

APENDIXES

1. Gantt chart for FYP 1 MAB 4012: An experimental study of strength of Friction Stir Spot Welding on overlapping sheet metal

No	Detail / Week	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
1	Selection of project topic		X													
2	Preliminary research work				X											
3	Submission of preliminary report															
4	Project work															
5	Design welding tool of FSSW															
6	Submission of progress report									X						
7	Obtain tool steel of FSSW (H13)												X			
8	Fabrication welding tool using CNC lathe													X		
9	Undergo heat treatment on welding tool													X		
10	Submission of Interim report final draft														X	
11	Oral Presentation															X

Process	
Suggested Milestone	X

2. Gantt chart for FYP 1 MAB 4012: An experimental study of strength of Friction Stir Spot Welding on overlapping sheet metal

No	Detail / Week	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
1	Project Work Continue															
2	Submission of Progress Report 1				X											
3	Apply FSSW (welding tool) on work piece															
4	Submission of Progress Report 2									X						
5	Seminar (compulsory)															
6	Pull to Break Test															
7	Poster Exhibition															
8	Submission of Dissertation (soft bound)															
9	Oral Presentation															
10	Submission of Project Dissertation (Hard Bound)															

Process	
Suggested Milestone	X

Appendix 2.1: Data sheet H13 steel

Hot Work Tool Steel

2344 / RDC 2V

PRODUCT FEATURES

2344 is a chromium-molybdenum-vanadium steel which has outstanding toughness and high hot hardness.

- Improved tool life
 - Specially annealed to remove all intergranular carbide precipitation and allow a fine globular carbide distribution.
- Higher toughness and hot hardness than H11 steels
 - Chromium-Molybdenum-Vanadium additions optimised to improve properties.

APPLICATIONS

- Hot work tools subjected to temperatures from 300°C to 580°C
- Hot extrusion tools for light alloys: Pressure discs, mandrels, stems, headers, centering and shearing mandrels, dies, liners
- Casting dies for light alloys: Cores, ejectors
- Plastic molding dies: Injection moulding applications
- Forging tools: Dies, die insert, punches, mandrels

EQUIVALENT STANDARDS

WN	DIN	AISI	JIS
1.2344	X40 CrMoV 5 1	H13	SKD 61

CHEMICAL ANALYSIS

Typical values (weight %)

C	Si	Mn	Cr	Mo	V
0.40	1.05	0.35	5.00	1.30	1.00

MECHANICAL PROPERTIES

Typical values

Hardness	Annealed (supplied condition)	229 HB max.
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PHYSICAL PROPERTIES

Typical values

Thermal Expansion Coefficient

°C	20-100	20-200	20-300	20-400	20-500	20-600	20-700
$10^{-6} \text{ } ^\circ\text{C}^{-1}$	10.9	11.9	12.3	12.7	13.0	13.3	13.5

