magnets grindstone
Electroerosion		E D M	Electrode master
Electroerosion	0.001011	WEDM	Wire

		11 1017 0																					
													* CENA	11 is an u	pdated ste	el for HF	2M50						
Materials			Machined m																				
			Nonferrous metal Untreated			TI	Thermal refined				Queno	ched/Te	mpered	i									
Parts materials Tools Tools materials	ts materials		Parts materials		Parts materials		Parts materials		(AI)) 8	S400(S S45	S41) iC	SKD11			35	2T			KS3	SKD11 SUJ2 SKH51)
	\	For plastic Mold	CU BsBN	12		X	SKD61	I S-	STAR	HPI NAK CEN FDA	M1 80 A1 C	ORVA (Age- harden	R SÚPI N Y H S—S	IAS1C AG PM38 STAR		forming)							
			HRC	1	0	2	0	3	0	4	10	Ę	i0		80	7	70						
High-speed steel	SKH-										\vdash												
Cemented carbide	Wn-Co																Г						
High-speed steel Cemented carbide	SKH- Wn-Co																						
High-speed steel Cemented carbide	SKH-																						
Boron	CBN			-											4								
	_			(N	onferro	us meta	al) 							_	(Carbi	de) ——	F						
Pink fused almina	PA																						
				(N	onferro	us meta	al)										F						
'				(N	onferro	us meta	al)								(Carbi	de) —							
Electrolytic copper Brass Copper tungsten Silver tungsten	Cu- -W			(10											(00.01	/							
Brass Tungsten	Cu—Zn																						
	Parts materials High-speed steel Cemented carbide High-speed steel Cemented carbide High-speed steel Cemented carbide High-speed steel Cemented carbide Boron Diamond White fused alumina Brown fused alumina Green silicon carbide Black silicon carbide Electrodeposited boron Electrodeposited diamond Electrolytic copper Trass Copper tungsten Brass	Parts materials Tools materials High-speed steel Cemented carbide Wn-Co High-speed steel Cemented carbide Wn-Co High-speed steel SKH— Cemented carbide Wn-Co Boron CBN Diamond D White fused alumina A Prink fused alumina PA Green silicon carbide GC Black silicon carbide C Electrodeposited boron CBN Electrodeposited diamond D Electrolytic copper Brass Copper tungsten Cymyster Copper silver tungsten Brass Cu-Zn	Parts materials For press die Tools materials High-speed steel Cemented carbide Wn-Co BORN High-speed steel Cemented carbide High-speed steel Cemente	Parts materials Por press die For press die For plastic Mold Bable HRC High-speed steel Cemented carbide High-speed steel Cemented carbide Wn-Co High-speed steel Cemented carbide For Wn-Co High-speed steel Cemented carbide Wn-Co Boron Diamond D White fused alumina Brown fused alumina Frink fused alumina Ceren silicon carbide Black silicon carbide C Electrodeposited boron CBN Electrodeposited diamond D Electrolytic copper Brass Cup-zn Brass Cu-Zn	Parts materials Parts materials For press die Cu plastic Mold BsBM2 HRC 1 High-speed steel Cemented carbide High-speed steel Cemented carbide High-speed steel Cemented carbide High-speed steel Cemented carbide Wn-Co High-speed steel Wn-Co High-speed steel Cemented carbide Wn-Co Boron CBN Diamond D White fused alumina A Pink fused alumina A Prink fused alumina A Foren silicon carbide Black silicon carbide Black silicon carbide Black silicon carbide Black silicon carbide CC CC CBN CBN CBN CC CC CC CC	Parts materials Por press die For plastic Mold For plastic Mold	Number N	Parts materials	Notifemus notial Untreated T	Numbers Numb	Notitemus mobil	Number N	Notiferrous midal	Naterials	Naterials	Parts materials	Notemus netal Untreated						