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# A study of the effect of heat treatments on EN9 steel - grain structure and mechanical properties

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The Plymouth Student Scientist

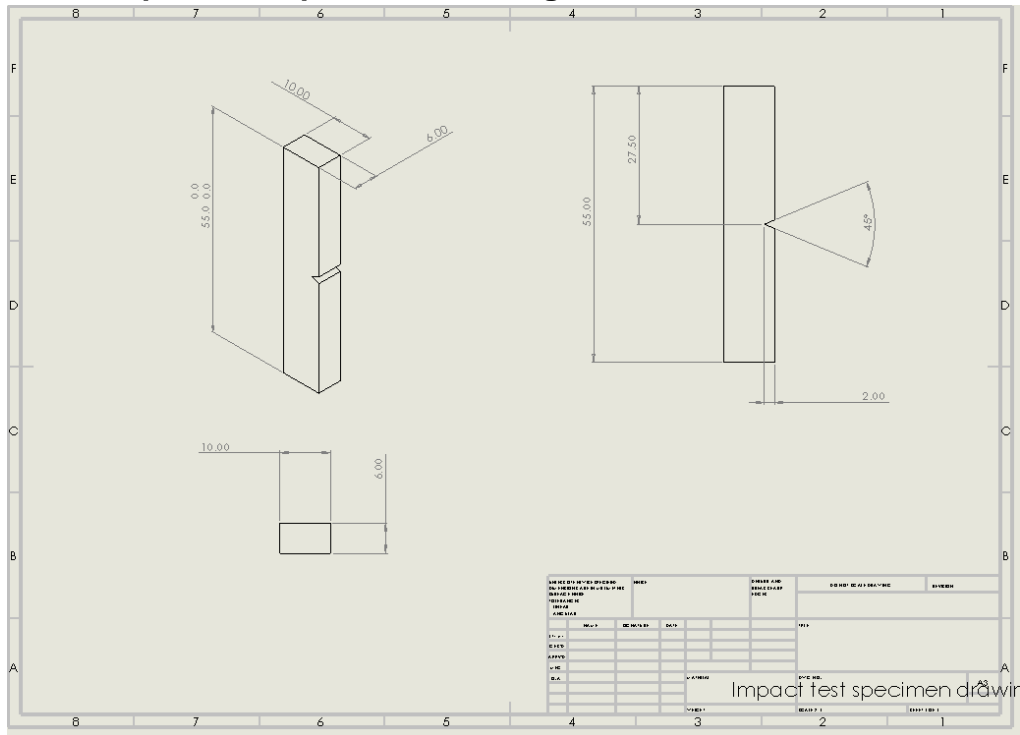
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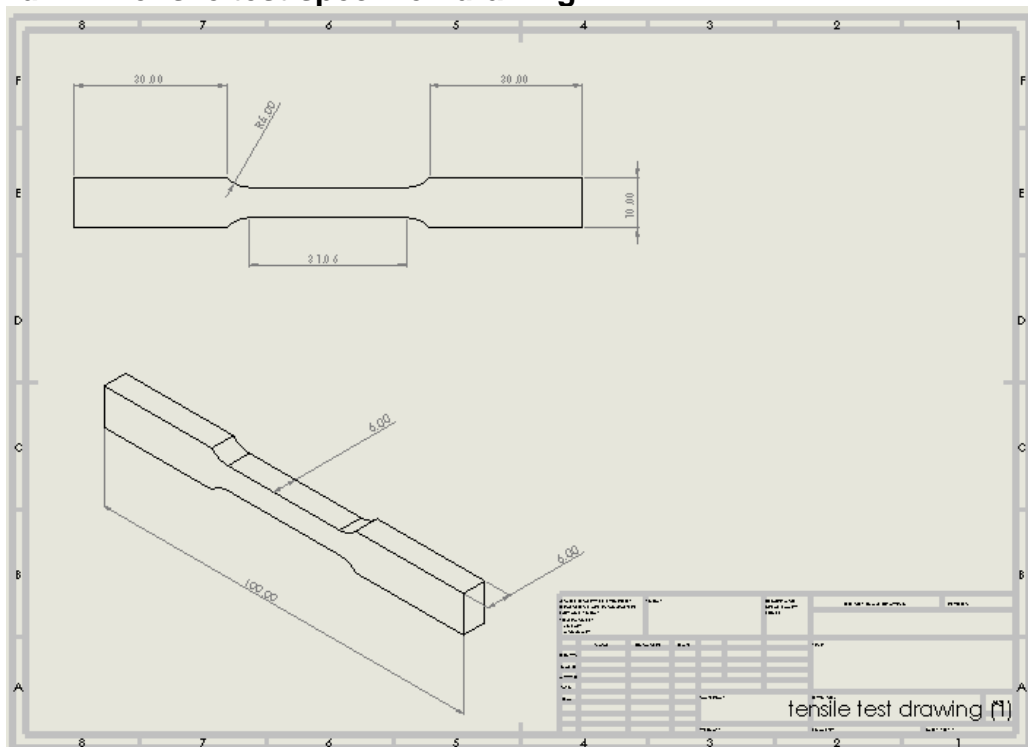
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## Appendices