Thermal Conductivity

°C	20	350	700
$\text{W m}^{-1} \text{ } ^\circ\text{C}^{-1}$	24.5	26.8	28.8

HEAT TREATMENT

Hardening Temperature 990 – 1050°C

Quenching Medium Oil, Air

Tempering Refer to tempering chart

Tempering Chart

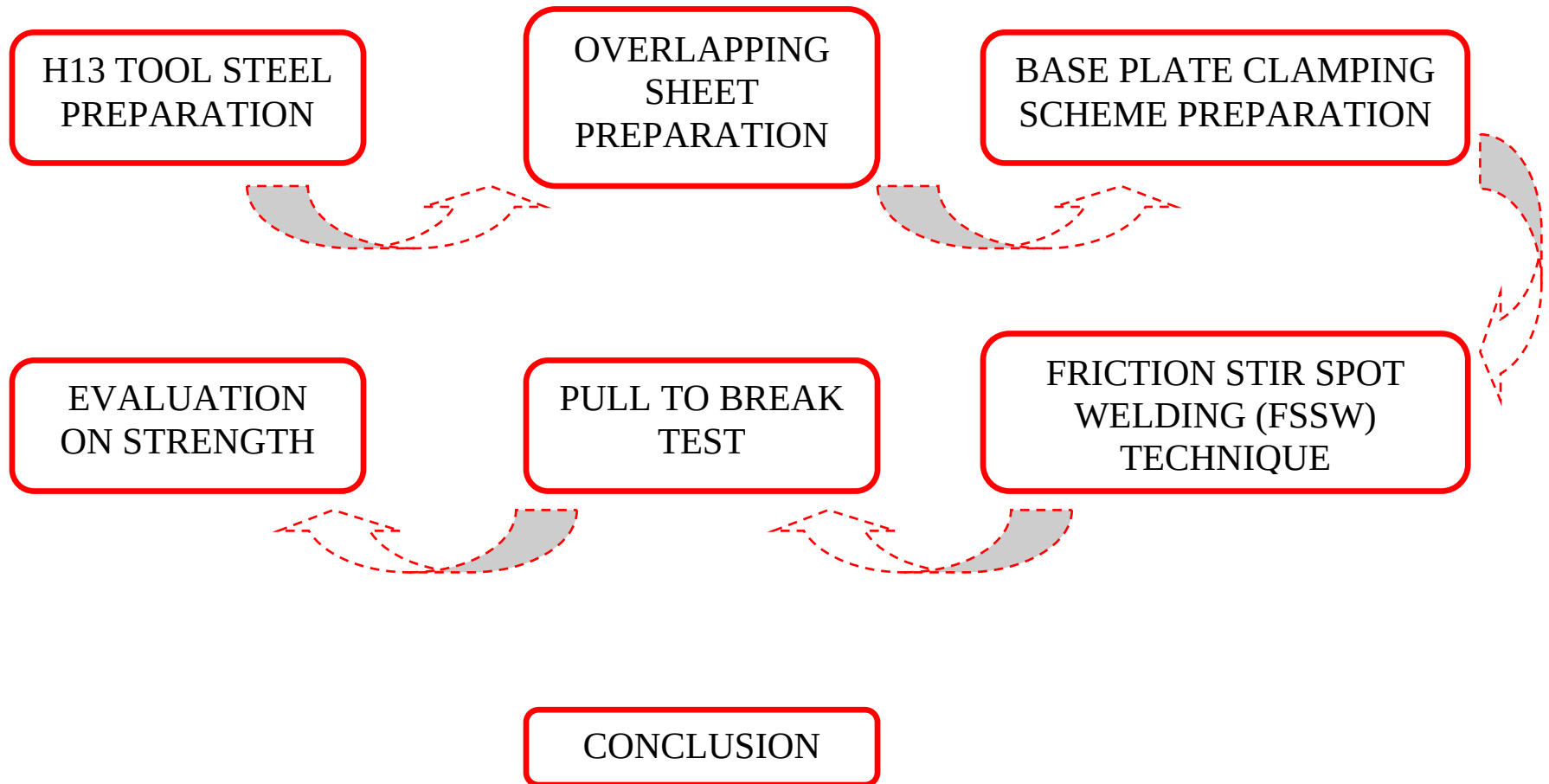
The chart is a line graph with Rockwell Hardness C on the y-axis (ranging from 30 to 70 in increments of 2) and Tempering temperature °C on the x-axis (ranging from 0 to 800 in increments of 100). The curve starts at approximately 62 HRC at 0°C, remains relatively flat until about 400°C, then drops sharply to about 42 HRC at 600°C.

