Appendix 1: Figures Final Report LEAN

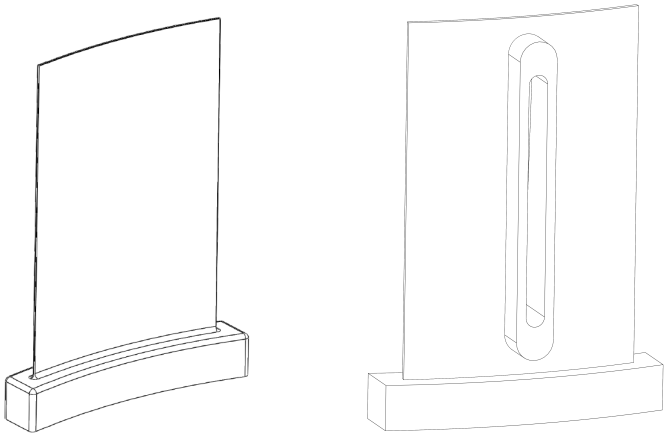


Figure 1: Two levels of geometrical complexity, (a) *Simple Geometry 1* and (b) *Simple Geometry 2*

Figure 2: Casting trials performed at TPC, *Simple Geometry 1*.

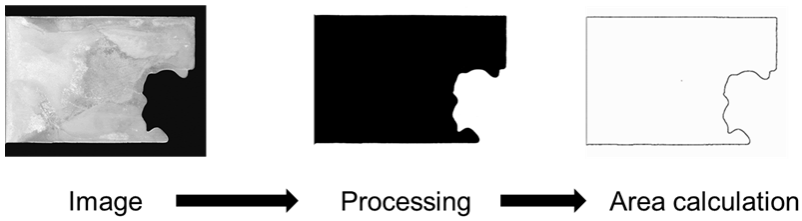


Figure 3: Evaluation of fluidity by measuring filled projected area of the blade.

Fe	C	Si	Mn	P	S	Cr	Ni	Cu	Nb	N
Bal.	0.042	0.72	0.60	0.014	0.014	16.36	3.73	3.1	0.042	0.057

Table 1: Composition of cast alloy.

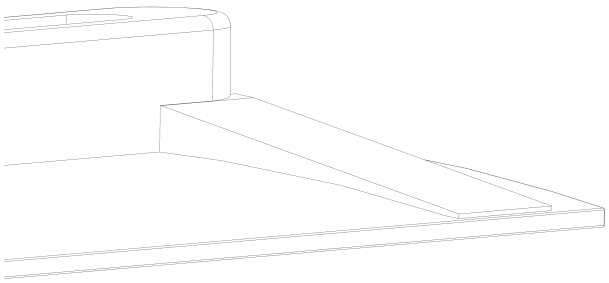
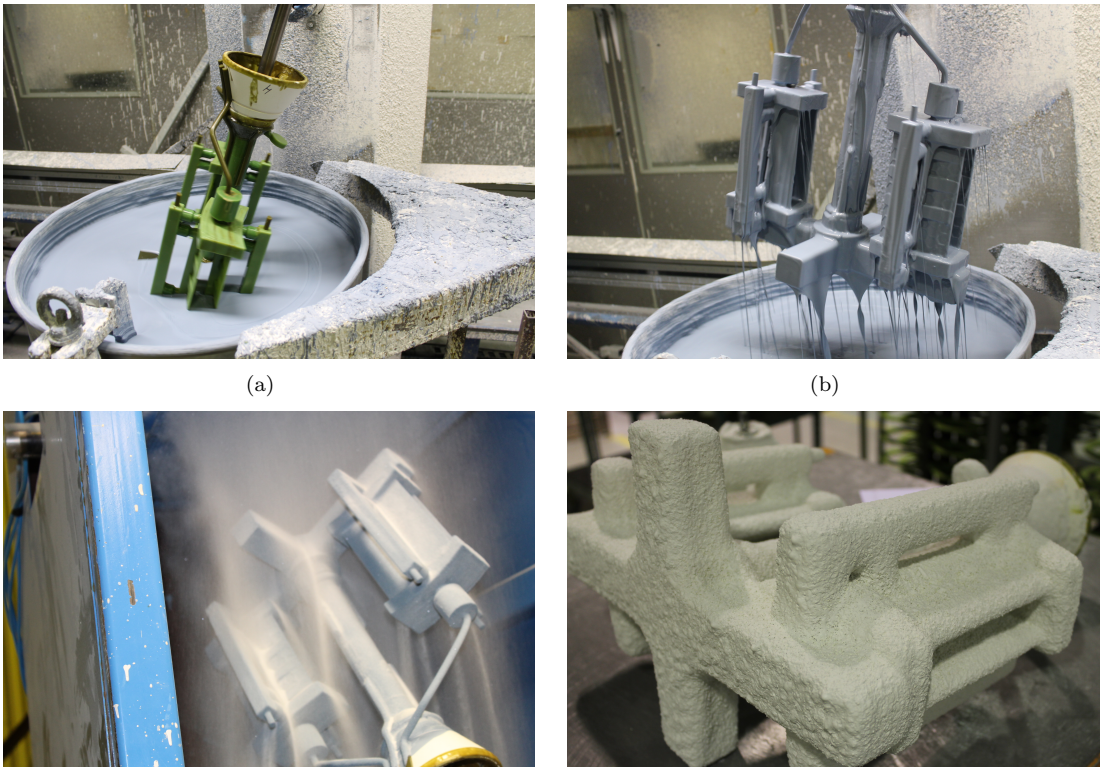


