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APPENDIX A-SAMPLE ELECTRODES AND BLOCK SIZES

Elec No	X (mm)	Y (mm)	Z (mm)	Block Size(mm ³)	Volume in '000 mm ³		
					500<=V	500>V>10	V=<10
11446r504	18	25	28	12,600	0	1	0
11446r505	18	28	25	12,600	0	1	0
11446r506	18	28	25	12,600	0	1	0
11446b513	16	32	25	12,800	0	1	0
11446b505	16	32	25	12,800	0	1	0
11420r409	32	16	25	12,800	0	1	0
11393r03	25	25	30	18,750	0	1	0
11446b515	30	30	25	22,500	0	1	0
11446b514	30	30	25	22,500	0	1	0
11446b507	30	30	25	22,500	0	1	0
11446b506	30	30	25	22,500	0	1	0
11393r06	60	25	20	30,000	0	1	0
11446b509	25	40	30	30,000	0	1	0
11446b501	25	40	30	30,000	0	1	0
11446r502	40	25	30	30,000	0	1	0
11393r02	30	30	40	36,000	0	1	0
11446f505	30	40	30	36,000	0	1	0
11398r202	30	30	40	36,000	0	1	0
11420r410	42	30	30	37,800	0	1	0
11446b510	32	30	40	38,400	0	1	0
11446b502	32	30	40	38,400	0	1	0
11398r203	30	44	30	39,600	0	1	0
11446f504	30	36	40	43,200	0	1	0
11446r512	32	34	40	43,520	0	1	0
11446r513	32	34	40	43,520	0	1	0
11398r204	30	50	30	45,000	0	1	0
11398r205	30	50	30	45,000	0	1	0
11398r201	30	38	40	45,600	0	1	0
11371r301	40	40	30	48,000	0	1	0
11371r302	40	40	30	48,000	0	1	0
11371r303	55	30	30	49,500	0	1	0
11408f104	40	42	30	50,400	0	1	0
11398r206	47	42	30	59,220	0	1	0
11348f502	50	40	30	60,000	0	1	0
11408f101	26	80	30	62,400	0	1	0
11446r101	26	80	30	62,400	0	1	0
11446r501	45	50	30	67,500	0	1	0
11391r202	30	86	30	77,400	0	1	0
11391r203	30	86	30	77,400	0	1	0
11391r201	30	86	40	103,200	0	1	0

11393r01	82	42	30	103,320	0	1	0
11391r200	36	80	40	115,200	0	1	0
11371r300	100	40	30	120,000	0	1	0
11446f503	45	55	50	123,750	0	1	0
11408f103	54	58	40	125,280	0	1	0
11420r400	65	50	40	130,000	0	1	0
11348f03	43	61	50	131,150	0	1	0
11446r100	40	110	30	132,000	0	1	0
11348f505	61	35	70	149,450	0	1	0
11446f502	60	49	60	176,400	0	1	0
11348f04	65	61	50	198,250	0	1	0
11398r200	99	47	50	232,650	0	1	0
11446r500	71	55	60	234,300	0	1	0
11446r511	55	55	82	248,050	0	1	0
11348f01	65	61	70	277,550	0	1	0
11348f02	65	61	70	277,550	0	1	0
11446b508	110	70	40	308,000	0	1	0
11446b500	110	70	40	308,000	0	1	0
11391r205	93	114	30	318,060	0	1	0
11446f501	85	65	70	386,750	0	1	0
11393r04	99	102	40	403,920	0	1	0
11391r204	120	88	40	422,400	0	1	0
11348f503	85	61	82	425,170	0	1	0
11348f504	95	59	82	459,610	0	1	0
11446f500	95	71	72	485,640	0	1	0
11348f501	137	55	87	655,545	1	0	0
11393r05	120	170	40	816,000	1	0	0
11348f500	125	91	82	932,750	1	0	0
				Total	3	65	0
				Percentage	4	96	0

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APPENDIX B-EXPERIMENTAL DATA

Electrode No:	Material	Machine	Tool	Diameter	Achieved surface	Tool Type	Step over	Depth of cut
11433b412	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11408b200	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11420r400	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11387r102	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11408b201	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
11393r04	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
11446r500	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
11446b101	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	4.5max
11433b410	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	2.5
11446f500	Graphite	Roders	Ball nose	8	Rough	Graph X	3.2	2.5
11367s406	Graphite	Roders	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11368b201	Graphite	Roders	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11368b203	Graphite	Roders	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11408f100	Graphite	Roders	Ball nose	6	Rough	Graph X	2.4	3.5max
11368b200	Graphite	Roders	Ball nose	6	Rough	Graph X	2.4	3.5max
11396r205	Graphite	SNC64	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11433f413	Graphite	Roders	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11433f410	Graphite	Roders	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11433f406	Graphite	Roders	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11433b414	Graphite	Roders	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11425r100	Graphite	Roders	Ball nose	2	Fine	Graph X	0.07	0.07
11433b402	Graphite	Roders	Ball nose	2	Fine	Graph X	0.07	0.07
14374r01	Graphite	Roders	Ball nose	2	Fine	Graph X	0.07	0.07
11433f407	Graphite	Roders	Ball nose	1.5	Fine	Graph X	0.05	0.05
11396r205	Graphite	Roders	Ball nose	1.5	Fine	Graph X	0.05	0.05
11424f201	Graphite	Roders	Ball nose	1.5	Fine	Graph X	0.05	0.05
11433b402	Graphite	Roders	Ball nose	1	Fine	Graph X	0.03	0.03
11433b400	Graphite	Roders	Ball nose	1	Fine	Graph X	0.03	0.03
11392f4011	Graphite	Roders	Ball nose	1	Fine	Graph X	0.03	0.03
11425r100	Graphite	Roders	Ball nose	0.8	Fine	Graph X	0.03	0.03
14374r01	Graphite	Roders	Ball nose	0.8	Fine	Graph X	0.03	0.03
11424f201	Graphite	Roders	Ball nose	0.8	Fine	Graph X	0.03	0.03
11425r100	Graphite	Roders	Ball nose	0.5	Fine	Graph X	0.01	0.01
14374r01	Graphite	Roders	Ball nose	0.5	Fine	Graph X	0.01	0.01
11392f4011	Graphite	Roders	Ball nose	0.5	Fine	Graph X	0.01	0.01

