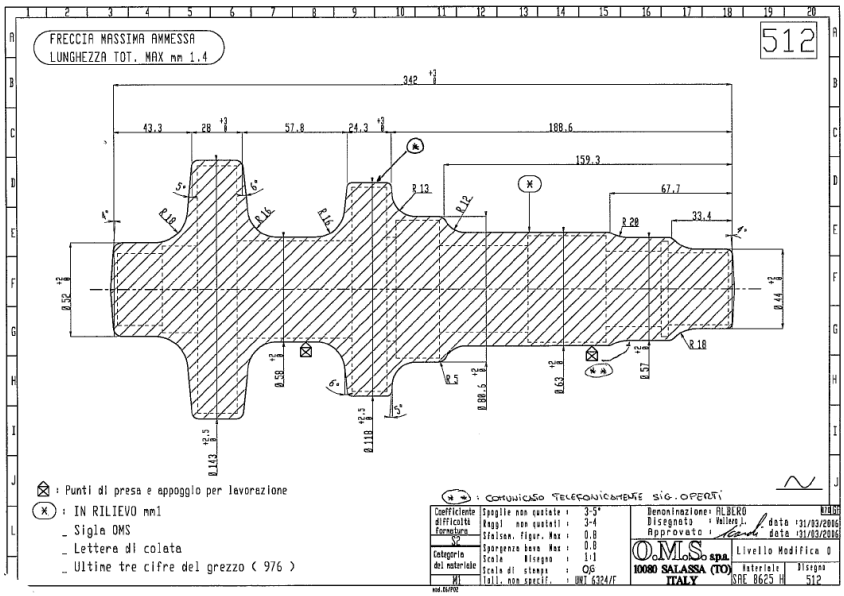

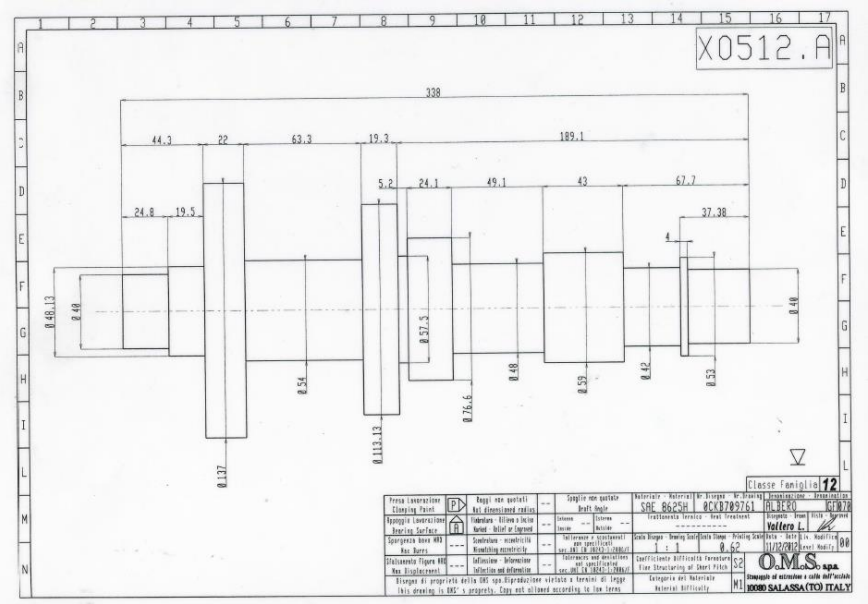

Figure 1: X0512.A preform and final geometry

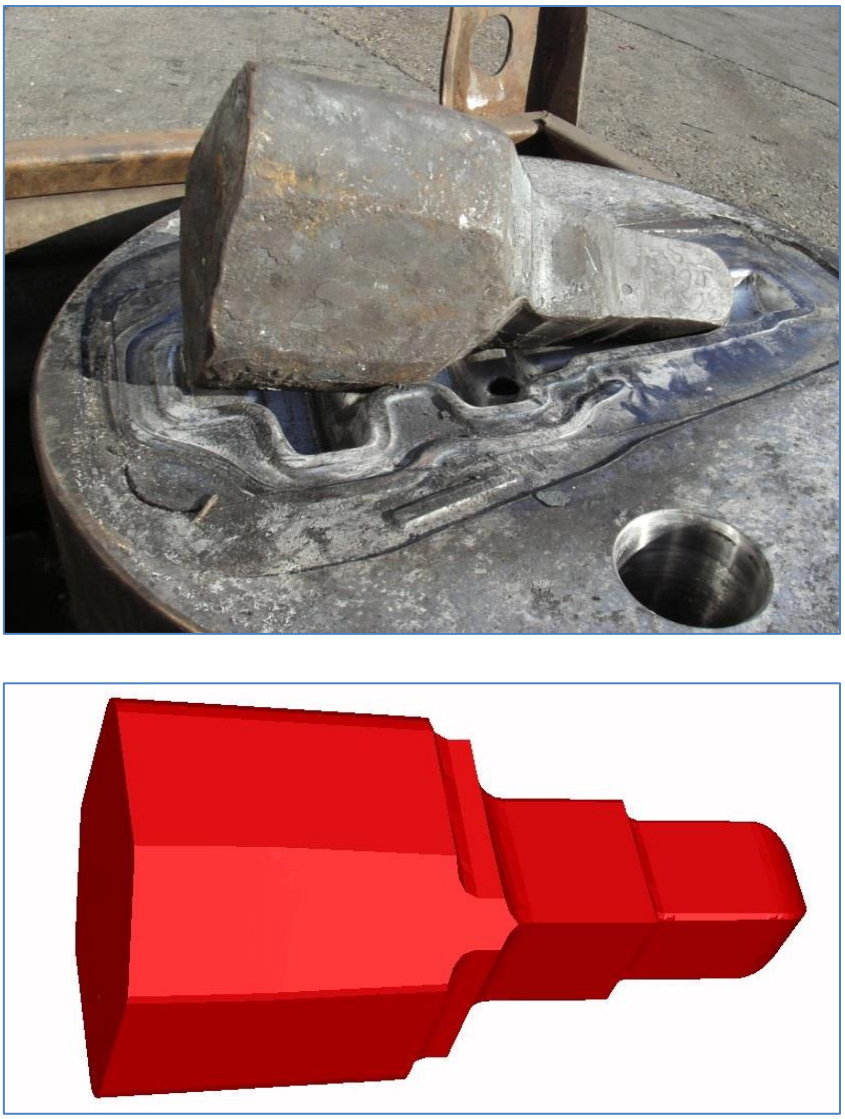

Figure 2: Geometry of current forging preform

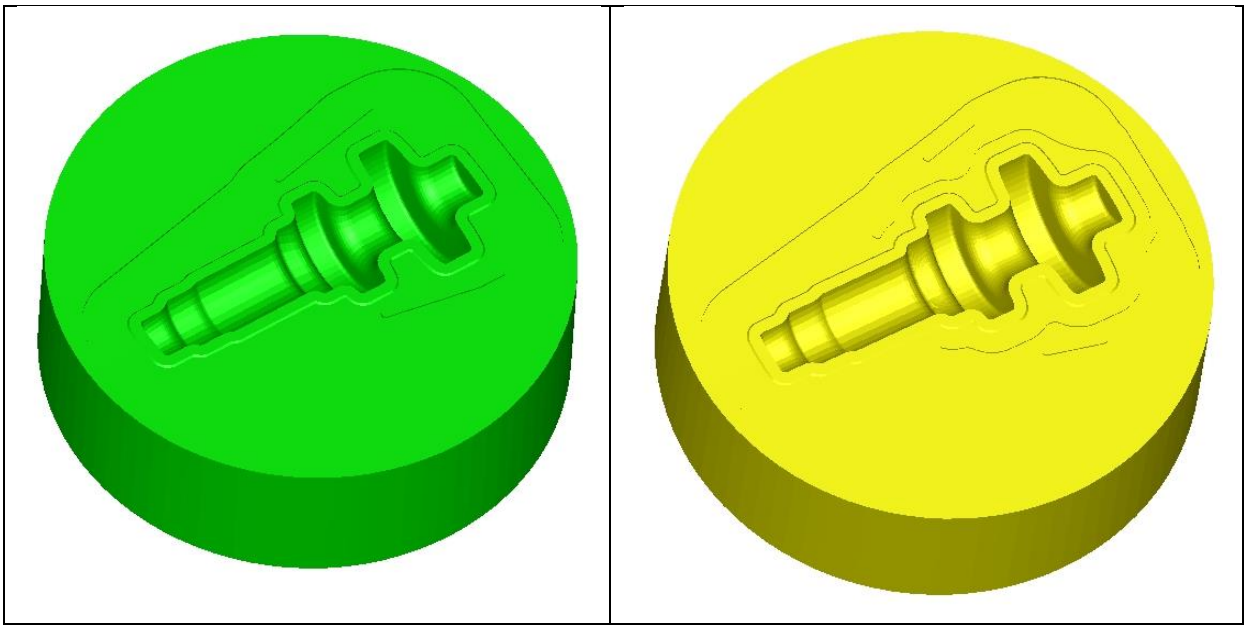