Figure 4: Illustrating feeding wedges added to the blade.



(a) (b)

(c) (d)

Figure 5: Manufacturing of the shells for the *Complex Geometry*.

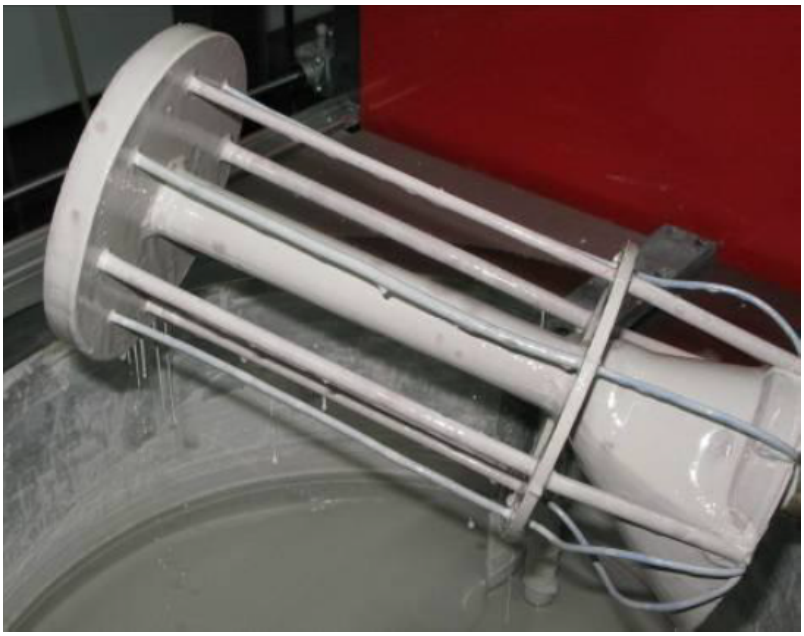


Figure 6: Test geometry used for fluidity test.

Alloy	C	Mn	P	S	Si	Cr	Ni	Cu	Ni+Ta	Mo	V	Co	Al
17-4PH	0.04	0.75	0.012	0.009	0.503	16.39	4.74	3.97	0.173				
CSS 42L	0.21	0.80			0.500	18.85	3.00			3.90	0.40	5.50	
Jethete 152M	0.14	0.45			0.135	11.87	3.15			2.29	0.18		
PH13-8M	0.04	0.46	0.01	0.01	0.200	10.40	8.45			2.05			0.52
Custom 465	0.02	0.35	0.008	0.006	0.255	12.15	10.46			1.26			
L0H12N4M	0.06	0.54	0.013	0.007	0.59	12.56	4.35			0.92			

Table 2: Chemical composition of the selected alloys.

Alloy	$T_{Liquidus}$ $(^{\circ}C)$	$T_{Solidus}$ $(^{\circ}C)$	$T_{Tapping}$ $(^{\circ}C)$	$T_{SuperHeat}$ $(^{\circ}C)$
17-4PH	1479	1444	1640	161
PH13-8M	1480	1464	1700	220
CSS 42L	1477	1362	1640	163
JETHETE 152M	N/A	N/A	1580	N/A
CUSTOM 465	1479	1464	1650	171
L0H12N4M	N/A	1485	1620	N/A

Table 3: Liquids and solidus measurement for alloys.