Speed	Feed Cutting	Feed plunging	Rapid feed	Mill strategy	Time taken				Time secs	VDI	Volomes in mm ³	
					Min	sec	Min	Sec			Initial Vol	Final vol
14000	4500	2250	30000	3D Offset Rough	2	59	3	30	179		185976	
14000	4000	2000	30000	Raster,3D Offset,Const Z	19	44	19	37	1184	30	84330	
14000	4500	2250	30000	3D Offset Rough	1	16	1	22	76		61250	
14000	4000	2000	30000	Raster,3D Offset,Const Z	8	9	8	46	489	30	18032	
14000	4500	2250	30000	3D Offset Rough	1	20	1	14	80		129600	
14000	4000	2000	30000	Raster,3D Offset,Const Z	16	30	16	28	990	30	80581	
14000	4500	2250	30000	3D Offset Rough	1	45	1	44	105		68376	
14000	4000	2000	30000	Raster,3D Offset,Const Z	7	25	7	16	445	27	18393	
14000	4500	2250	30000	3D Offset Rough	1	28	1	22	88		61250	
14000	4500	2250	30000	3D Offset Rough	5	25	1	44	325		403920	
14000	4500	2250	30000	3D Offset Rough	3	12	1	44	192		230395	
14000	4500	2250	30000	3D Offset Rough	5	59	1	44	359		396480	
10000	2500	1250	30000	3D Offset Rough	19	43	18	44	1183		498750	
10000	2500	1250	30000	3D Offset Rough	18	52	18	44	1132		485640	
16000	4000	2000	30000	3D Offset Rough		44	0	39	44		24150	
14000	3600	1800	30000	Raster,3D Offset,Const Z	6	6	6	5	366	27	12213	
16000	4000	2000	30000	3D Offset Rough	1	5	1	7	65		34200	
14000	3600	1800	30000	Raster,3D Offset,Const Z	8	12	8	7	492	27	13524	
16000	4000	2000	30000	3D Offset Rough		49	0	51	49		26100	
14000	3600	1800	30000	Raster,3D Offset,Const Z	6	24	6	21	384	27	12451	
16000	4000	2000	30000	3D Offset Rough	3	10	2	41	190		116480	
16000	4000	2000	30000	3D Offset Rough	1	17	1	7	77		34200	
16000	4000	2000	30000	3D Offset Rough	1	8	1	3	68		40950	
14000	3600	1800	30000	Raster,3D Offset,Const Z	10	11	11	6	611		19145	
18000	2000	1000	30000	3D Offset Rough		158			158		50400	
16000	1750	875	30000	Raster,3D Offset,Const Z	13	40	13	37	820	27	21335	
18000	2000	1000	30000	3D Offset Rough	1	22	1	10	82		18600	
16000	3500	1750	30000	Raster,3D Offset,Const Z	3	50	4	25	230	27	3981	
18000	4000	2000	30000	3D Offset Rough	1	30	1	18	90		25200	
16000	3500	1750	30000	Raster,3D Offset,Const Z	6	11	6	9	371	27	8800	
18000	4000	2000	30000	3D Offset Rough	2	15	2	0	135		42120	
16000	3500	1750	30000	Raster,3D Offset,Const Z	9	26	9	22	566	27	17752	
18000	1350	675	30000	3D offset	0	35	0	22	35	27		
18000	1350	675	30000	3D offset	0	18	0	13	18	27		
18000	1350	675	30000	3D offset	0	16	0	7	16	27		
26000	1000	500	30000	Along corner	0	14	0	14	14	27		
26000	1000	500	30000	Along corner	1	56	2	39	116			
26000	1000	500	30000	Optimized	0	13	2	39	13			
30000	750	375	30000	Along	0	30	0	26	30	27		
30000	750	375	30000	Optimized	0	57	0	26	57	27		
30000	750	375	30000	Optimized	4	36	0	26	276	27		
32000	600	300	30000	3D offset	1	58	1	22	118	27		
32000	600	300	30000	3D offset	1	22	0	33	82	27		
32000	600	300	30000	3D offset	0	28	0	33	28	27		
36000	450	225	30000	3D offset	3	46	2	39	226	27		
36000	450	225	30000	3D offset	1	57	0	43	117	27		
36000	450	225	30000	3D offset	9	22	0	43	562	27		



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CAD Vol	Vol Removed	MRR(mm3/sec)	Finished area	Times in secs			mm ³ /sec			mm ² /sec		
				Total milling time	Fine milling rate(mm2/sec)	Reductio %	Av.MRR HI	MED	LOW	Average Fin rat HI	MED	LOW
84218	101758	568.48				55						
17843	43407	571.14	9455.00	1363	8.0							
80367	49233		3452.00	565	7.1							
17921	50455		7604.00	1070	7.7							
13434	47816	543.36	3171.00	550	7.1							
224048	179872	553.45										
115934	114461	596.15										
179465	217015	604.50				55						
248386	250364	211.63										
224283	261357	230.88										
12084	12066	274.23				50						
13527	20673	318.05	1873.00	410	5.1							
12318	13782	281.27	2640.00	557	5.4							
58058	58422	307.48	1930.00	433	5.0							
10107	26093	602.21				50						
22933	14746	113.80	4092.00	978	5.0							
4181	14419	175.84	1194.00	312	5.2							
9093	16107	178.97	2096.00	461	5.6							
18246	23874	176.84	2945.00	701	5.2						176	
			58.00		1.7							
			26.00		1.4							
			27.00		1.7					1.4	1.6	1.7
			16		1.1							
			149	116	1.3							
			12.37	13	1.0					1.0	1.2	1.3
			12.44		0.41							
			27.80		0.49							
			155.00		0.56					0.41	0.5	0.6
			44.00		0.37							
			13.00		0.16							
			4.60		0.16					0.16	0.3	0.4
			17.00		0.08							
			6.00		0.05							
			52.28		0.09					0.05	0.1	0.1