Figure 3: Final forging stage dies; lower die (left)- upper die (right)

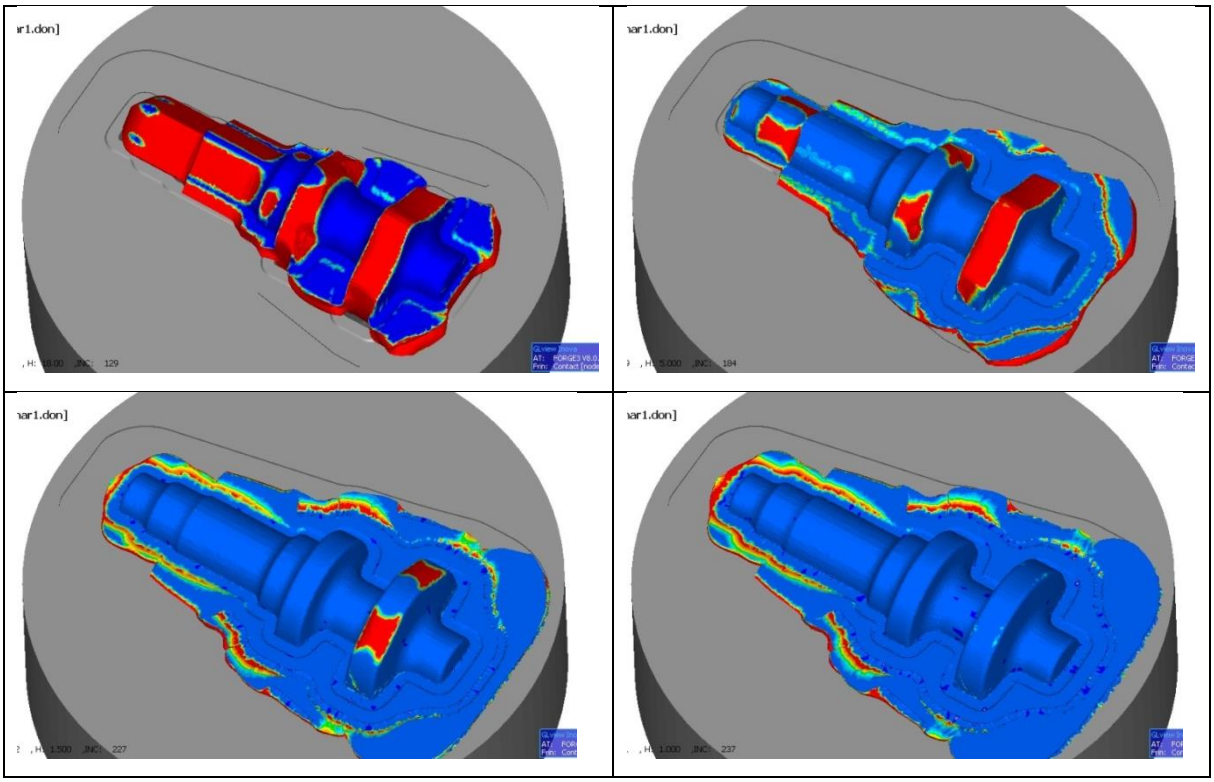

Figure 4: Evolution of material flow; red colour -no contact between part and dies; blue colour -contact between part and dies