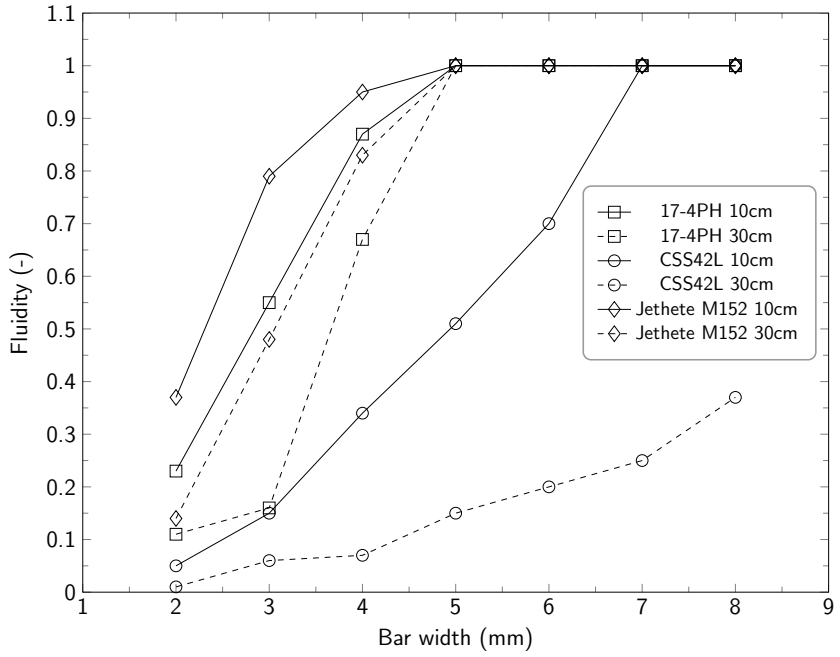


Figure 7: Illustrates fluidity results for 17-4PH, CSS42L and Jethete M152.

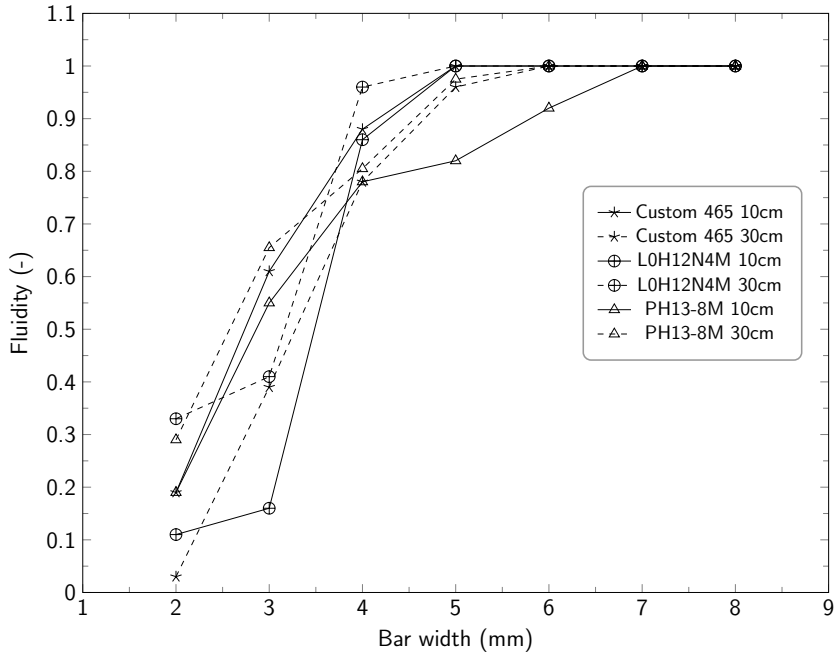
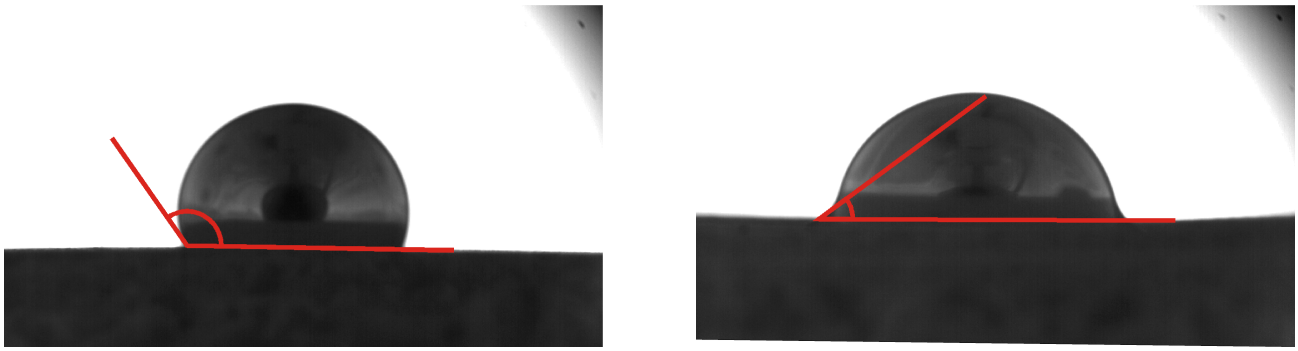