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Electrode No:	Material	Machine	Tool	Diameter	Achieved surface	Tool Type	Step over	Depth of cut
11433b412	Graphite	SNC64	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11408b200	Graphite	SNC64	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11408b201	Graphite	SNC64	Ball nose	8	Rough	Graph X	3.2	4.5max
11446b101	Graphite	SNC64	Ball nose	8	Rough	Graph X	3.2	4.5max
11392f401	Graphite	SNC64	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11408b200	Graphite	SNC64	Ball nose	8	Rough	Graph X	3.2	4.5max
			Ball nose	8	Fine	Graph X	0.14	0.14
11392f402	Graphite	SNC64	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11396r202	Graphite	SNC64	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11396r205	Graphite	SNC64	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11367s406	Graphite	SNC 64	Ball nose	6	Rough	Graph X	2.4	3.5max
			Ball nose	6	Fine	Graph X	0.12	0.12
11368b201	Graphite	SNC 64	Ball nose	6	Rough	Graph X	2.4	3.5max
11408f100	Graphite	SNC 64	Ball nose	6	Rough	Graph X	2.4	3.5max
11368b200	Graphite	SNC 64	Ball nose	6	Rough	Graph X	2.4	3.5max
11408f104	Graphite	SNC64	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11433f413	Graphite	SNC64	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11433f410	Graphite	SNC64	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.1	0.1
11433f413	Graphite	SNC64	Ball nose	4	Rough	Graph X	1.6	2.5max
11433f410	Graphite	SNC64	Ball nose	4	Rough	Graph X	1.6	2.5max
11433f406	Graphite	Roders	Ball nose	4	Rough	Graph X	1.6	2.5max
			Ball nose	4	Fine	Graph X	0.12	0.12
11433b414	Graphite	SNC64	Ball nose	4	Rough	Graph X	1.6	2.5max
14374r01	Graphite	SNC 64	Ball nose	2	Fine	Graph X	0.07	0.07
11433b402	Graphite	SNC 64	Ball nose	2	Fine	Graph X	0.07	0.07
11425r100	Graphite	SNC 64	Ball nose	2	Fine	Graph X	0.07	0.07
11433f407	Graphite	SNC64	Ball nose	1.5	Fine	Graph X	0.05	0.05
11396r205	Graphite	SNC 64	Ball nose	1.5	Fine	Graph X	0.05	0.05
11424f201	Graphite	SNC 64	Ball nose	1.5	Fine	Graph X	0.05	0.05
11433b402	Graphite	SNC64	Ball nose	1	Fine	Graph X	0.03	0.03
11433b400	Graphite	SNC 64	Ball nose	1	Fine	Graph X	0.03	0.03
11392f4011	Graphite	SNC 64	Ball nose	1	Fine	Graph X	0.03	0.03
11446b500	Graphite	SNC 64	Ball nose	1	Fine	Graph X	0.03	0.03
11425r100	Graphite	SNC 64	Ball nose	0.8	Fine	Graph X	0.03	0.03
14374r01	Graphite	SNC 64	Ball nose	0.8	Fine	Graph X	0.03	0.03
11424f201	Graphite	SNC 64	Ball nose	0.8	Fine	Graph X	0.03	0.03
11425r100	Graphite	SNC 64	Ball nose	0.5	Fine	Graph X	0.01	0.01
14374r01	Graphite	SNC 64	Ball nose	0.5	Fine	Graph X	0.01	0.01
11392f4011	Graphite	SNC 64	Ball nose	0.5	Fine	Graph X	0.01	0.01

Speed	Feed Cutting	Feed plunging	Rapid feed	Mill strategy	Time taken				Time secs	VDI	Initial Vol	Final vol
18000	4500	2250	30000	3D Offset Rough	2	59	3	30	179		185976	
11000	3000	1500	30000	Raster,3D Offset,Const Z	26	18	19	37	1578	30		84330
18000	4500	2250	30000	3D Offset Rough	1	16	1	22	76		61250	
11000	3000	1500	30000	Raster,3D Offset,Const Z	12	13	8	46	733	30		18032
18000	4500	2250	30000	3D Offset Rough	1	28	1	22	88		61250	
18000	4500	2250	30000	3D Offset Rough	5	59	1	44	359		396480	
18000	4500	2250	30000	3D Offset Rough	1	40	1	30	100		89889	
11000	3000	1500	30000	Raster,3D Offset,Const Z	18	28	18	21	1108	33		46791
18000	4500	2250	30000	3D Offset Rough	1	28	1	22	88		60025	
11000	3000	1500	30000	Raster,3D Offset,Const Z	12	20	11	41	740		18032	
19500	4000	2000	30000	3D Offset Rough	1	15	1	7	75		29304	
14660	3000	1500	30000	Raster,3D Offset,Const Z	8	2	7	19	482	33		11263
19500	4000	2000	30000	3D Offset Rough	1	13	1	5	73		35100	
14660	3000	1500	30000	Raster,3D Offset,Const Z	9	17	9	16	557	27		14982
19500	4000	2000	30000	3D Offset Rough	1	8	1	3	68		40950	
14660	3000	1500	30000	Raster,3D Offset,Const Z	12	13	12	11	733		19145	
16000	4000	2000	30000	3D Offset Rough		44	0	39	44		24150	
14660	3000	1800	30000	Raster,3D Offset,Const Z	7	19	6	5	439	27		12213
16000	4000	2000	30000	3D Offset Rough	1	5	1	7	65		34200	
16000	4000	2000	30000	3D Offset Rough	3	10	2	41	190		116480	
16000	4000	2000	30000	3D Offset Rough	1	17	1	7	77		34200	
24000	4000	2000	30000	3D Offset Rough	2	58	2	50	178		51156	
22000	3000	1500	30000	Raster,3D Offset,Const Z	12	3	11	19	754			22471
24000	4000	2000	30000	3D Offset Rough	2	32	2	18	152		48510	
22000	1500	750	30000	Raster,3D Offset,Const Z	12	1	1	1	957			21335
24000	4000	2000	30000	3D Offset Rough	1	21	1	10	81		17100	
22000	3000	1500	30000	Raster,3D Offset,Const Z	5	13	5	9	313			3981
18000	4000	2000	30000	3D Offset Rough	2	38	2	18	158		50400	
24000	4000	2000	30000	3D Offset Rough	1	22	1	10	82		18600	
24000	4000	2000	30000	3D Offset Rough	1	30	1	18	90		25200	
22000	3000	1500	30000	Raster,3D Offset,Const Z	7	33	6	9	453	27		8800
24000	4000	2000	30000	3D Offset Rough	2	15	2	0	135		42120	
18000	2000	1000	30000	3D offset	0	11	0	7	11	27		
18000	2000	1000	30000	3D offset	0	12	0	8	12	27		
18000	2000	1000	30000	3D offset	0	24	0	22	24	27		
26000	1500	750	30000	Along corner	0	13	0	9	13	27		
26000	1500	750	30000	Along corner	1	49	1	17	109			
26000	1500	750	30000	Optimized	0	9	1	17	9			
30000	1000	500	30000	Along corner	0	23	0	19	23	27		
30000	1000	500	30000	Along corner	0	43	0	26	43	27		
30000	1000	500	30000	Along corner	3	30	0	26	210	27		
30000	1000	500	30000	Along corner	0	9	0	26	9	27		
32000	900	450	30000	3D offset	1	45	1	13	105	27		
32000	900	450	30000	3D offset	0	55	0	21	55	27		
32000	900	450	30000	3D offset	0	19	0	21	19	27		
30000	500	250	30000	3D offset	3	24	2	23	204	27		
36000	500	250	30000	Optimized	1	46	0	38	106	27		
36000	500	250	30000	Optimized	8	26	0	38	506	27		