Quenched from 1020°C in air

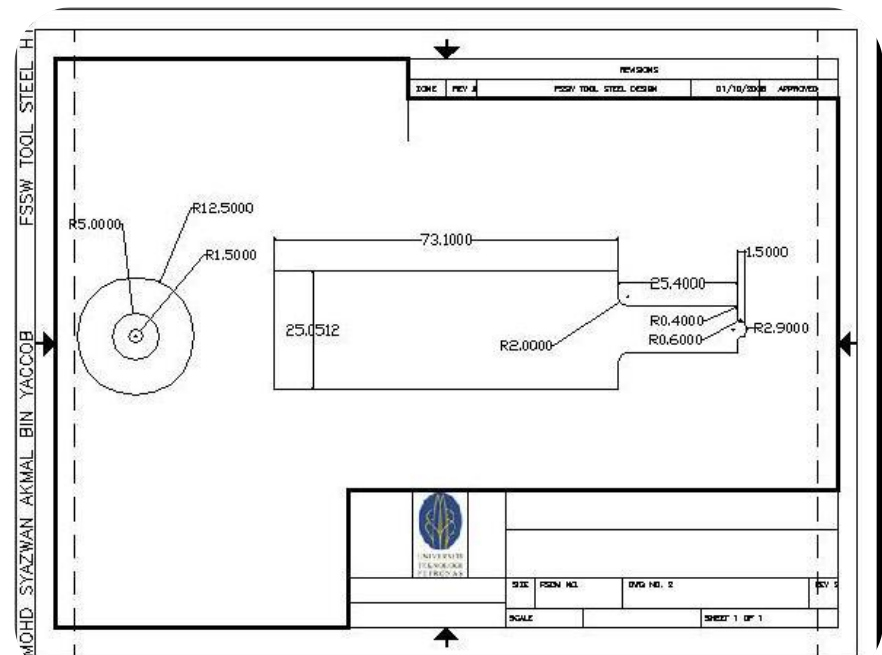
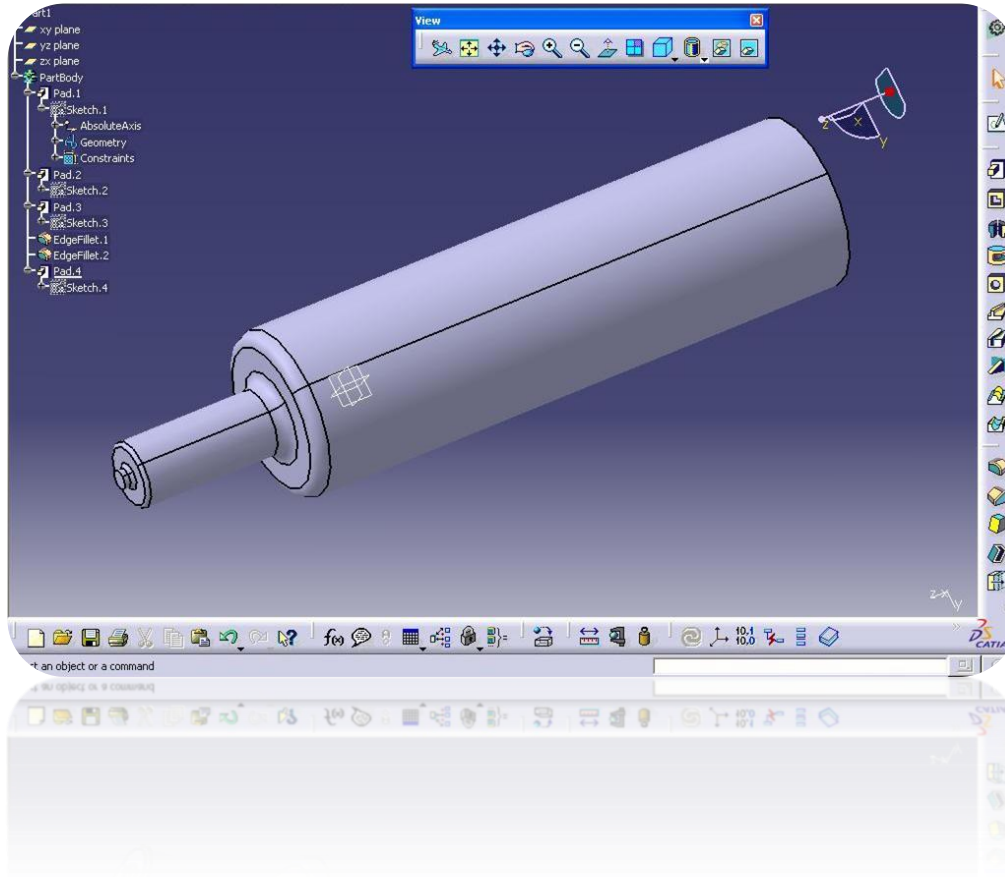
WINGKOH SPECIALTY METALS Sdn. Bhd.
(No. Syarikat: 209172-P)
8, Persewaan Perusahaan Kledang Utara 1/3,
Kawasan Perindustrian Chenderu Jaya,
31450 Ipoh, Perak.