Figure 8: Illustrates fluidity results for Custom 465, L0H12N4M and PH13-8M.



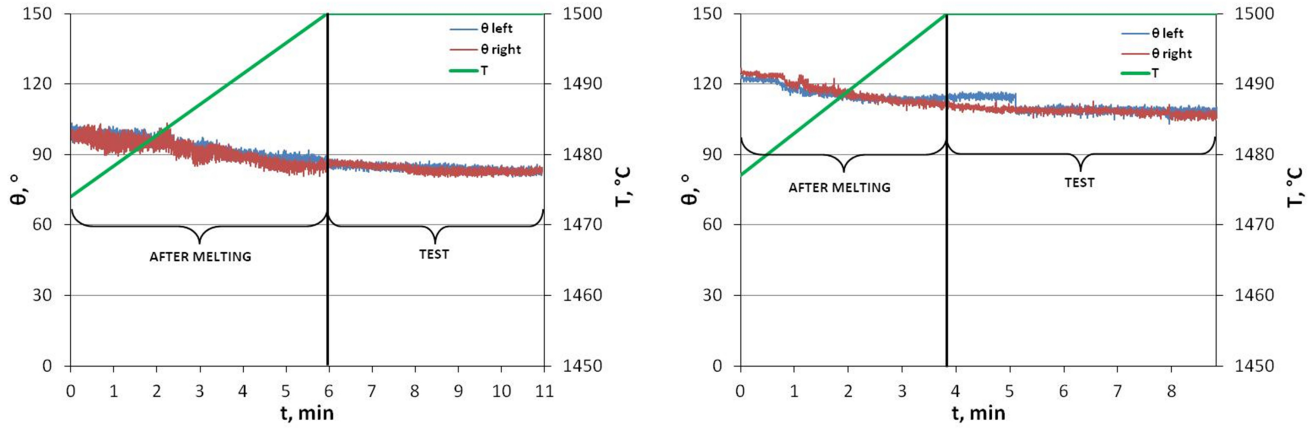
(a) 17-4PH TPC

(b) 17-4PH FRI

Figure 9: Illustration of the wettability test.

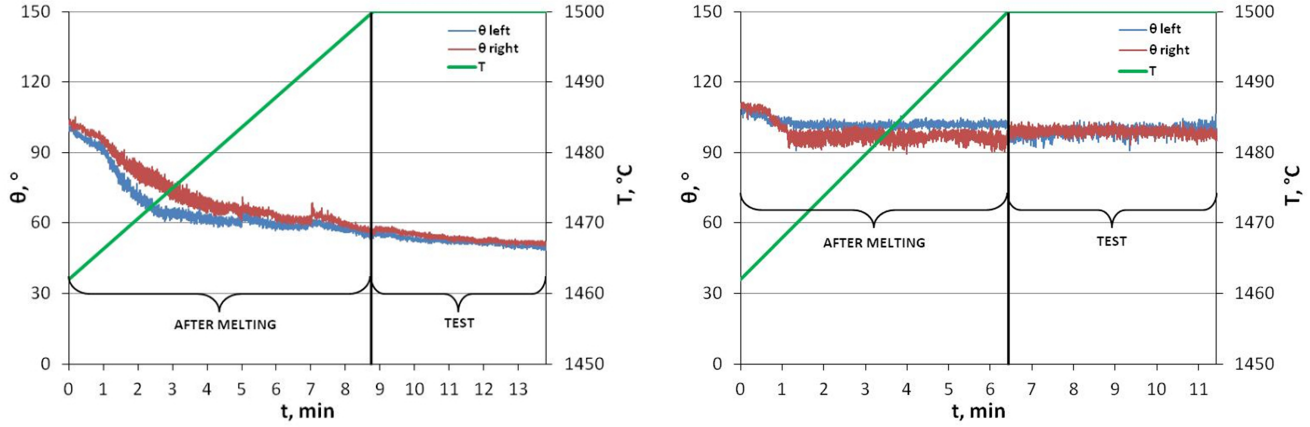
Fe	C	Si	Mn	P	S	Cr	Ni	Cu	Nb+Ta	Mo
Bal.	0.02	0.52	0.65	0.025	0.002	15.93	4.28	3.23	0.21	0.14

Table 4: Composition of cast alloy.