CAD Vol	Vol Removed	MRR(mm3/sec)	Finished	Total milling	Fine milling	Reductio	Av.MRR	Average Fin rat		
84218	101758	568.48				55				
			9455.00	1363	6.0					
17843	43407	571.14				71				
			3452.00	635	6.2					
13434	47816	543.36				78				
179465	217015	604.50				55				
	89889					100				
		0.00	6575.00	1208	5.9					
	60025					100				
		0.00	3452.00	828	4.7					
		0.00				0				
		0.00	2197.00	557	4.6					
						0				
		0.00	2508.00	630	4.5					
		0.00				0				
		0.00	3403.00	801	4.6					
12084	12066	274.23				50				
		0.00	1873.00	483	4.3					
13527	20673	305.26				58				
58058	58422	307.48				50				
10107	24093	300.45				68				
	51156					100				
		0.00	3135.00	932	4.2					
	48510	319.14				100				
		0.00	4092.00	1109	4.3					
		0.00	1397.00	394	4.5					
22933	175.84					54				
4181	175.84					78				
9093	16107	178.97				64				
		0.00	2096.00	543	4.6					
18246	23874	176.84				57				
			27.00		2.5					
			26.00		2.2					
			58.00		2.4			2.2	2.4	2.5
			16		1.2					
			149	5070	1.4					
			12.37	4346	1.4			1.2	1.3	1.4
			12.44		0.5					
			27.80		0.6					
			155.00		0.7					
			9.00		1.0			0.50	0.8	1
			44.00		0.42					
			13.00		0.24					
			4.60		0.24			0.24	0.3	0.4
			17.00		0.08					
			6.00		0.06					
			52.28		0.10			0.06	0.1	0.10



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Electrode No:	Material	Machine	Tool	Diameter	Achieved surface	Tool Type	Step over	Depth of cut
11362k02	Copper	Roders	Ball nose	6	Rough	Hard X	2.4	0.2
11420r401	Copper	Roders	Ball nose	6	Rough	Hard X	2.4	0.2
11397u400	Copper	Roders	Ball nose	6	Rough	Hard X	2.4	0.2
11367r411	Copper	Roders	Ball nose	6	Rough	Hard X	2.4	0.2
11408r104	Copper	Roders	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11408r103	Copper	Roders	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11408r102	Copper	Roders	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11368r209	Copper	Roders	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11389k201	Copper	Roders	Ball nose	4	Rough	Hard X	1.6	0.16
11389k200	Copper	Roders	Ball nose	4	Rough	Hard X	1.6	0.16
11405fr06	Copper	Roders	Ball nose	4	Rough	Hard X	1.6	0.16
11390b1502	Copper	Roders	Ball nose	4	Rough	Hard X	1.6	0.16
11362k02	Copper	Roders	Ball nose	6	Fine	Hard X	0.12	0.12
11420r401	Copper	Roders	Ball nose	6	Fine	Hard X	0.12	0.12
11397u400	Copper	Roders	Ball nose	6	Fine	Hard X	0.12	0.12
11368r209	Copper	Roders	Ball nose	6	Fine	Hard X	0.12	0.12
11389k201	Copper	Roders	Ball nose	4	Fine	Hard X	0.1	0.1
11389k200	Copper	Roders	Ball nose	4	Fine	Hard X	0.1	0.1
11405r05	Copper	Roders	Ball nose	4	Fine	Hard X	0.1	0.1
11405fr06	Copper	Roders	Ball nose	4	Fine	Hard X	0.1	0.1
14156r211	Copper	Roders	Ball nose	2	Fine	Hard X	0.06	0.06
11446b513	Copper	Roders	Ball nose	2	Fine	Hard X	0.06	0.06
11446b512	Copper	Roders	Ball nose	2	Fine	Hard X	0.06	0.06
14156k203	Copper	Roders	Ball nose	1.5	Fine	Hard X	0.045	0.045
11446r503	Copper	Roders	Ball nose	1.5	Fine	Hard X	0.045	0.045
1403202r05	Copper	Roders	Ball nose	1.5	Fine	Hard X	0.045	0.045
1403202r05	Copper	Roders	Ball nose	0.8	Fine	Hard X	0.024	0.024
11446b513	Copper	Roders	Ball nose	0.8	Fine	Hard X	0.024	0.024
11446b512	Copper	Roders	Ball nose	0.8	Fine	Hard X	0.024	0.024
1403201r01	Copper	Roders	Ball nose	0.5	Fine	Hard X	0.015	0.015
1403202r05	Copper	Roders	Ball nose	0.5	Fine	Hard X	0.015	0.015
11446r503	Copper	Roders	Ball nose	0.5	Fine	Hard X	0.015	0.015

