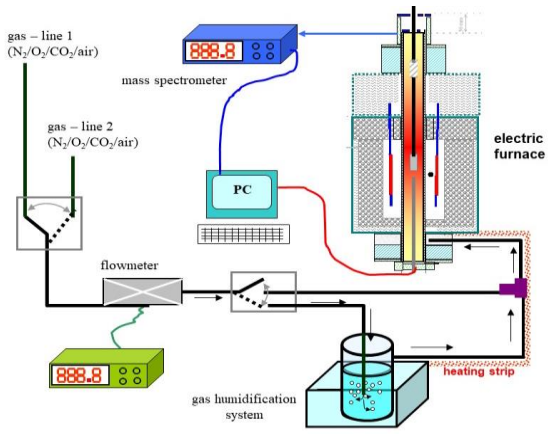
HyTecHeat	**HyTecHeat** **HYbrid TEChnologies for sustainable steel reHEATing**	Co-funded by the European Union

HyTecHeat Project

The project is aimed at hybrid heating demonstration in steelmaking downstream processes (reheating furnaces and refractory preheating). Three *democases* are envisioned: (1) a hybrid by-design burner designed and tested in a combustion chamber, directly fed by Green Hydrogen produced by purposely installed 1 MW electrolyser; (2) adaptation of a burner designed for Natural Gas to work in hybrid heating gas atmospheres (NG/H2); (3) full scale testing of ladle preheating burners by a blend NG/Hydrogen.

An important part of the project is focused on the investigation of hydrogen combustion atmosphere on steel surfaces, in terms of scale formation and descaling properties. The tests (lab oxidation and descaling tests) are carried out on a large variety of steel grades.

OXIDATION TESTS



Thermogravimetric apparatus

Tests under atmosphere simulating hydrogen combustion are carried out on different steel grades, to evaluate the effect of steel compositions.

Tests presented here are carried out carried out by Rina CSM and AMMR.

Carbon steels, special steels and stainless steels have been used for oxidation and descaling tests. Tests have been carried out in the temperatures range 900°C-1230°C by Rina CSM and AMMR in thermogravimetric apparatus, under atmosphere simulating natural gas and hydrogen combustion, Tables report the investigated steel grades and the chemical compositions.

Steel grades investigated by AMMR

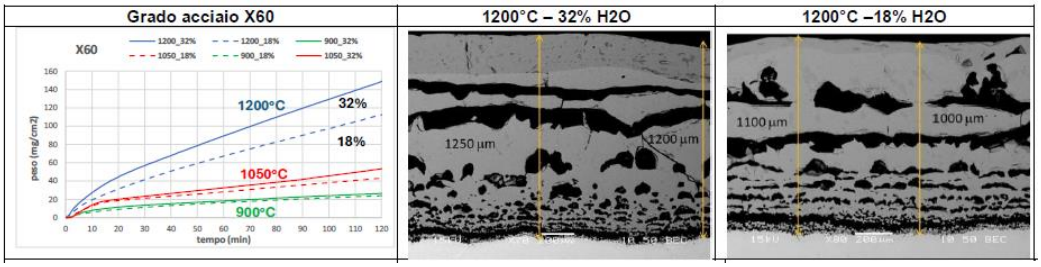
Name	C	Mn	Si	Cr	Ni	Cu	Heating
HSLA	45	976	20	36	49	138	①
DD11	52	154	28	54	62	163	①
ST52	177	1160	212	22	40	85	①
DP600	70	842	224	695	22	17	②
S420MC	67	704	11	14	22	8	②
ULC	13	993	93	433	142	214	②
1.9Mn0.8Si	230	1900	790	100	-	-	②

Steel grades investigated by RINA CSM

Partner	Steel grade	C	Cr	Mn	Mo	Si	Ni	P	S	V	Al
Nunki steel	X22CrMoV	0.18-0.24	11.0-12.5	0.4-0.9	0.8-1.2	< 0.5	0.3-1.5	< 0.025	< 0.015	0.25	
	AISI 316	< 0.07	16.5-18.5	< 2.0	2.0-2.5	< 1	10-13	< 0.05	< 0.02		
Tenaris	*13 Cr * (AP1 5CT)*	*< 0.05*	*11.5-13.5*	*0.25-1.0*	-	*< 1*	*< 0.5*	*< 0.02*	*< 0.01*		
	P91 (ASTM A335)	0.08-0.12	8.0-9.5	0.30-0.6	0.85-1.05	0.2-0.5	<0.12	< 0.02	< 0.01	0.19-0.25	<0.01
	N80Q	0.23-0.26	0.40-0.50	1.25-1.40	0.08-0.10	0.15-0.30	-	< 0.020	<0.010	-	0.02-0.035
	X60/X65 (AP1 5L)	0.08-0.19	<0.6	0.1-1.4	<0.07	0.2-0.35	<0.15	< 0.015	< 0.003	0.04-0.1	0.02-0.04
Tata steel	HSLA (400)	0.05	-	1.3							
	DP800HpF	0.2	-	2		0.4					0.7