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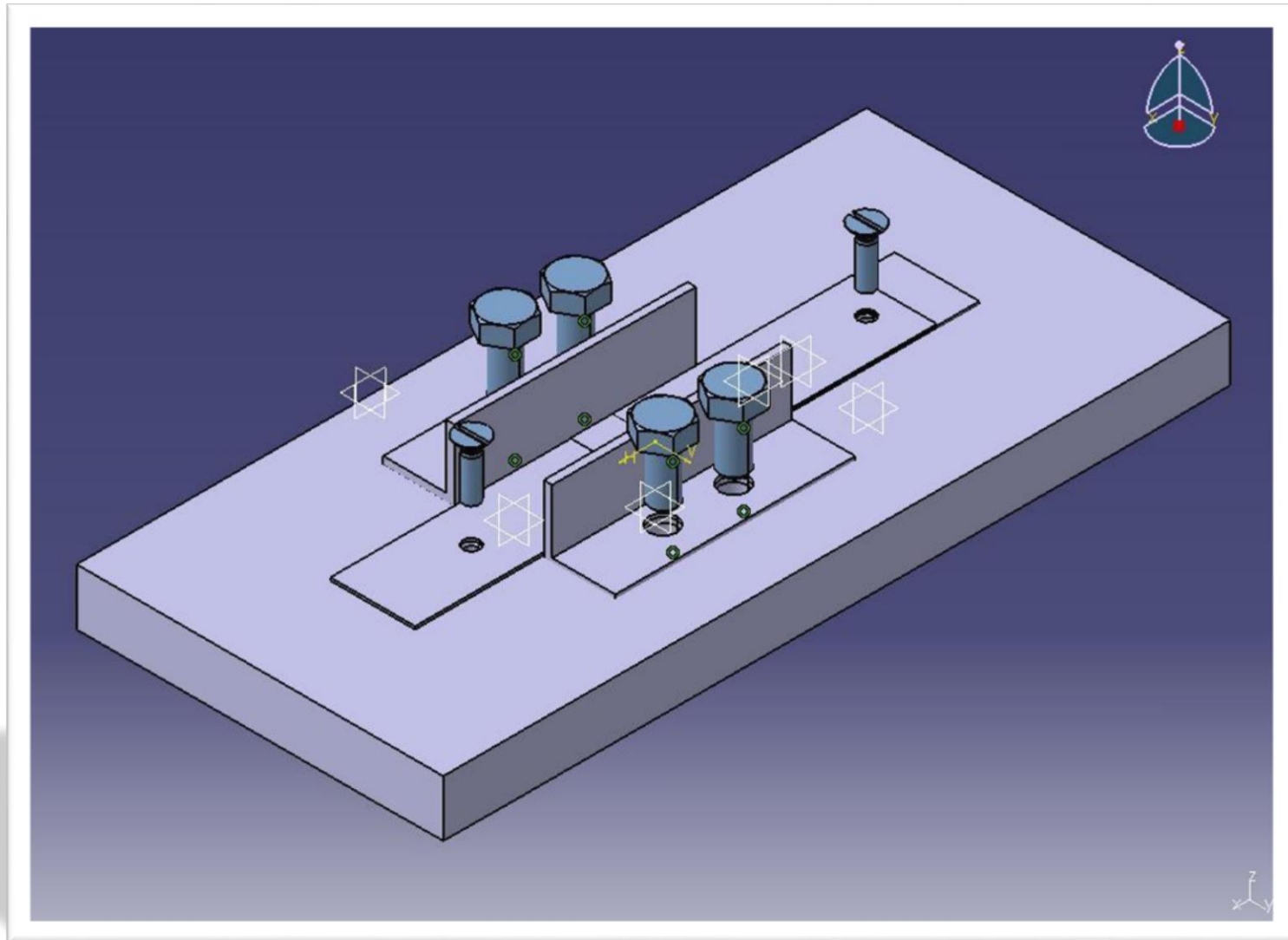
Appendix 2.1: Project methodology