Speed	Feed Cutting	Feed plunging	Rapid feed	Mill strategy	Time taken				Time secs	VDI	Initial Vol	Final vol
21000	2500	1250	30000	3D Offset Rough	7	43	6	31	463		3375	
21000	2500	1250	30000	3D Offset Rough	4	6	3	36	246		2925	
21000	2500	1250	30000	3D Offset Rough	4	58	3	9	298		2250	
21000	2500	1250	30000	3D Offset Rough	8	3	5	2	483		3375	
16000	2500	1250	30000	3D Offset Rough	4	47	3	17	287		3600	
16000	2500	1250	30000	3D Offset Rough	5	53	3	57	353		3600	
16000	2500	1250	30000	3D Offset Rough	6	2	3	59	362		3600	
16000	2500	1250	30000	3D Offset Rough	6	28	3	31	388		3375	
32000	3000	1500	30000	3D Offset Rough	6	3	5	38	363		3600	
32000	3000	1500	30000	3D Offset Rough	7	25	6	22	445		3600	
32000	3000	1500	30000	3D Offset Rough	10	49	10	20	649		3600	
32000	3000	1500	30000	3D Offset Rough	6	8	4	52	368		2250	
21000	2500	1250	30000	Raster,3D Offset,Const Z	2	42	2	55	162			1404
21000	2500	1250	30000	Raster,3D Offset,Const Z	3	55	3	24	235			1885
21000	2500	1250	30000	Raster,3D Offset,Const Z	2	35	3	24	155			1885
21000	2500	1250	30000	Raster,3D Offset,Const Z	3	9	3	18	189			1563
32000	3000	1500	30000	Raster,3D Offset,Const Z	2	19	2	6	139			1475
32000	3000	1500	30000	Raster,3D Offset,Const Z	3	13	6	26	193			1908
20000	3000	1500	30000	Raster,3D Offset,Const Z	3	4	2	47	184			2203
20000	3000	1500	30000	Raster,3D Offset,Const Z	2	20	2	17	140			1352
38000	1700	1850	30000	3D Offset	0	11	0	22	11			
38000	1700	1850	30000	3D Offset	0	18	0	22	18			
38000	1850	1000	30000	3D Offset	0	10	0	10	10			
40000	1200	600	30000	3D Offset	0	42	0	15	42			
40000	1200	600	30000	3D Offset	0	3	0	39	3			
40000	1200	600	30000	3D Offset	0	18	0	21	18			
42000	800	400	30000	3D Offset	0	56	0	50	56			
42000	800	400	30000	3D Offset	0	56	0	50	56			
42000	800	400	30000	3D Offset	0	16	0	50	16			
42000	500	250	30000	3D Offset	5	25	2	19	325			
42000	500	250	30000	3D Offset	1	13	1	2	73			
42000	500	250	30000	3D Offset	0	15	1	2	15			



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CAD Vol	Vol Removed	MRR(mm3/sec)	Finished	Total milling	Fine milling	Reduction	Av.MRR	Average Fin rat		
1406	1969	4.25				58				
2133	792	3.22				27				
1078	1172	3.93				52				
1020	2355	4.88				70				
2258	1342	4.68				37				
1833	1767	5.01				49				
1792	1808	4.99				50				
1451	1924	4.96				57	4.91			
1849	1751	4.82				49				
1839	1761	3.96				49				
1396	2204	3.40				61				
1035	1215	3.30				54				
			562.00	1624	3.5					
			673.00	1414	2.9					
			455.00	920	2.9					
			579.00	2566	3.1			2.9	3.2	3.5
			494.00	2705	4.1					
			800.00	808	4.1					
			800.00	2274	4.3					
			647.00	517	4.6			4.1	4.4	4.6
			38.20		3.5					
			14.02		1.4			1.4	2.5	3.5
			5.00		1.3					
			3.50		1.2					
			17.00		0.9			0.9	1.1	1.3
			16.40		0.29					
			17.70		0.32					
			5.18		0.32			0.29	0.31	0.32
			21.00		0.06					
			10.00		0.14					
			1.58		0.11			0.06	0.1	0.1