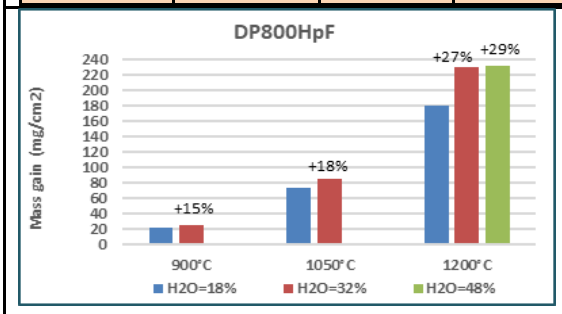
* Not subjected to descaling test (only TGA).

Tests in thermogravimetric apparatus reveal a significant influence of scale growth as a function of temperature and steel composition. In case of specific carbon steels, H_2 combustion atmosphere at high temperatures up to 1200°C contributes to an increasing scale formation up to 30%, compared with natural gas combustion. Anyhow, at 900°C, small effect was found for all the steel grades (test duration of two hours).

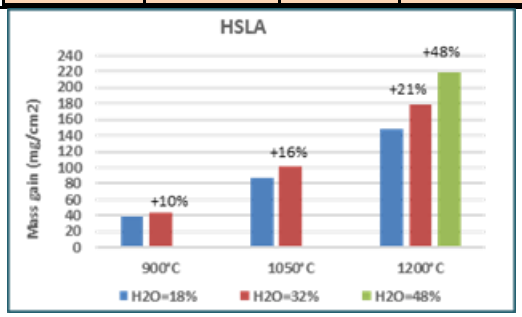


Scale formation up to 30% increase at 1200°C for C steel

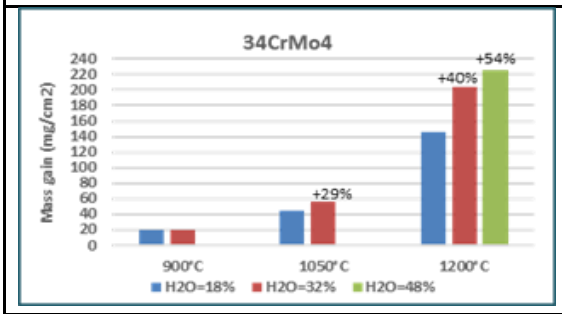
C	Mn	Si	Cr
0.20	2.0	0.4	-



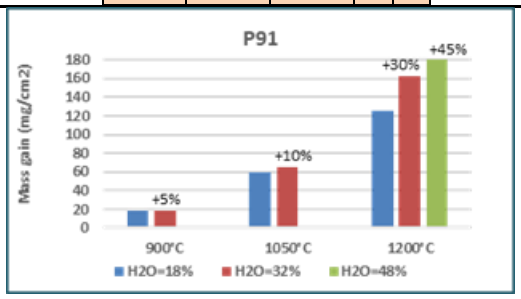
C	Mn	Si	Cr
0.05	1.3	-	-



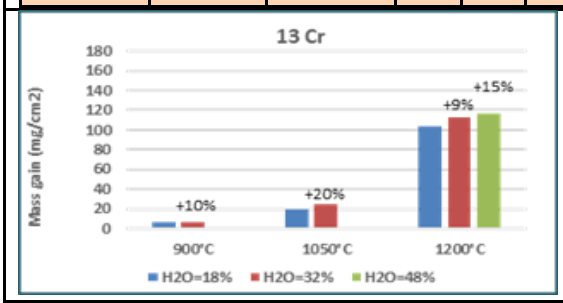
C	Mn	Si	Cr
0.34÷0.36	0.7÷0.80	0.20÷0.35	1.0



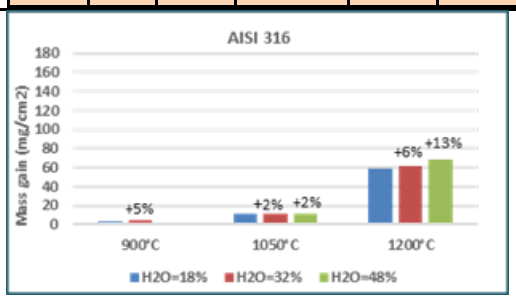
C	Mn	Si	Cr	Mo
0.08÷0.12	0.30÷0.50	0.30÷0.50	9.0	1.0



