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

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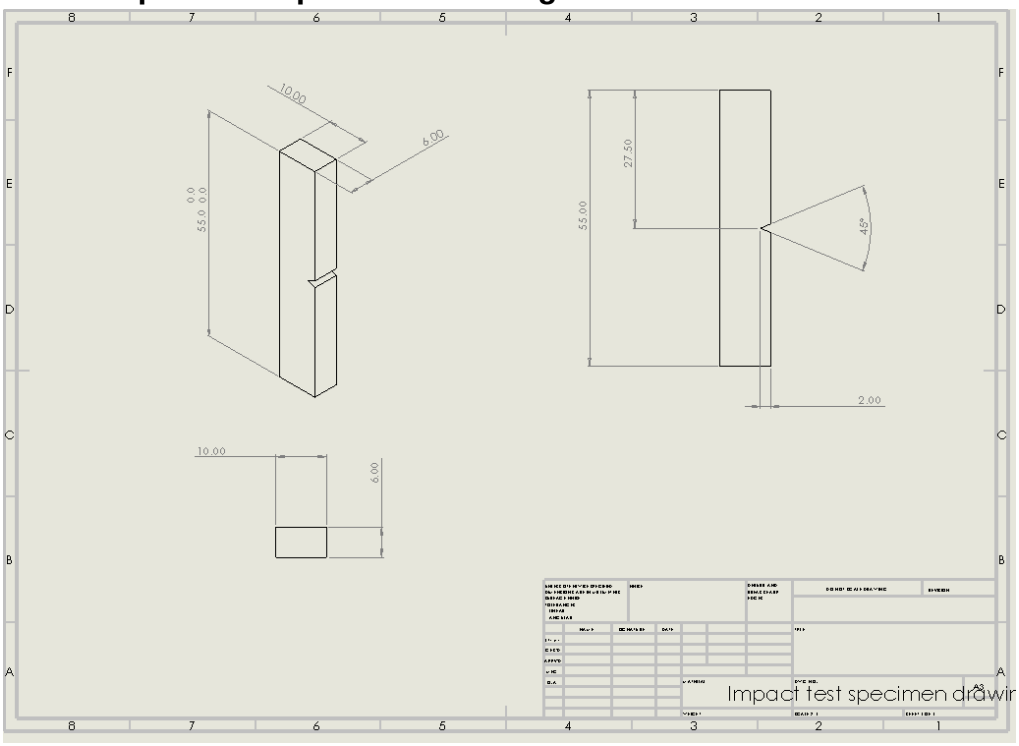
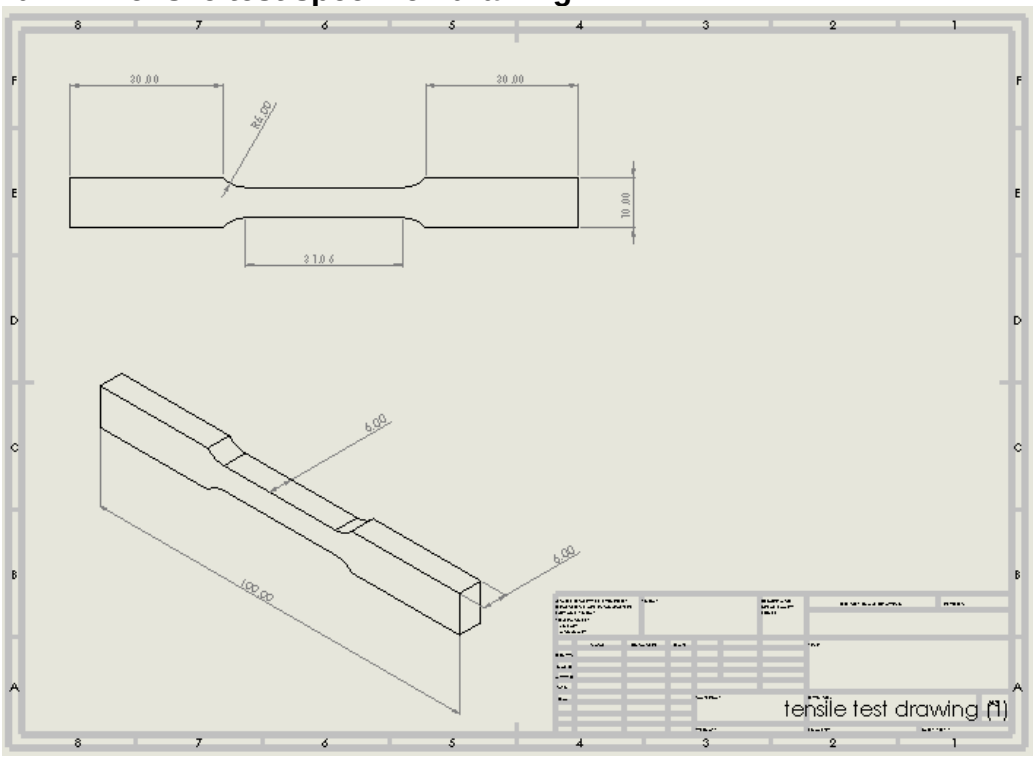
Appendices