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Electrode No:	Material	Machine	Tool	Diameter	Achieved surface	Tool Type	Step over	Depth of cut
11408r104	Copper	Hyper5	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11408r103	Copper	Hyper5	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11408r102	Copper	Hyper5	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11368r209	Copper	Hyper5	Tip radius	6(0.3)	Rough	Hard X	2.4	0.2
11420r401	Copper	Hyper5	Ball nose	6	Rough	Hard X	2.4	0.2
11362k02	Copper	Hyper5	Ball nose	6	Rough	Hard X	2.4	0.2
11420r401	Copper	Hyper5	Ball nose	6	Rough	Hard X	2.4	0.2
11397u400	Copper	Hyper5	Ball nose	6	Rough	Hard X	2.4	0.2
11389k201	Copper	Hyper5	Ball nose	4	Rough	Hard X	1.6	0.16
11389k200	Copper	Hyper5	Ball nose	4	Rough	Hard X	1.6	0.16
11390b1502	Copper	Hyper5	Ball nose	4	Rough	Hard X	1.6	0.16
11405fr06	Copper	Hyper5	Ball nose	4	Rough	Hard X	1.6	0.16
11397u400	Copper	Hyper5	Ball nose	6	Fine	Hard X	0.12	0.12
11368r209	Copper	Hyper5	Ball nose	6	Fine	Hard X	0.12	0.12
11362k02	Copper	Hyper5	Ball nose	6	Fine	Hard X	0.12	0.12
11420r401	Copper	Hyper5	Ball nose	6	Fine	Hard X	0.12	0.12
11405fr06	Copper	Hyper5	Ball nose	4	Fine	Hard X	0.1	0.1
11397u401	Copper	Hyper5	Ball nose	4	Fine	Hard X	0.1	0.1
11405r05	Copper	Hyper5	Ball nose	4	Fine	Hard X	0.1	0.1
11390b1502	Copper	Hyper5	Ball nose	4	Fine	Hard X	0.1	0.1
14156r211	Copper	Hyper5	Ball nose	2	Fine	Hard X	0.06	0.06
11446b513	Copper	Hyper5	Ball nose	2	Fine	Hard X	0.06	0.06
11446b512	Copper	Hyper5	Ball nose	2	Fine	Hard X	0.06	0.06
11446r503	Copper	Hyper5	Ball nose	1.5	Rough	Hard X	0.045	0.045
14156k203	Copper	Hyper5	Ball nose	1.5	Fine	Hard X	0.045	0.045
1403202r05	Copper	Hyper5	Ball nose	1.5	Fine	Hard X	0.045	0.045
1403202r05	Copper	Hyper5	Ball nose	0.8	Fine	Hard X	0.024	0.024
11446b513	Copper	Hyper5	Ball nose	0.8	Fine	Hard X	0.024	0.024
11446b512	Copper	Hyper5	Ball nose	0.8	Fine	Hard X	0.024	0.024
1403201r01	Copper	Hyper5	Ball nose	0.5	Fine	Hard X	0.015	0.015
1403202r05	Copper	Hyper5	Ball nose	0.5	Fine	Hard X	0.015	0.015
11446r503	Copper	Hyper5	Ball nose	0.5	Fine	Hard X	0.015	0.015

Speed	Feed Cutting	Feed plunging	Rapid feed	Mill strategy	Time taken				Time secs	VDI	Initial Vol	Final vol
11400	3500	1750	30000	3D Offset Rough	3	27	3	17	207		3600	
11400	3500	1750	30000	3D Offset Rough	4	15	3	57	255		3600	
11400	3500	1750	30000	3D Offset Rough	4	21	3	59	261		3600	
11400	3500	1750	30000	3D Offset Rough	3	46	3	31	226		3330	
16000	3400	1700	30000	3D Offset Rough	3	6	2	53	186		2925	
16000	3400	1700	30000	3D Offset Rough	7	43	6	31	463		3375	
16000	3400	1250	30000	3D Offset Rough	4	6	3	36	246		2925	
16000	3400	1250	30000	3D Offset Rough	4	58	3	9	298		2250	
32000	3000	1500	30000	3D Offset Rough	6	3	5	38	363		3600	
32000	3000	1500	30000	3D Offset Rough	7	25	6	22	445		3600	
20000	3000	1500	30000	3D Offset Rough	6	8	4	52	368		2250	
20000	3000	1500	30000	3D Offset Rough	10	49	10	20	649		3600	
21000	3400	1700	30000	Raster,3D Offset,Const Z	1	54	3	24	114			
16000	3400	1700	30000	Raster,3D Offset,Const Z	2	21	3	18	141			
21000	3400	1700	30000	Raster,3D Offset,Const Z	2	22	2	55	142			
21000	3400	1700	30000	Raster,3D Offset,Const Z	2	57	3	24	177			
20000	3000	1500	30000	Raster,3D Offset,Const Z	3	1	2	17	181			
20000	3000	1500	30000	Raster,3D Offset,Const Z	1	55	1	21	115			
20000	3000	1500	30000	Raster,3D Offset,Const Z	3	13	2	47	193			
20000	3000	1500	30000	Raster,3D Offset,Const Z	2	14	1	55	134			
16000	1500	750	30000	3D Offset	0	23	0	22	23			
16000	1500	750	30000	3D Offset	0	21	0	22	21			
16000	1500	750	30000	3D Offset	0	11	0	22	11			
24000	500	500	30000	3D Offset	0	4	0	15	4			
24000	1000	500	30000	3D Offset	0	50	0	39	50			
24000	1000	500	30000	3D Offset	0	22	0	21	22			
30000	750	375	30000	3D Offset	0	59	0	50	59			
30000	750	375	30000	3D Offset	1	0	0	50	60			
30000	750	375	30000	3D Offset	0	18	0	50	18			
40000	350	175	30000	3D Offset	6	45	2	19	405			
40000	350	175	30000	3D Offset	1	47	1	2	107			
40000	350	175	30000	3D Offset	0	20	1	2	20			



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CAD Vol	Vol Removed	MRR(mm3/sec)	Finished	Total milling	Fine milling	Reductio	Av.MRR	Average Fin rat		
2258	1342	6.48				37				
1833	1767	6.93				49				
1792	1808	6.93				50				
1772	1558	6.89				47	6.81			
2134	791	4.25				27				
1406	1969	4.25				58				
2133	792	3.22				27				
1078	1172	3.93				52				
1849	1751	4.82				49				
1839	1761	3.96				49				
1035	1215	3.30				54				
1396	2204	3.40				61				
			455.00	2946	4.0					
			579.00	3499	4.1					
			562.00	3229	4.0					
			673.00	2943	3.8			3.8	4	4.1
			647.00	181	3.6					
			435.00	296	3.8					
			800.00	489	4.1					
			503.00	623	3.8			3.6	3.9	4.1
			38.20		1.7					
			11.00		0.5					
			14.02		1.3			1.3	1.5	1.7
			3.19		0.9					
			55.00		1.1					
			17.00		0.8			0.8	1	1.1
			16.40		0.28					
			17.70		0.30					
			5.18		0.29			0.28	0.3	0.30
			21.00		0.05					
			10.00		0.09					
			1.58		0.08			0.05	0.1	0.1



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APPENDIX C- MAGAFORCE TOOL PRICE LIST

(Prices in 2011)