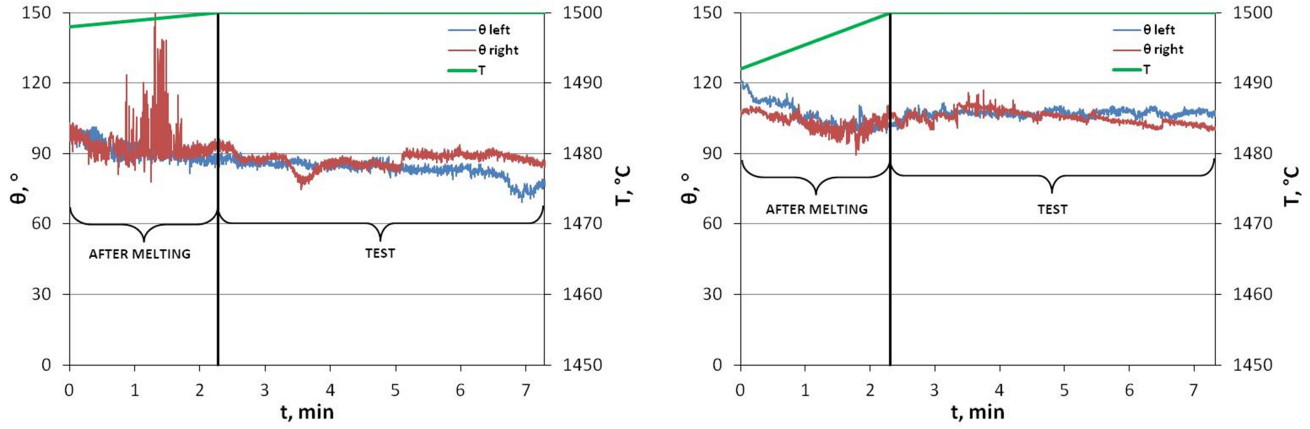
(a) FRI Shell (b) TPC shell

Figure 10: Results from the wettability for 17-4PH TPC.



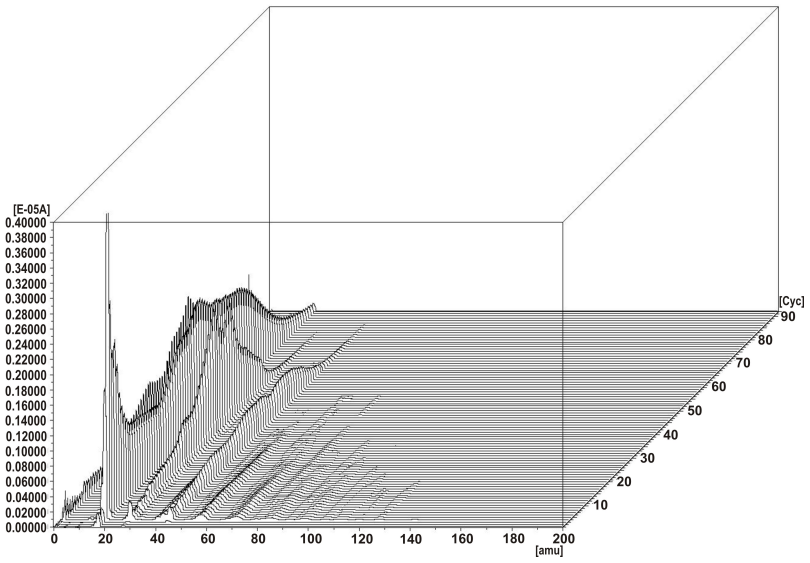
(a) FRI shell (b) TPC shell

Figure 11: Results from the wettability for 17-4PH FRI.