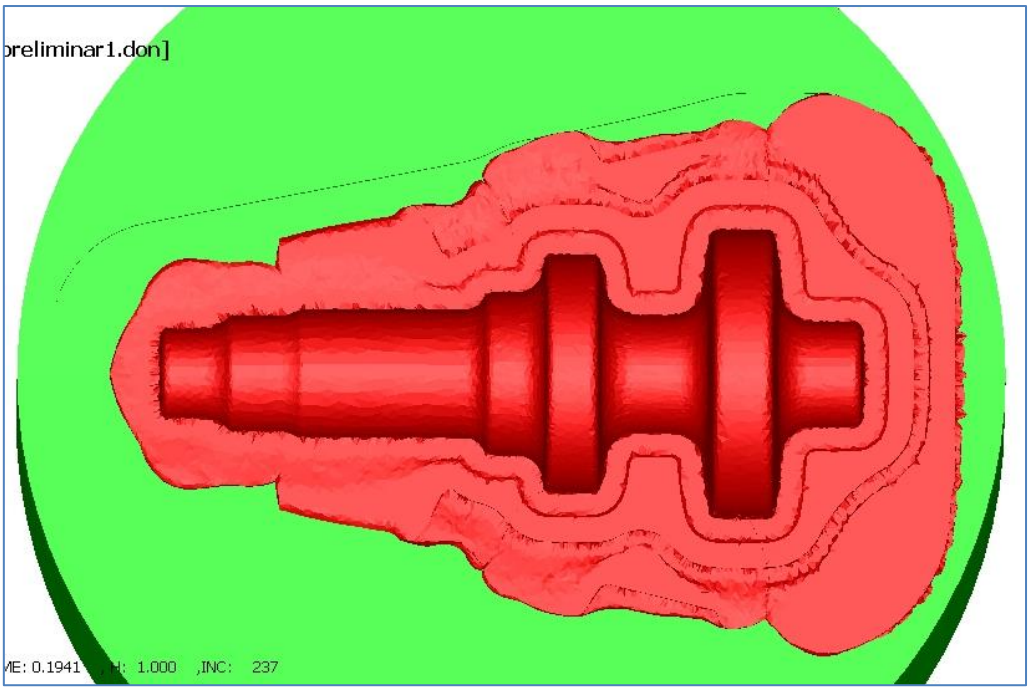

Figure 5: Flash distribution after final forging stage for current preform

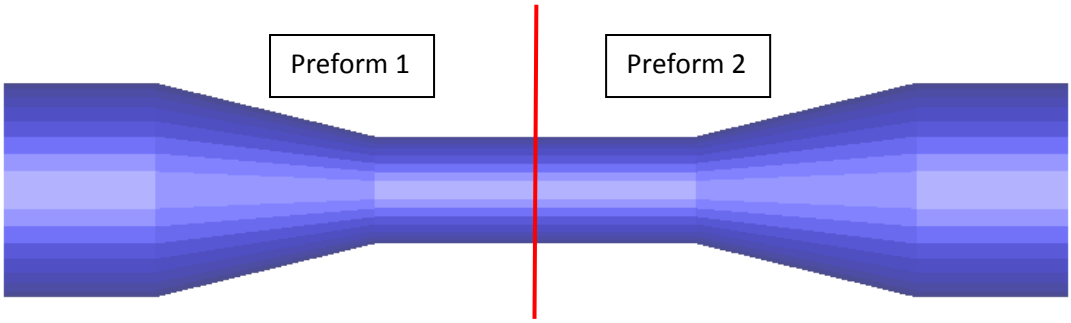

Figure 6: Drawing of rolled preform to be obtained by CWR

Optimisation Info

Computation_Name	Cost_Function	Fold	Die_Filling	Die_Filling_1	Volume	Diameter_1	Diameter_2
1 Gen1_Ind2	5.0905e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.0338e+006	1.1986e+002	5.9904e+001
2 Gen2_Ind1	5.1787e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.0710e+006	1.2185e+002	6.1059e+001
3 Gen2_Ind0	5.2003e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.0803e+006	1.2483e+002	5.7483e+001
4 Gen1_Ind3	5.3011e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.1248e+006	1.2495e+002	6.2599e+001
5 Gen2_Ind2	5.3089e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.1284e+006	1.2756e+002	5.8778e+001
6 Gen0_Ind1	5.3156e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.1314e+006	1.2996e+002	5.5005e+001
7 Gen1_Ind0	5.4059e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.1732e+006	1.3000e+002	6.0052e+001
8 Gen0_Ind3	5.4939e-001	0.0000e+000	0.0000e+000	0.0000e+000	1.2156e+006	1.2996e+002	6.4986e+001
9 Gen1_Ind1	2.6416e+000	0.0000e+000	5.9728e-002	9.2137e-002	1.0005e+006	1.2027e+002	5.5080e+001
10 Gen2_Ind3	2.6835e+000	0.0000e+000	1.0159e-001	1.0362e-001	9.8655e+005	1.1506e+002	6.2117e+001
Gen0_Ind0	2.7408e+000	0.0000e+000	1.4798e-001	1.4203e-001	9.4847e+005	1.1000e+002	6.4999e+001
Gen0_Ind2	2.9972e+000	0.0000e+000	3.6273e-001	3.6011e-001	8.7106e+005	1.1000e+002	5.5015e+001