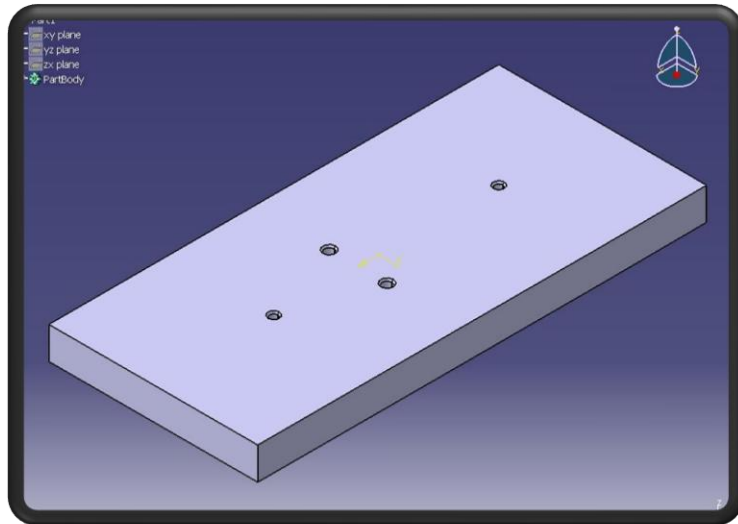
Appendix 3.1: H13 tool steel engineering drawing revision 1 (Auto CAD and CATIA)



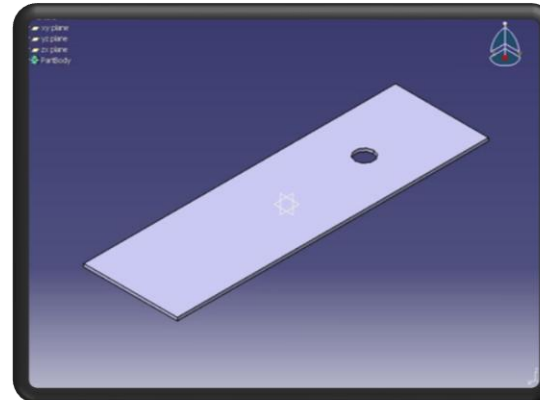
Appendix 3.2: Engineering Assembly Design Rev 2