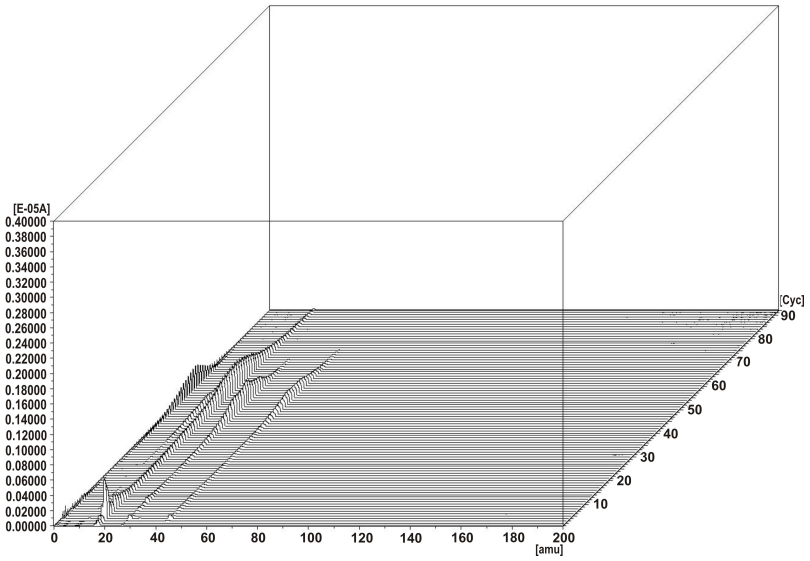


(a) Shell FRI (b) Shell TPC

Figure 12: Results from the wettability for L0H12N4.

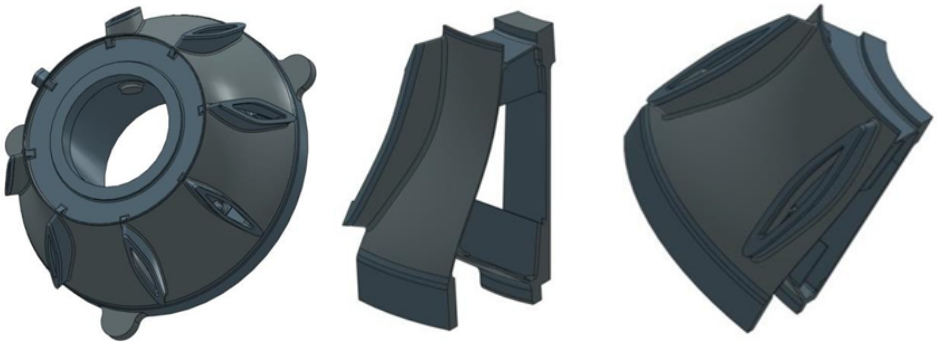


(a) TPC shell



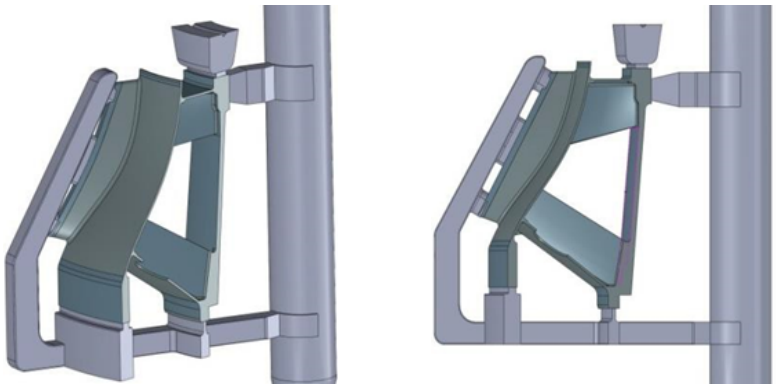
(b) FRI shell

Figure 13: Results from the gasification tests.