Figure 7: Optimization process results chart

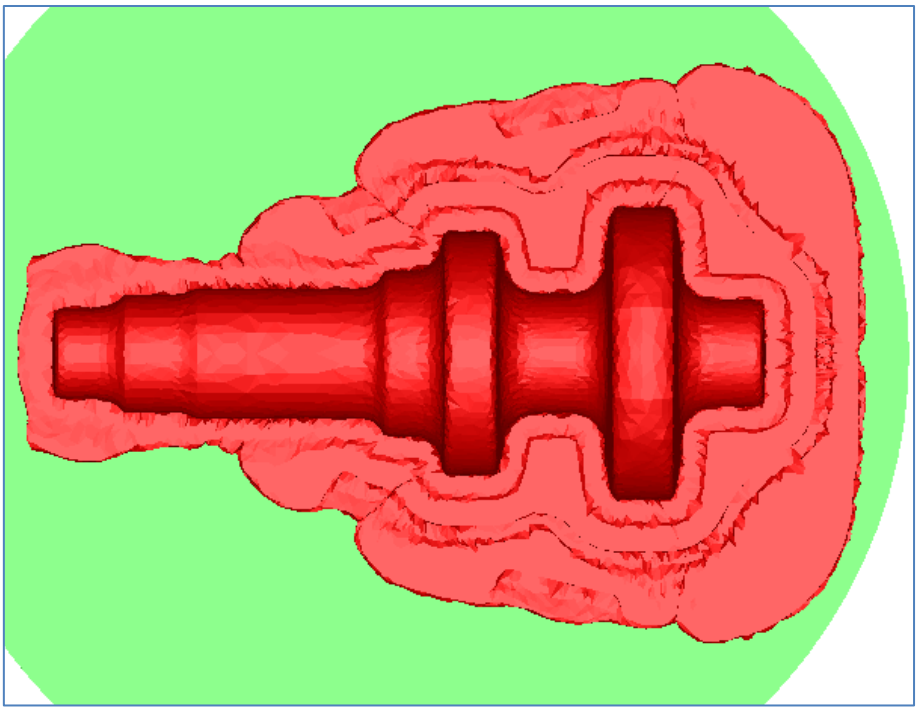

Figure 8: Flash distribution after final forging stage for rolled preform

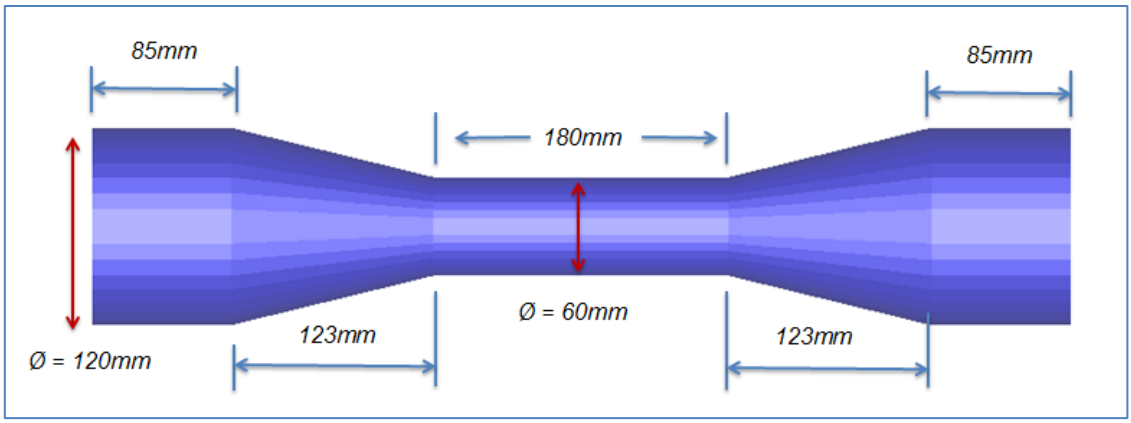

Figure 9: Preform to be obtained by CWR technology

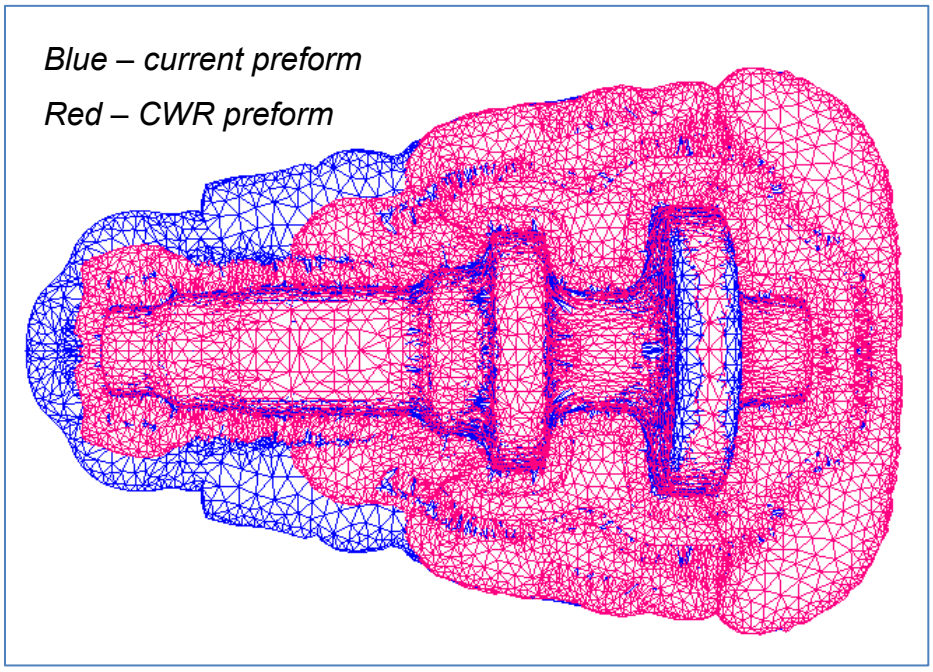

Figure 10: Flash comparison between current preform and CWR preform

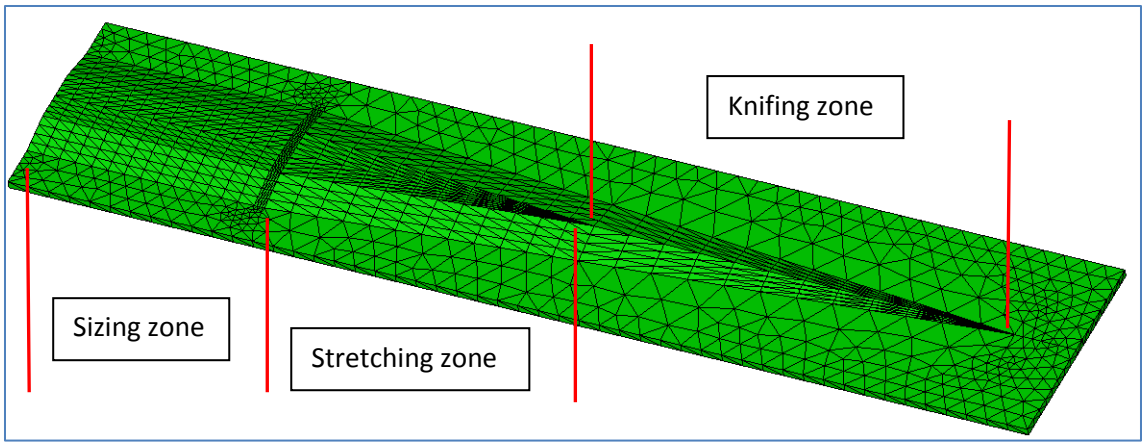

Figure 11: CWR die for rolled preform

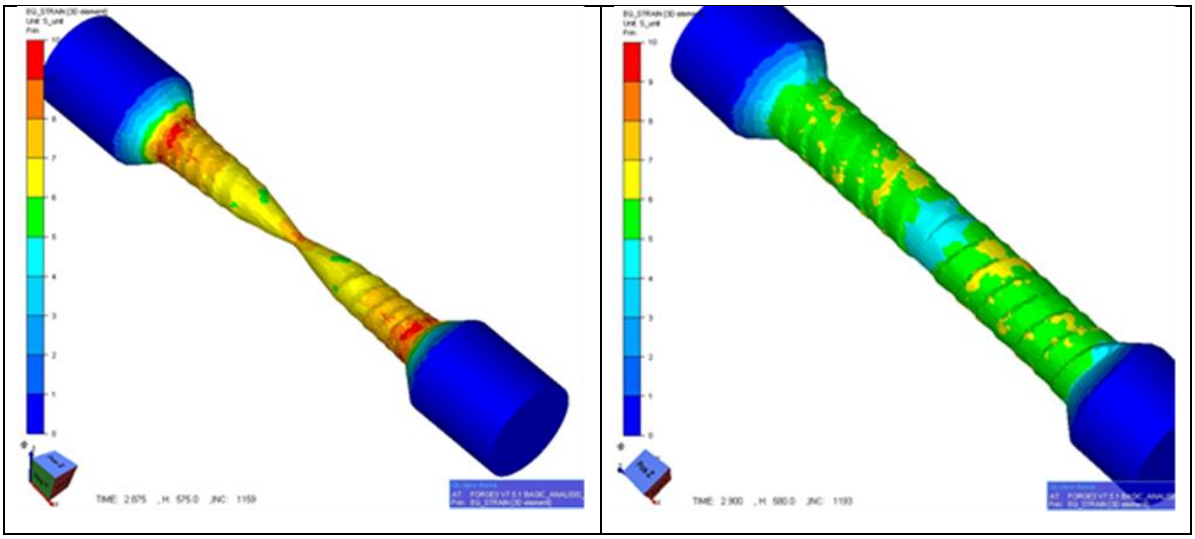

Figure 12: Some typical defects when applying CWR technology (left: necking; right: spirals)