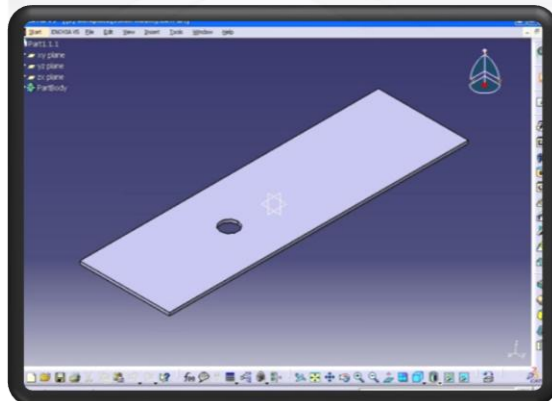
Appendix 3.3: Part Design Rev 0



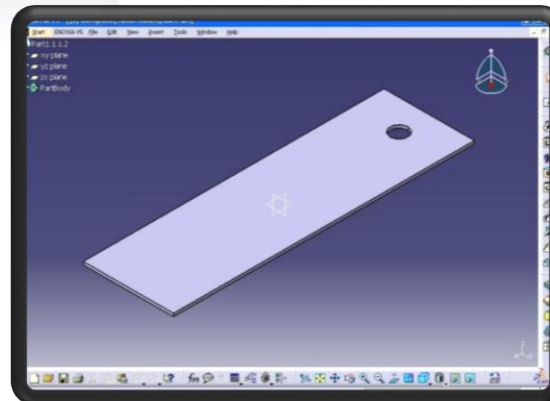
Base Plate with mounting hole



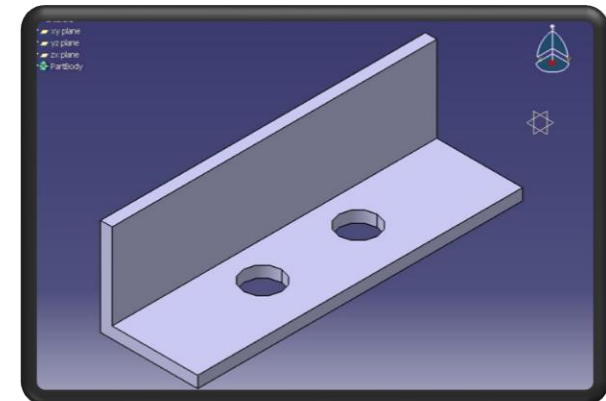
Overlapping Sheet 1



Overlapping Sheet 2

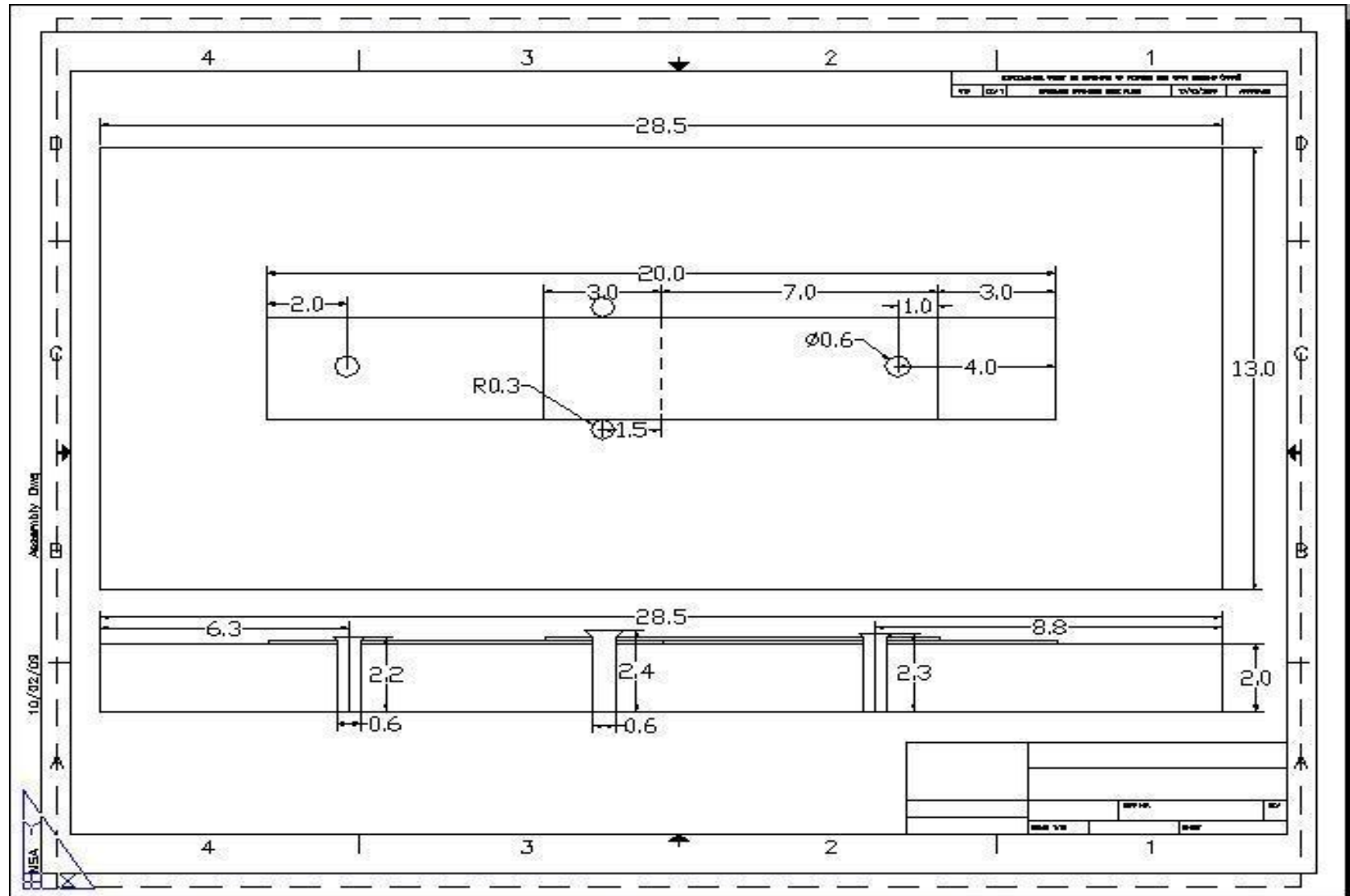


Overlapping Sheet 3



L angle Bar

Appendix 3.4: Assembly drawing Revision 1



Appendix 4.1: Pull to Break Test Result of 4000 rpm with penetration rate vary ranging 45 mm/min to 75 mm/min