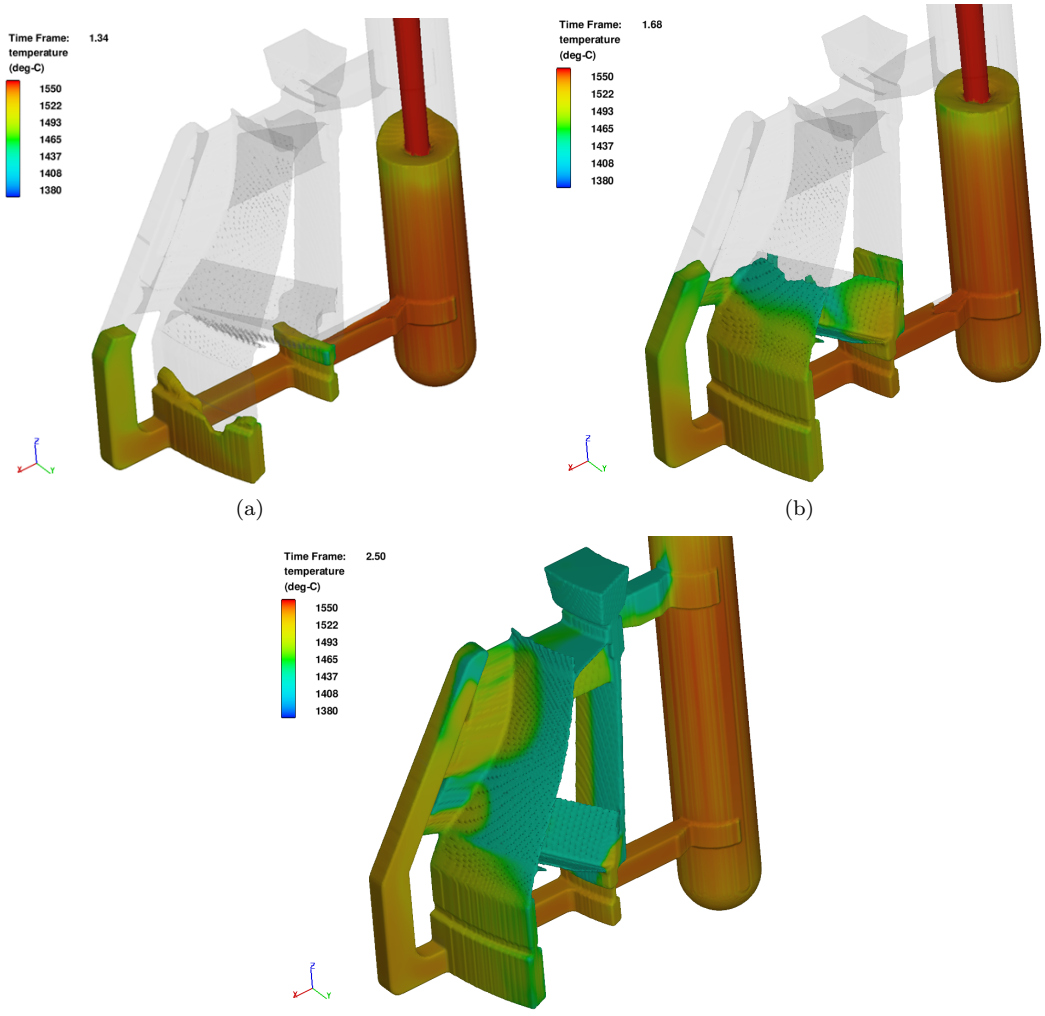
(a) GKN-Geometry (b) 1/16 part (c) 1/4 part

Figure 14: Illustrating the complex geometries used in *Task 3.2*.



(a) (b)

Figure 15: Illustrating the final gating and inlet system after optimisation for the 1/16 part geometry.



(a) (b)

(c)

Figure 16: Illustrating simulation of filling (Flow3D).

(a)

(b)

Figure 17: Illustrating, (a) the final gating and inlet system after optimisation for the 1/4 part geometry and (b) the final shell.

Figure 18: Illustrating shells embedded in sand.

(a)

(b)

Figure 19: Illustrating the results from the casting trials for 1/16 part geometry.