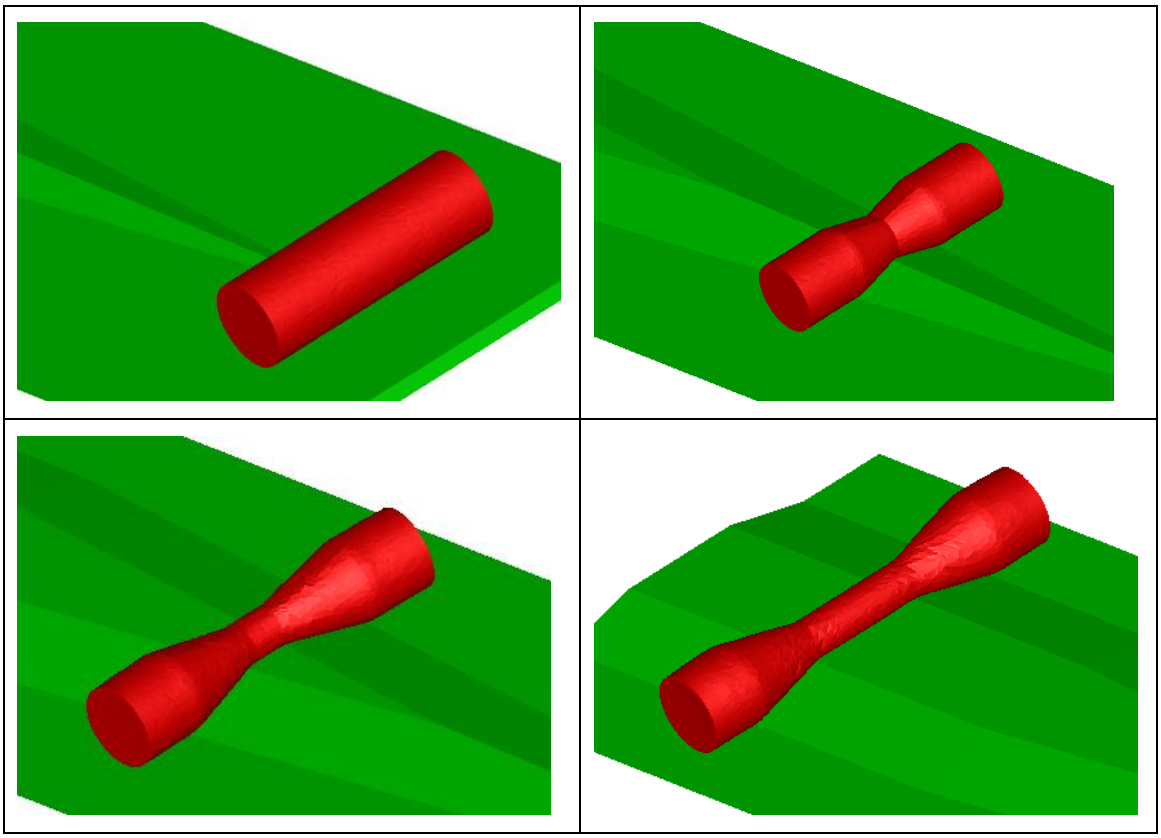

Figure 13: Material flow evolution during CWR process (top left: initial position; top right: knifing zone; bottom left: stretching zone; bottom right: sizing zone)

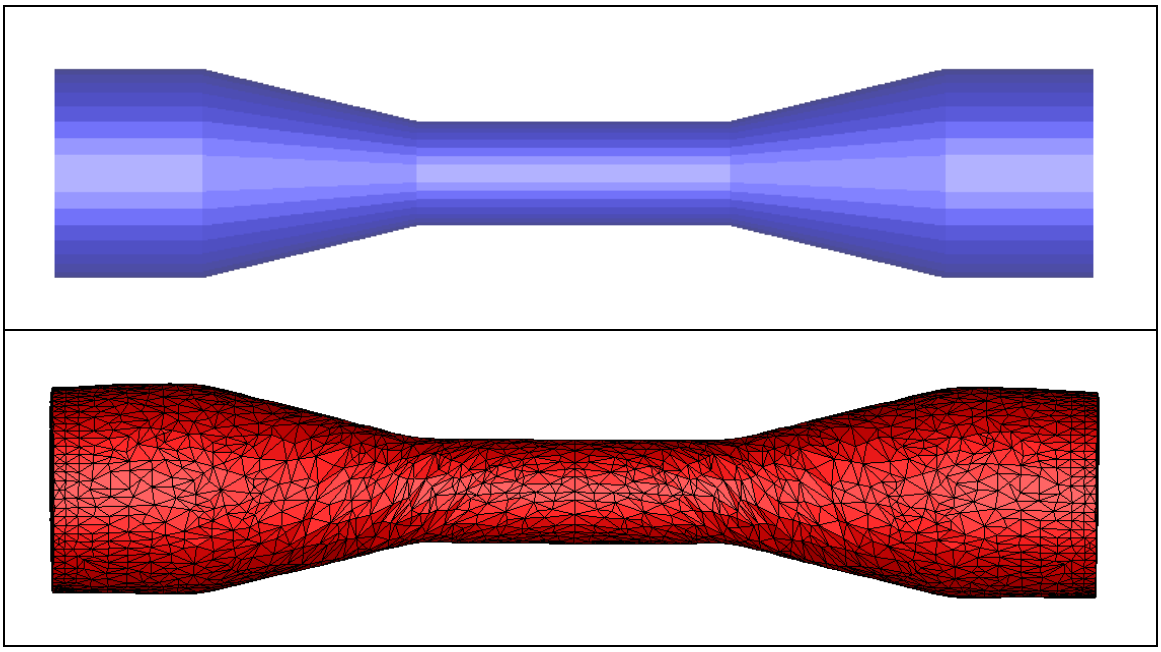

Figure 14: Comparison between theoretical (top) and simulated rolled preform (bottom)

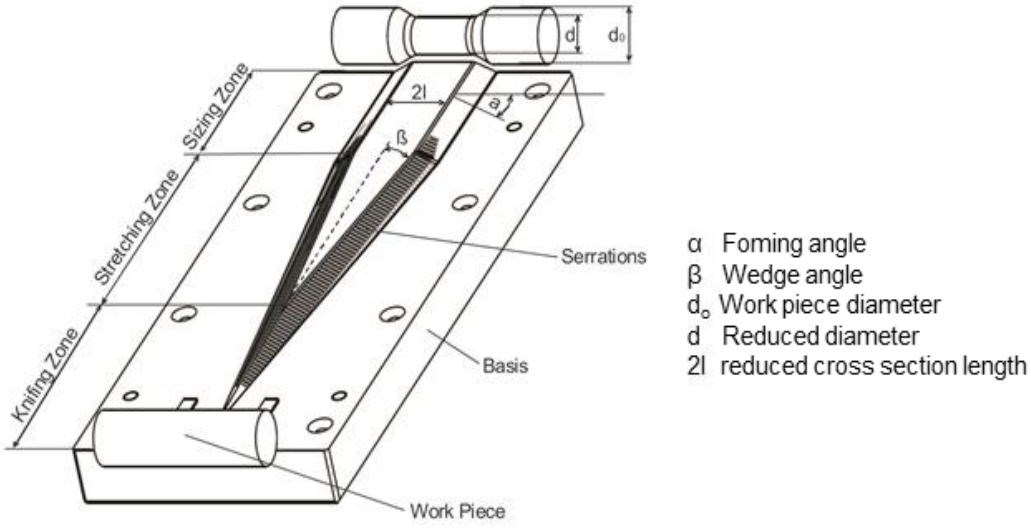

Figure 15: CWR tool

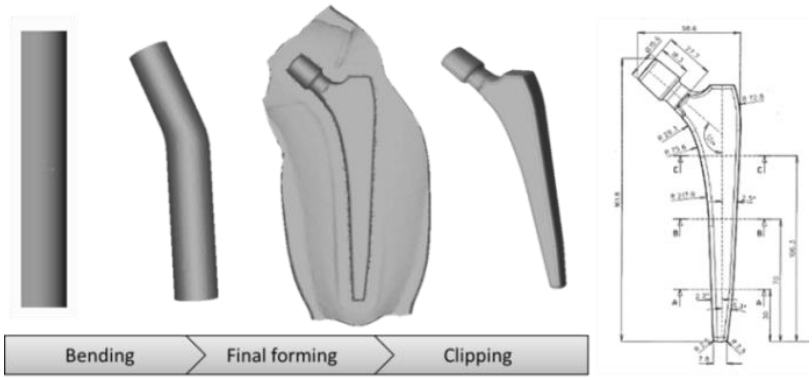

Figure 16: Left: conventional forging sequence; Right: technical drawing of the hip implant