Diamond coated magaforce Graph'X 8529G K15 carbide)- Graphite milling

Hard'X coating magaforce Hard'X 8529H K15 carbide)-Copper milling

Tool Diameter	Graphite Milling Tool	Copper Milling Tool
	Price(Euro)	Price(Euro)
8 Ball	82.45	
6 -0.3tip		70.63
6Ball	71.24	51.62
4Ball	67.98	46.87
3Ball	66.95	45.84
2Ball	61.8	39.14
1.5Ball	61.8	39.14
1Ball	61.8	39.14
0.8Ball	62.83	40.70
0.5Ball	63.86	41.20



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APPENDIX D- COST CALCULATOR

					1-Graphite Grade1	7.9*10 ⁻⁴	4-copper block	6.89*10 ⁻⁴				
					2-Graphite Grade2	2.1*10 ⁻⁴	5-Standered bar	6.39*10 ⁻⁴				
					3=Graphite Grade3	5.9*10 ⁻⁵						
Roders Graphite Milling Machine										Complexity of electrode surface		
Elect. No	X	Y	Z	Block Size/mm	Material grad	Rate	CAD Volume		SELECT	ROUGH	TOOL	
									8	6	4	
11395r08	21	21	26	11466	2	0	3002	Rough1 tool used	0	1	0	
						0.00021		Time(T _m)	0.00	30.89	0.00	
						0		Rough2 Vol		0	0	
						0		Time rough2/sec	0	0	0	
						0		Machine Time(T _M)	0.00	40.89	0.00	
SNC 64 Graphite Milling Machine										Complexity of electrode surface		
Elect. No	X	Y	Z	Block Size/mm	Material grad	Rate	CAD Volume		SELECT	ROUGH	TOOL	
									8	6	4	
11395r08	21	21	26	11466	2	0	3002	Rough1 tool used	0	1	0	
						0.00021		Time(T _m)	0	30.89051095	0	
						0		Rough2 Vol		0	0	
						0		Time rough2/sec	0	0	0	
						0		Machine Time(T _M)	0	40.89051095	0	
V55 Copper Milling Machine										Complexity of electrode surface		
Elect. No	X	Y	Z	Block Size/mm	Material grad	Rate	CAD Volume		SELECT	ROUGH	TOOL	
									6mm0.3Tip	6	4	
11395f03	15	15	19	4275	5	0	1840	Rough1 tool used	1	0	0	
						0.000639		Time(T _m)	357.6475934	0	0	
						0		Rough2 Vol		0	0	
						0		Time rough2/sec	0	0	0	
						0		Machine Time(T _M)	367.6475934	0	0	
Roders Copper Milling Machine										Complexity of electrode surface		
Elect. No	X	Y	Z	Block Size/mm	Material grad	Rate	CAD Volume		SELECT	ROUGH	TOOL	
									6mm0.3Tip	6	4	
11395f03	15	15	19	4275	5	0	1840	Rough1 tool used	1	0	0	
						0.000639		Time(T _m)	496.0564547	0	0	
						0		Rough2 Vol		0	0	
						0		Time rough2/sec	0	0	0	
						0		Machine Time(T _M)	506.0564547	0	0	



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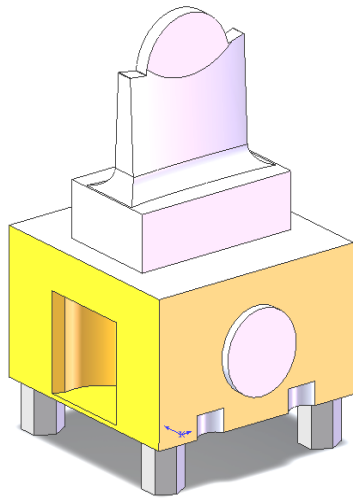
COST CALCULATOR

HIGH MED LOW																	
1 0 0																	
A R E A D O N E																	
F I N E T O O L																	
8	6	4	2	1.5	1	0.8	0.5	Material Cost	Rough Tool cost	Fine tool cost	Cost involved with machine	Design and Programming Cost	Holder Cost	Other cost	Total cost of Producing Electrode	Total Time /mins	
0 863 0												Time spent/min					
T I M E								0	2.439814462			30	25	2			30
0 0 173 0 0 0 0 0								2.40786								Shop Floor	
C O S T								0								3.72	
0 0 15 0 0 0 0 0								0									
MACHINE TIME								0									
0 0 183 0 0 0 0 0								2.41	2.44	14.82	41.35	114	25	2	202.01	33.72	
HIGH MED LOW																	
1 0 0																	
A R E A D O N E																	
F I N E T O O L																	
8	6	4	2	1.5	1	0.8	0.5	Material Cost	Rough Tool cost	Fine tool cost	Cost involved with machine	Design and Programming Cost	Holder cost	Other cost	Total cost of Producing Electrode	Total Time /mins	
0 863 0												Time spent/min					
T I M E								0	2.439814462			30	25	2		30	
0 0 205 0 0 0 0 0								2.40786								Shop Floor	
T O O L C O S T								0								4.27	
0 0 18 0 0 0 0 0								0									
MACHINE TIME								0									
0 0 215 0 0 0 0 0								2.41	2.44	17.64	45.38	114	25	2	208.86	34.27	
HIGH MED LOW																	
0 0 1																	
A R E A D O N E																	
F I N E T O O L																	
6	Tip	6	4	2	1.5	1	0.8	0.5	Material Cost	Rough Tool cost	Fine tool cost	Cost involved with machine	Design and Programming Cost	Holder cost	Other cost	Total cost of Producing Electrode	Total Time /mins
0 863 0												Time spent/min					
T I M E								0	22.96498491			30	25	2		30	
0 0 210 0 0 0 0 0								0								Shop Floor	
C O S T								0								9.80	
0 0 10 0 0 0 0 0								0									
MACHINE TIME								2.731725									
0 0 220 0 0 0 0 0								2.73	22.96	9.97	73.52	114	25	2	250.18	39.80	
HIGH MED LOW																	
0 0 1																	
A R E A D O N E																	
F I N E T O O L																	
6	Tip	6	4	2	1.5	1	0.8	0.5	Material Cost	Rough Tool cost	Fine tool cost	Cost involved with machine	Design and Programming Cost	Holder cost	Other cost	Total cost of Producing Electrode	Total Time /mins
0 863 0												Time spent/min					
T I M E								0	31.85238544			30	25	2		30	
0 0 188 0 0 0 0 0								0								Shop Floor	
T O O L C O S T								0								11.73	
0 8.9 0 0 0 0 0 0								0									
MACHINE TIME								2.731725									
0 0 198 0 0 0 0 0								2.73	31.85	8.88	130.18	114	25	2	314.64	41.73	