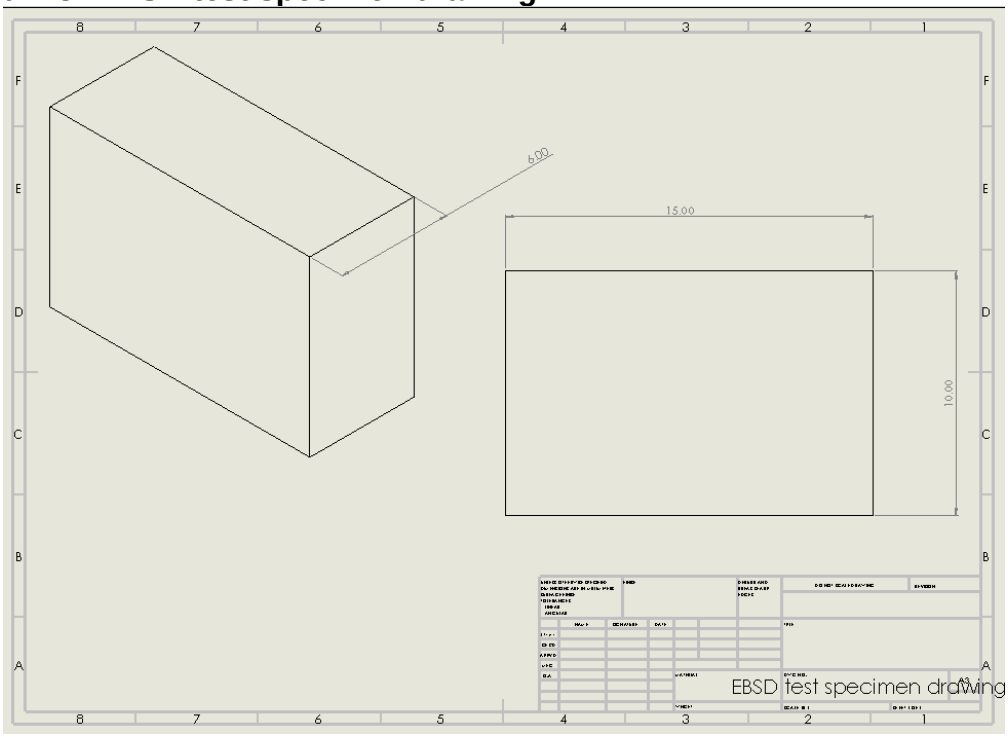
Appendix 1: Impact test specimen drawing



Appendix 2: Tensile test specimen drawing.



Appendix 3: EBSD test specimen drawing



Appendix 4: Results of energy absorption from impact testing.

		Testing Parameters				
Property	**Unit**	**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.

		Testing Parameters				
Property	Unit	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.

		Testing Parameters				
Property	Unit	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.

		Testing Parameters				
Property	Unit	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.

		Testing Parameters				
Distance from centre edge	**Unit**	**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**
Mean Hardness Value	**HV**	**259.88**	**683.57**	**646.18**	**452.75**	**315.49**
Standard deviation	**-**	**3.42**	**70.30**	**13.88**	**5.02**	**5.07**
Coefficient of variation	**%**	**1.31**	**10.28**	**2.15**	**1.11**	**1.61**