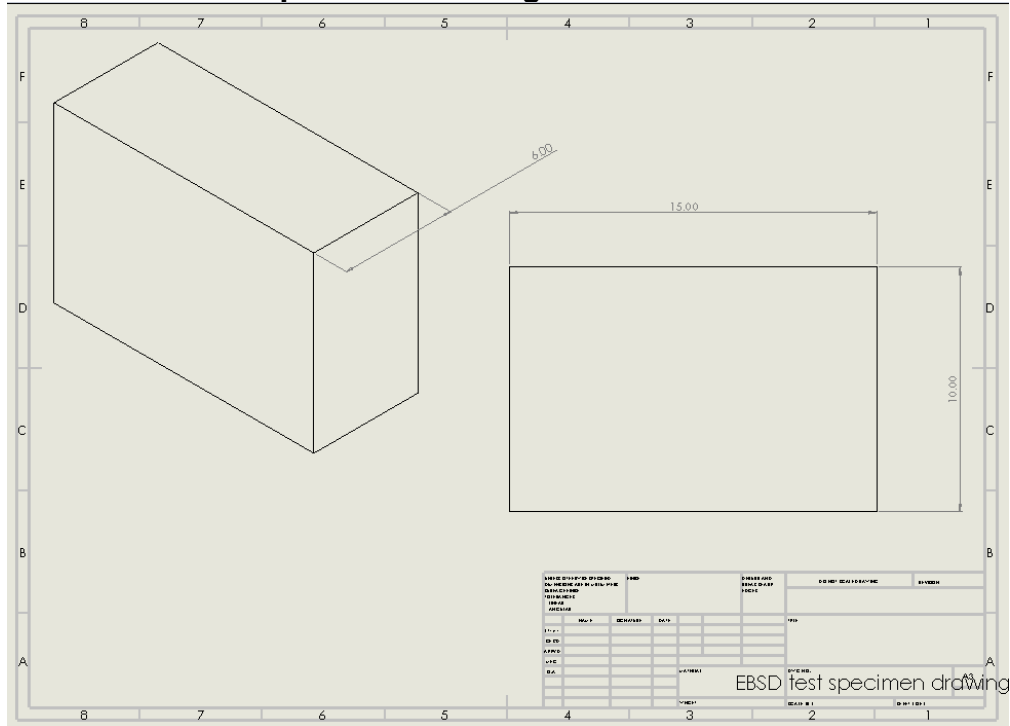
### Appendix 1: Impact test specimen drawing



### Appendix 2: Tensile test specimen drawing.



### Appendix 3: EBSD test specimen drawing



### Appendix 4: Results of energy absorption from impact testing.

Property	Unit	Testing Parameters				
		Normalised	Quenched	250°C Temper	450°C Temper	650°C Temper
Test 1	J	43.00	11.00	5.00	67.00	68.00
Test 2	J	48.00	10.00	6.00	47.00	103.00
Test 3	J	48.00	8.00	13.00	51.00	130.00
Test 4	J	46.00	7.00	12.00	51.00	82.00
Test 5	J	46.00	9.00	13.00	54.00	137.00
Mean Impact Energy Absorption	J	46.20	9.00	9.80	54.00	104.00
Standard deviation	-	1.83	1.41	3.54	6.87	26.63
Coefficient of variation	%	3.97	15.71	36.16	12.72	25.61