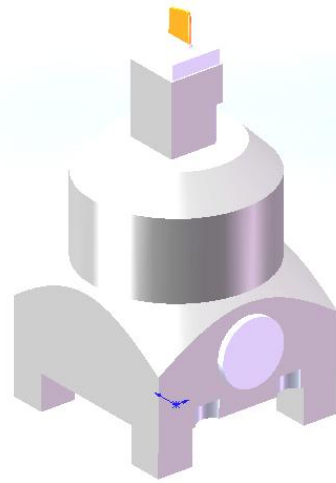
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APPENDIX E – CAD MODELS



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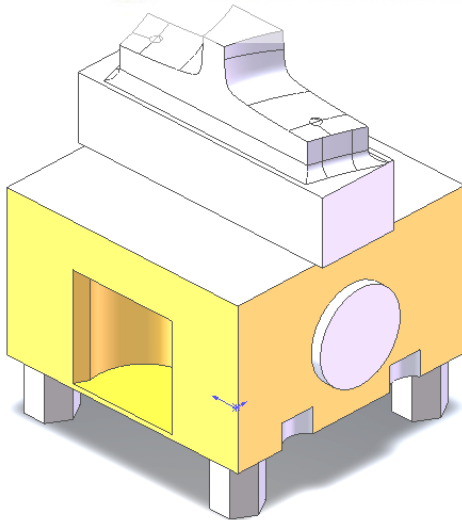
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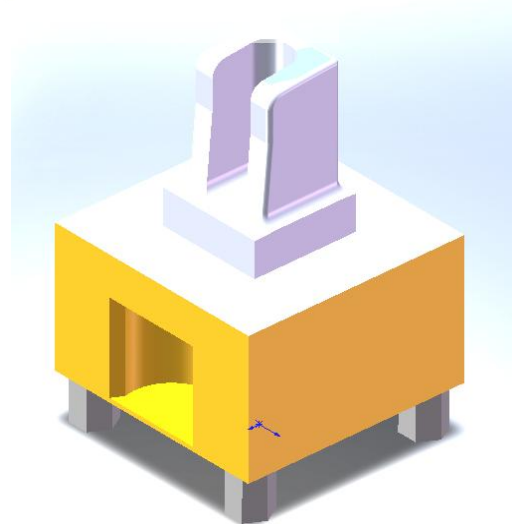
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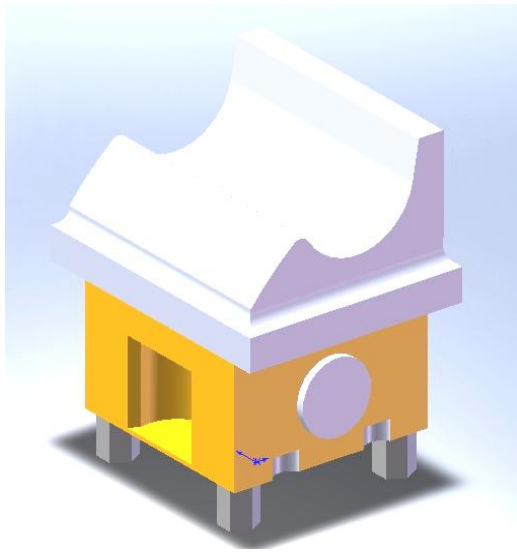
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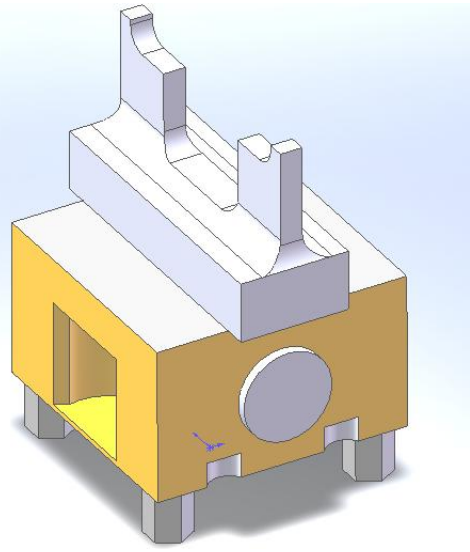
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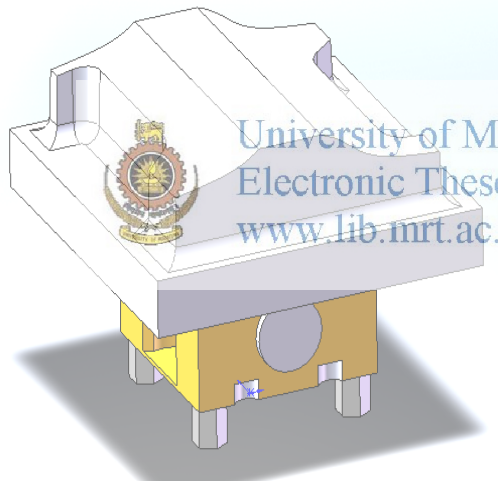
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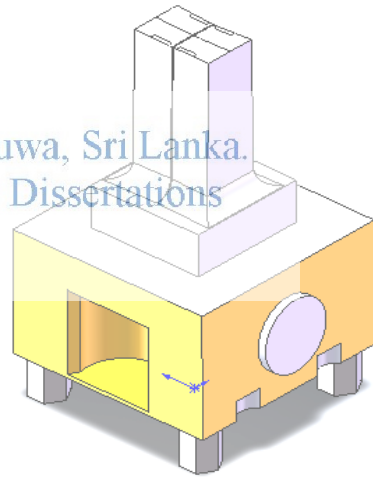
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Electrode no: 11387r102



Electrode no: 11393r04



Electrode no: 11408b200

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