Sample Reference	Maximum Load (N)	Deflection at Maximum Load (mm)	Work to Maximum Load (J)	Stiffness (N/m)	Load at Break (N)	Deflection at Break (mm)	Work to Break (J)
1	1602.044164	8.805801456	2.443501312	887810.2889	160.2044164	10.57785064	3.72102618
2	1184.023439	7.90970505	1.756623036	683492.1186	118.4023439	9.226474765	2.565195703
3	1860.975663	11.43196831	3.557984971	1051886.463	186.0975663	13.27879009	5.239146811
4	1654.438842	10.8717717	4.881255278	830517.8508	165.4438842	12.31223634	6.183936788
5	1702.79427	19.99319233	7.322633166	768398.5775	170.279427	21.673354	8.820857247
6	1550.64375	16.75213214	4.740896997	852168.4243	155.064375	18.28637265	5.920759695
7	0.170314675	16.82333262	-0.005715962	3054.312354	0.017031468	19.20325379	-0.005493006

Appendix 4.2: Pull to Break Test Result of 4000 rpm with penetration rate vary ranging 45 mm/min to 75 mm/min

	Maximum	Minimum	Mean	Median	Variance	Standard Deviation	TRUE
SamplePassed							100.00%
Speed	50.000 mm/min	50.000 mm/min	50.000 mm/min	50.000 mm/min	0.00%	0.00000 mm/min	
Preload							0.00%
Maximum Load	1861.0 N	0.17031 N	1365.0 N	1602.0 N	43.16%	589.19 N	
Deflection at Maximum Load	19.993 mm	7.9097 mm	13.227 mm	11.432 mm	32.30%	4.2717 mm	
Work to Maximum Load	7.3226 J	-0.0057160 J	3.5282 J	3.5580 J	62.93%	2.2202 J	
Stiffness	1050000 N/m	3050 N/m	725000 N/m	831000 N/m	43.14%	313000 N/m	
Load at Break	186.10 N	0.017031 N	136.50 N	160.20 N	43.16%	58.919 N	
Deflection at Break	21.673 mm	9.2265 mm	14.937 mm	13.279 mm	29.51%	4.4086 mm	
Work to Break	8.8209 J	-0.0054930 J	4.6351 J	5.2391 J	56.84%	2.6347 J	
Number of Rows that Passed	7						
Number of Rows that Failed	0						

Appendix 4.3: Pull to Break Test Result of 5000 rpm with penetration rate vary ranging 45 mm/min to 75 mm/min

Sample Reference	Maximum Load (N)	Deflection at Maximum Load (mm)	Work to Maximum Load (J)	Stiffness (N/m)	Load at Break (N)	Deflection at Break (mm)	Work to Break (J)
1	1774.341	7.262505	2.767967	907667.6	177.4341	9.386979	4.45785
2	1826.634	20.51426	6.375312	800172.1	182.6634	22.5992	8.310071
3	1612.44	15.61153	4.755671	871581.8	161.244	17.893	6.737974
4	1906.632	12.32939	6.697422	611884.5	190.6632	14.72204	9.404589
5	1732.25	11.93808	5.944038	515895	173.225	14.1453	7.812992
6	1793.239	20.48237	5.559385	734631.2	179.3239	22.65366	7.596707
7	1774.341	7.262505	2.767967	907667.6	177.4341	9.386979	4.45785

Appendix 4.4: Pull to Break Test Result of 5000 rpm with penetration rate vary ranging 45 mm/min to 75 mm/min