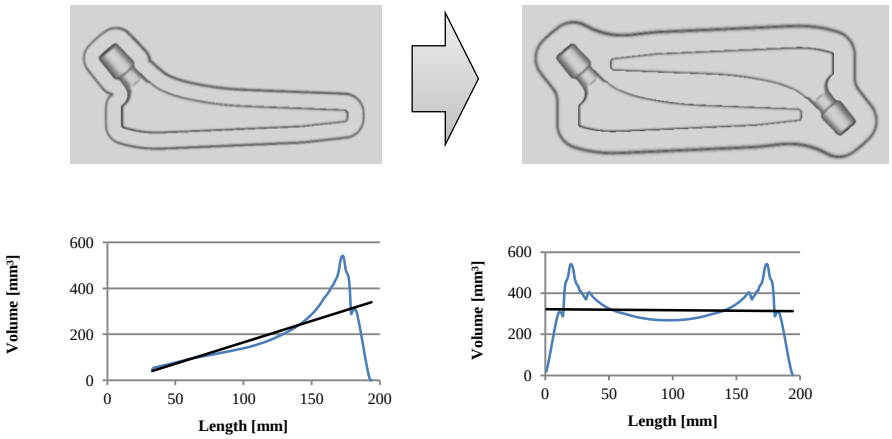

Figure 17: Top: Change of final forging die design and the resulting mass distribution; Bottom: Mass distribution with trend

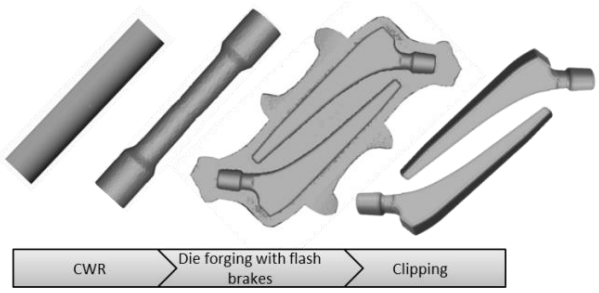

Figure 18: New forging sequence containing CWR and die forging with flash brakes

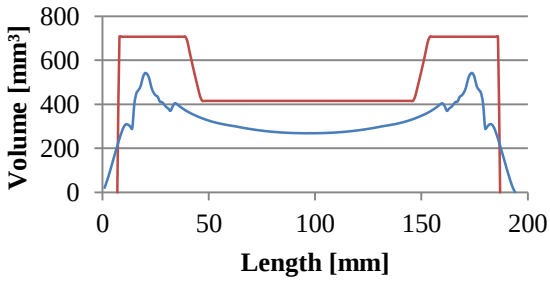

Figure 19: Mass distribution; Red: CWR preform; Blue: new design

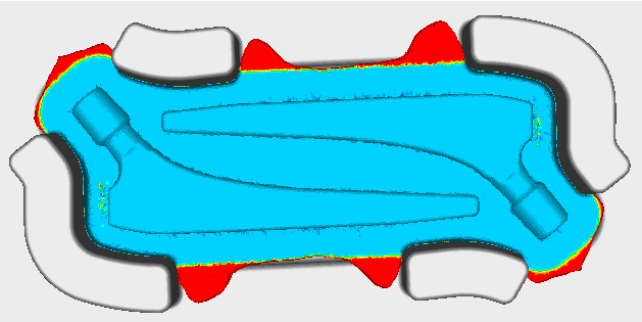

Figure 20: CWR and die forging with flash brakes - 100 % form filling (blue color means form filling)