**Appendix 5: Results of the tensile modulus from tensile testing.**

Property	Unit	Testing Parameters				
		Normalised	Quenched	250°C Temper	450°C Temper	650°C Temper
Test 1	Mpa	797.93	646.68	1333.40	1388.33	901.82
Test 2	Mpa	795.26	N/A	986.81	1234.77	901.02
Test 3	Mpa	802.21	1311.26	634.28	1248.99	934.71
Test 4	Mpa	814.54	481.50	1379.91	1347.82	881.23
Test 5	Mpa	823.02	605.08	983.35	1190.70	867.28
Mean Tensile Strength	Mpa	806.59	761.13	1063.55	1282.12	897.21
Standard deviation	-	10.54	323.37	271.84	73.88	22.78
Coefficient of variation	%	1.31	42.49	25.56	5.76	2.54

**Appendix 6: Results of the tensile strength testing from tensile testing.**

Property	Unit	Testing Parameters				
		Normalised	Quenched	250°C Temper	450°C Temper	650°C Temper
Test 1	GPa	203.43	255.55	200.72	179.34	220.68
Test 2	GPa	209.30	N/A	199.48	180.81	252.08
Test 3	GPa	N/A	130.23	239.48	274.44	209.15
Test 4	GPa	229.69	190.45	177.78	237.70	242.32
Test 5	GPa	221.97	219.14	154.60	204.09	243.88
Mean tensile Modulus	GPa	216.10	198.84	194.41	215.28	233.62
Standard deviation	-	10.32	45.84	28.14	36.35	16.05
Coefficient of variation	%	4.78	23.05	14.47	16.89	6.87

**Appendix 7: Results of the yield strength from tensile testing.**

Property	Unit	Testing Parameters				
		Normalised	Quenched	250°C Temper	450°C Temper	650°C Temper
Test 1	Mpa	485.49	646.68	1333.40	501.73	757.86
Test 2	Mpa	491.73	N/A	986.81	1234.77	757.30
Test 3	Mpa	485.80	1311.26	634.28	1127.99	877.81
Test 4	Mpa	497.33	481.50	1379.91	1161.22	770.24
Test 5	Mpa	499.38	605.08	983.35	1138.05	756.28
Mean Yield Strength	Mpa	491.95	761.13	1063.55	1032.75	783.90
Standard deviation	-	5.72	323.37	271.84	268.12	47.23
Coefficient of variation	%	1.16	42.49	25.56	25.96	6.03

**Appendix 8: Results of the Vicker’s hardness testing.**

Distance from centre edge	Unit	Testing Parameters				
		Normalised	Quenched	250°C Temper	450°C Temper	650°C Temper
0.50	HV	260.20	744.30	N/A	456.50	317.40
1.50	HV	262.70	744.30	640.00	461.10	315.50
2.50	HV	263.70	749.00	679.20	449.70	320.10
3.50	HV	266.20	595.00	649.60	453.10	315.50
4.50	HV	259.70	778.80	661.40	458.80	315.60
5.50	HV	254.40	766.20	621.40	449.70	324.20
6.50	HV	258.70	N/A	636.20	448.60	309.00
7.50	HV	257.30	725.60	640.00	447.30	308.40
8.50	HV	259.70	703.20	643.80	448.60	307.70
9.50	HV	257.30	557.70	634.30	461.10	315.50
10.50	HV	252.50	649.60	641.90	458.80	309.60
11.50	HV	261.70	591.60	645.70	450.90	322.80
12.50	HV	260.20	610.60	640.00	445.30	312.20
13.50	HV	261.20	657.40	665.40	452.00	318.80
14.50	HV	262.70	696.70	647.60	449.70	320.10
<b>Mean Hardness Value</b>	HV	259.88	683.57	646.18	452.75	315.49
<b>Standard deviation</b>	-	3.42	70.30	13.88	5.02	5.07
<b>Coefficient of variation</b>	%	1.31	10.28	2.15	1.11	1.61