	Maximum	Minimum	Mean	Median	Variance	Standard Deviation	TRUE
SamplePassed							100.00%
Speed	50.000 mm/min	50.000 mm/min	50.000 mm/min	50.000 mm/min	0.00%	0.00000059605 mm/min	
Preload							0.00%
Maximum Load	1906.6 N	1612.4 N	1774.3 N	1783.8 N	5.07%	89.978 N	
Deflection at Maximum Load	20.514 mm	7.2625 mm	14.690 mm	13.970 mm	32.49%	4.7721 mm	
Work to Maximum Load	6.6974 J	2.7680 J	5.3500 J	5.7517 J	24.47%	1.3092 J	
Stiffness	908000 N/m	516000 N/m	740000 N/m	767000 N/m	18.76%	139000 N/m	
Load at Break	190.66 N	161.24 N	177.43 N	178.38 N	5.07%	8.9978 N	
Deflection at Break	22.654 mm	9.3870 mm	16.900 mm	16.308 mm	28.10%	4.7495 mm	
Work to Break	9.4046 J	4.4578 J	7.3867 J	7.7048 J	20.79%	1.5356 J	
Number of Rows that Passed	6						
Number of Rows that Failed	0						

Appendix 4.5: Pull to Break Test Result of 6000 rpm with penetration rate vary ranging 45 mm/min to 75 mm/min

Sample Reference	Maximum Load (N)	Deflection at Maximum Load (mm)	Work to Maximum Load (J)	Stiffness (N/m)	Load at Break (N)	Deflection at Break (mm)	Work to Break (J)
1	1795.095	11.10061	4.596534	784049.5	179.5095	14.10553	7.659766
2	1743.644	13.31213	6.07249	811455.7	174.3644	16.02785	8.802054
3	1751.778	14.04374	5.19188	657199.9	175.1778	16.6719	7.727066
4	1684.31	11.32284	3.809304	959589.5	168.431	14.00691	6.508496
5	1584.318	10.48866	5.707618	475598.5	158.4318	12.71059	7.522747
6	1694.97	18.02353	9.031023	605320.2	169.497	20.50781	11.30635
7	1668.521	18.80723	8.401206	494073.6	166.8521	20.95525	10.17154

Appendix 4.6: Pull to Break Test Result of 6000 rpm with penetration rate vary ranging 45 mm/min to 75 mm/min

	Maximum	Minimum	Mean	Median	Variance	Standard Deviation	TRUE
SamplePassed							100.00%
Speed	50.000 mm/min	50.000 mm/min	50.000 mm/min	50.000 mm/min	0.00%	0.00000 mm/min	
Preload							0.00%
Maximum Load	1795.1 N	1584.3 N	1703.2 N	1695.0 N	3.73%	63.471 N	
Deflection at Maximum Load	18.807 mm	10.489 mm	13.871 mm	13.312 mm	22.40%	3.1067 mm	
Work to Maximum Load	9.0310 J	3.8093 J	6.1157 J	5.7076 J	29.23%	1.7877 J	
Stiffness	960000 N/m	476000 N/m	684000 N/m	657000 N/m	24.00%	164000 N/m	
Load at Break	179.51 N	158.43 N	170.32 N	169.50 N	3.73%	6.3471 N	
Deflection at Break	20.955 mm	12.711 mm	16.427 mm	16.028 mm	18.18%	2.9865 mm	
Work to Break	11.306 J	6.5085 J	8.5283 J	7.7271 J	18.26%	1.5575 J	
Number of Rows that Passed	7						
Number of Rows that Failed	0						

Appendix 5.1: CNC Coding for the FSSW process used for the Mazak Variaxis 530 5X

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(PROGRAM NAME – 1302091)
(=DATE=DD-MM-YY – 13-02-09 TIME=HH:MM – 14:12)
N100G21
N102G0G17G40G49G80G90
(10.FLAT ENDMILL TOOL – 21 DIA. OFF. – 21 LEN. – 21 DIA. – 10.)
N104T21M6
N106G0G90G59X0.Y-50.A0.S2000M3
N108G43H21Z50.
N110Z10.
N112G1Z-.1F10.
N114Y50.F100.8
N116G0Z50.
N118M5
N120G91G28Z0.
N122G28X0.Y0.A0.
N124M30
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