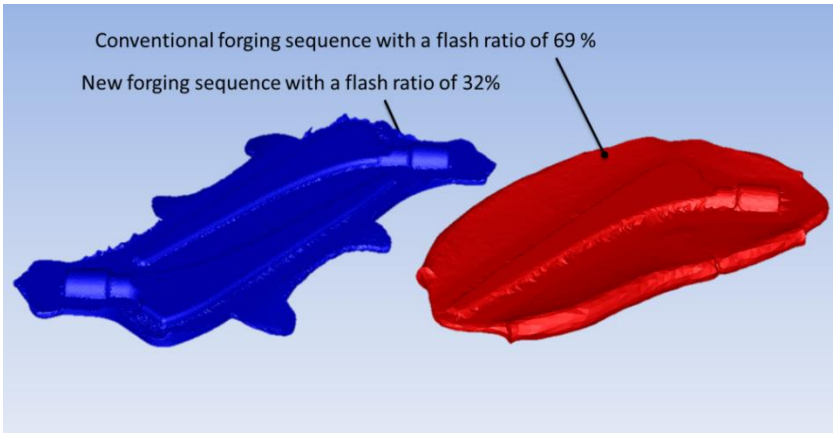

Figure 21: Comparison of conventional and new forging sequence

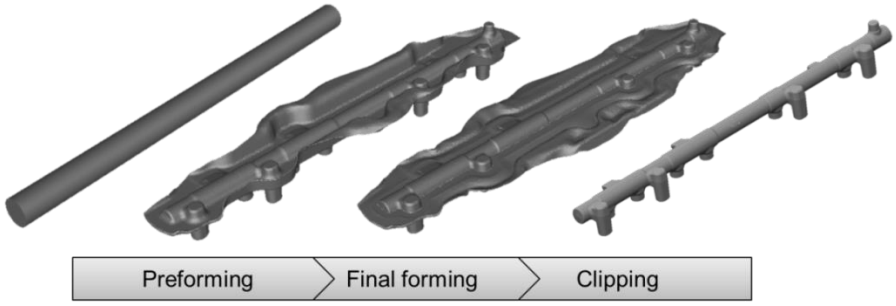

Figure 22: Conventional forging sequence

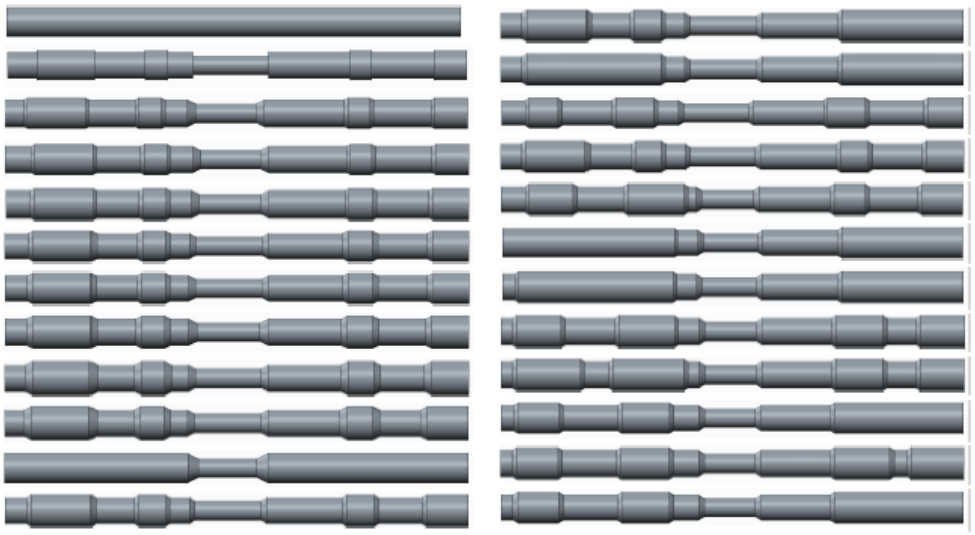

Figure 23: Different investigated CWR preforms for the common rail

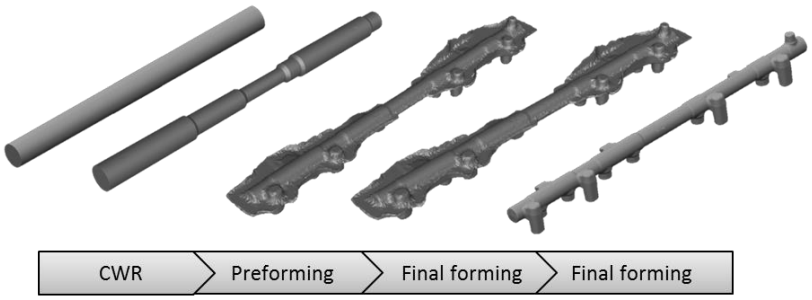

Figure 24: New forging sequence

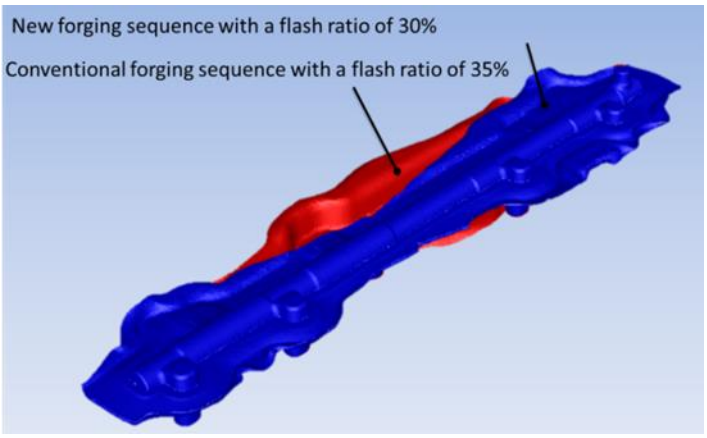

Figure 25: Comparison of conventional and new forging sequence

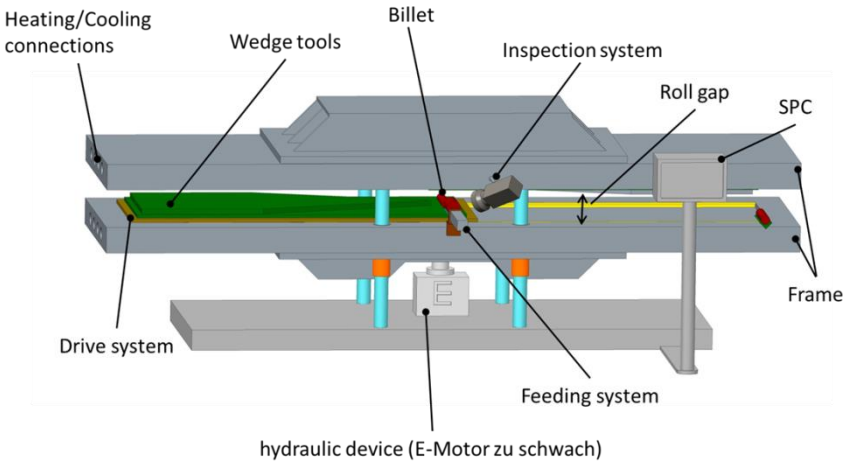

Figure 26: First concept of a CWR machine

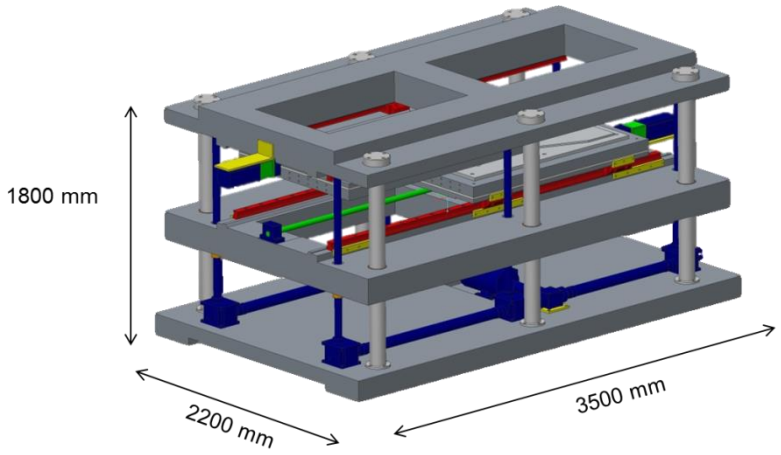

Figure 27: First concept of the CWR machine

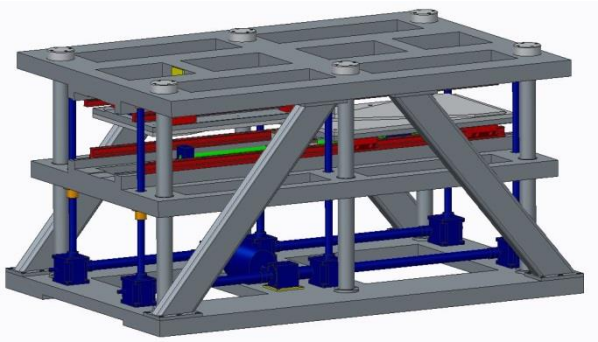

Figure 28: Adjusted design of CWR machine

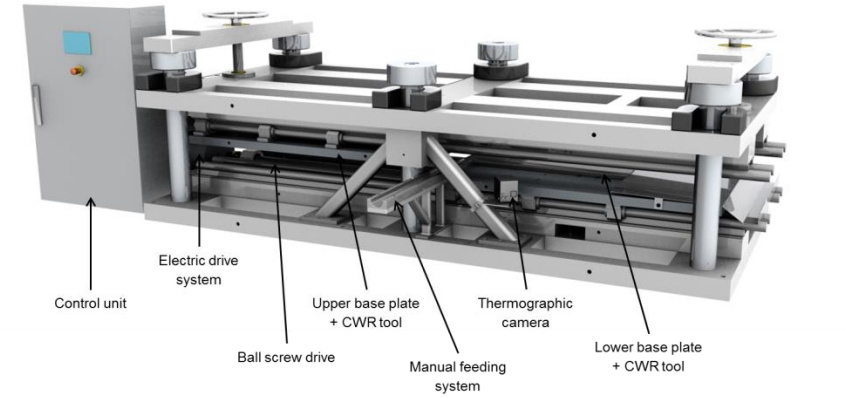

Figure 29: Final CAD design

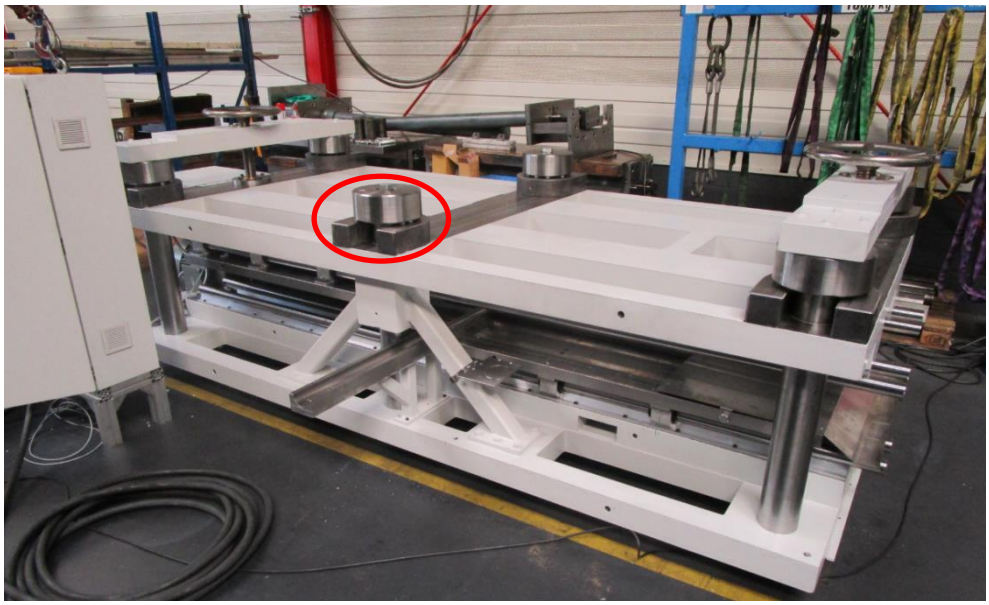

Figure 30: Final CWR machine with the spacer for realizing the correct roll gab

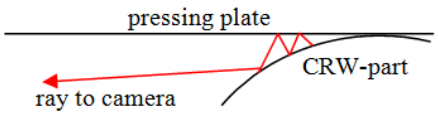

Figure 31. Multiple reflections in the CRW-machine.

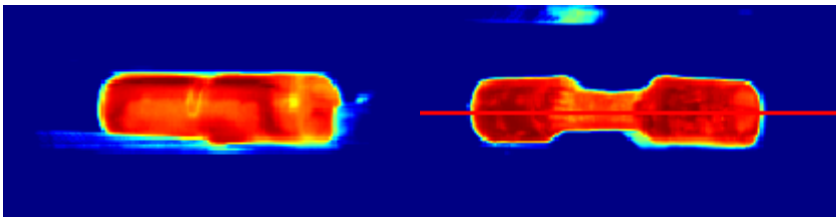

Figure 32 (left) thermal image of the part before and (right) after process. Time evolution of the profile along the red horizontal line is used to produce the signature of the production process.