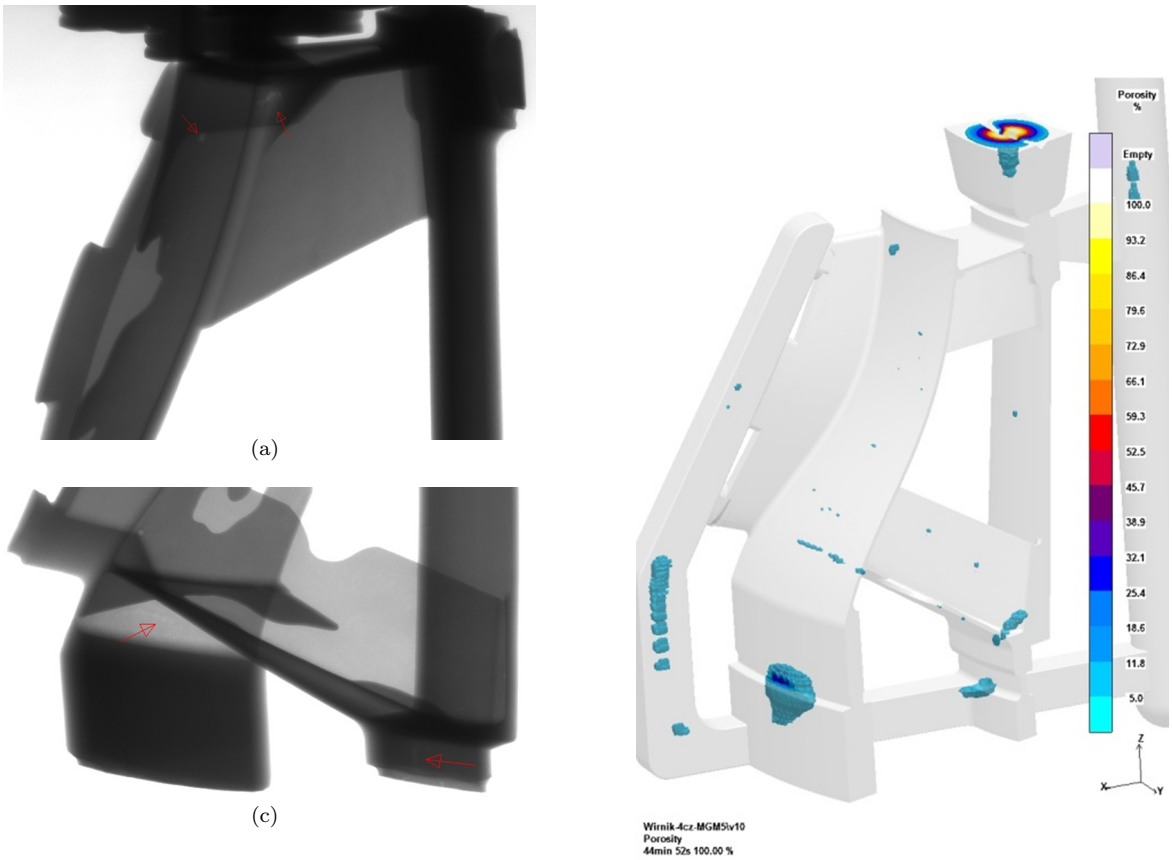
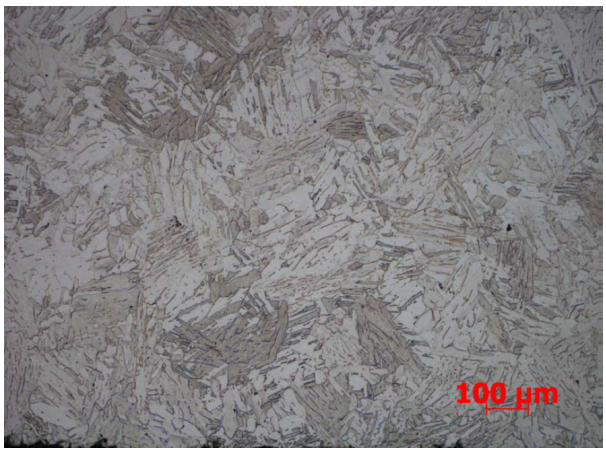


Figure 20: X-ray Computer Tomography and simulated porosity of 1/16 part geometry.

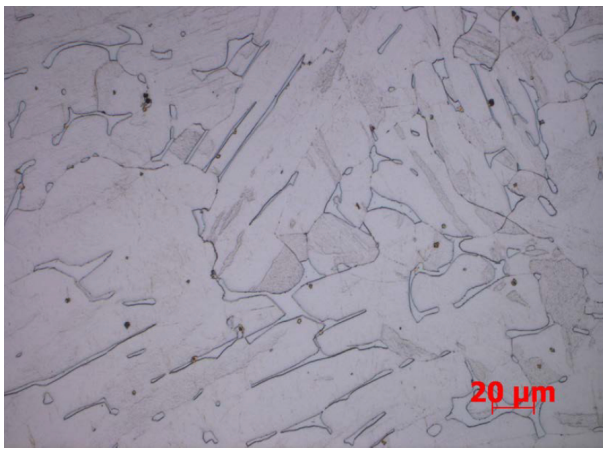
Figure 21: Illustrating the results from the casting trials for 1/4 part geometry.

	Temperature (°C)	Time (min)	Cooling
Homogenization	890	120	Furnace
Under critical annealing	700	360	air
Hardening	1050	60	oil
Tempering	480	180	air
Tempering	480	180	air

Table 5: Heat treatment sequence.



(a) 100x



(b) 500x

Figure 22: Illustrating micro-structure of the 1/16 GKN casting.