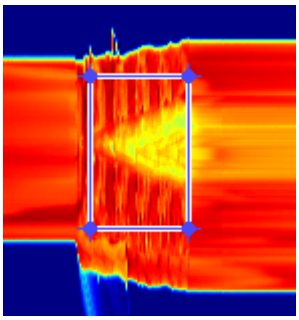

Figure33 Evolution of the temperature profile (time advances from left to right). The rectangle shows the area of interest (signature).

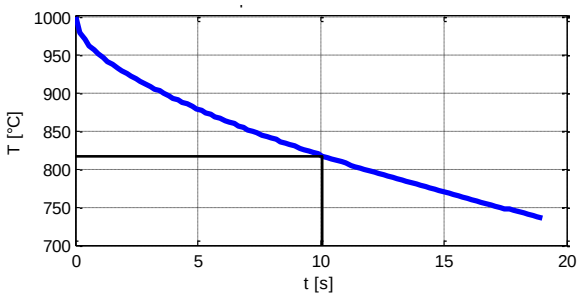

Figure 34 Cooling down of Ti6AlV4 working-sample; temperature at surface of billet-barrel at middle height

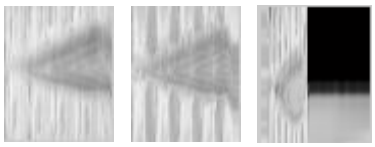

Figure 35 (Left) Template and the matched signatures for (middle) a normal and (right) an unusual process.

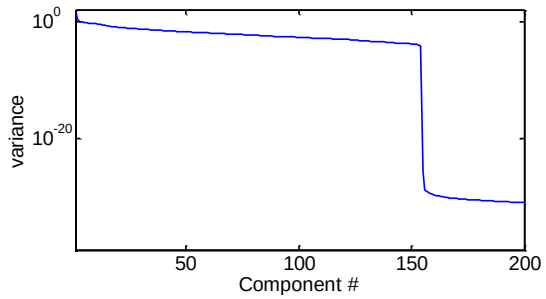

Figure 36 Variance of the first 200 PCs

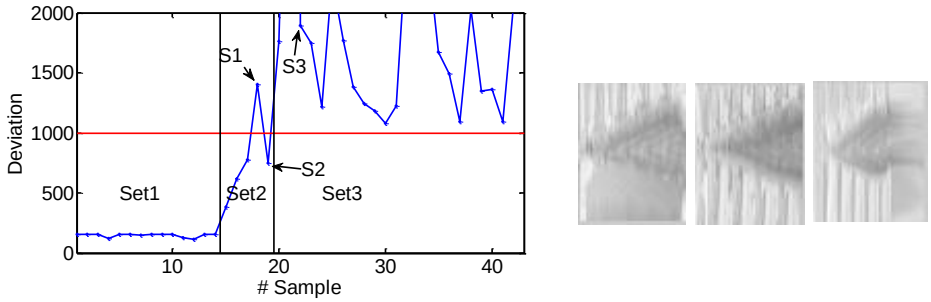

Figure 37 (Up) the value of deviation measure calculated for 3 sets of data. Set1, set2, and set3 correspond to training set, evaluation set produced with the same rolling parameters, and the evaluation set produced with a different (abnormal) rolling parameter (that is faster rolling speed). The threshold is plotted in red. (Down) from left to right are the samples labeled in the plot as S1, S2, and S3. High deviation values are correctly calculated for S1 and S3.