C	Mn	Si	Cr	Mo	Ni
< 0.2	0.5÷1.0	< 0.5	13.0	2.0	5.0

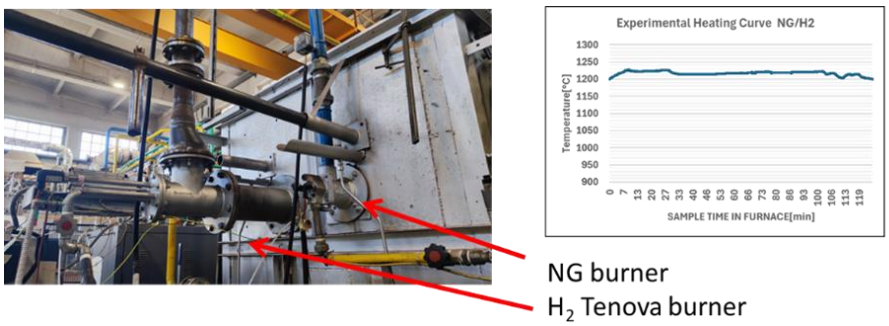


C	Mn	Si	Cr	Mo	Ni
< 0.07	< 2.0	< 1	16.5÷18.5	2.0-2.5	10÷13



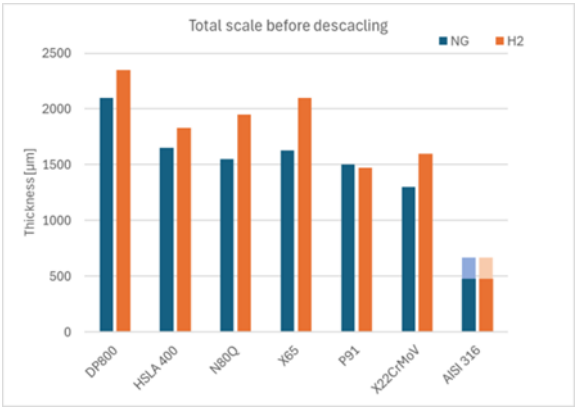
Mass Gain Values of steel grades after 120 min at 900°C, 1050°C, and 1200°C in atmospheres with 18%H2O, 32%H2O and 48%H2O

The descaling tests are conducted at the descaling pilot plant located at Rina Combustion in Dalmine. The test rig has been upgraded with the installation of a burner capable of operating with 100% hydrogen, supplied by Tenova.



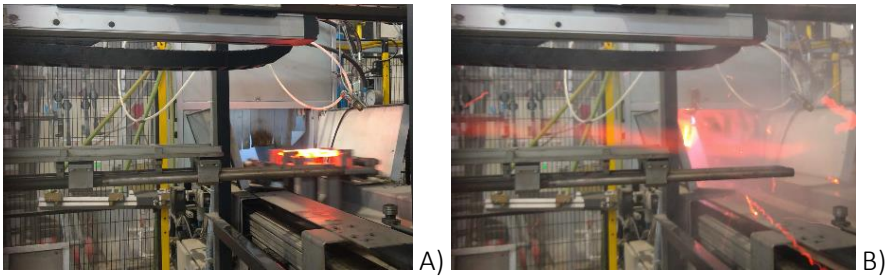
The test rig with burner capable of operating with 100 % hydrogen supplied by Tenova

Also tests heated in pilot plant descaler facilities reveal a significant influence of atmosphere composition in the scale growth. H_2 combustion atmosphere contributes to the increase of scale formation up to 30%, compared with natural gas combustion.



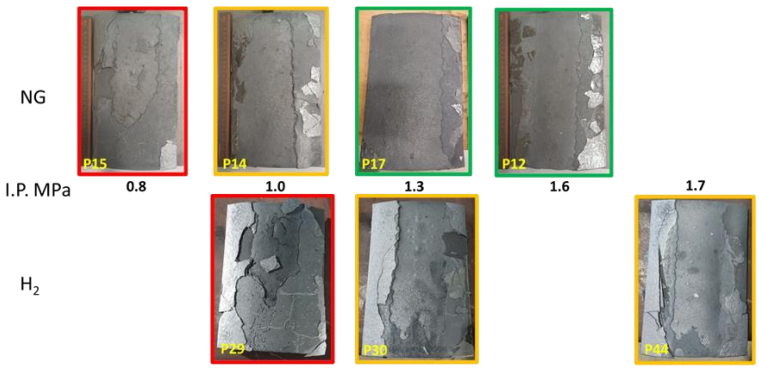
Scale formation increases at 1200°C for different steel grades

The samples are subjected to high water jet descaling,



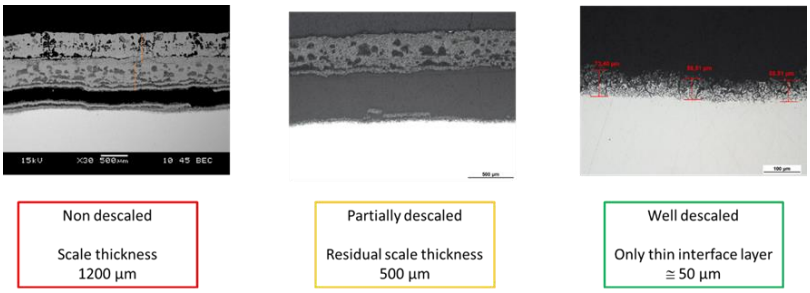
Sample after heating and before descaling (A) and during descaling (B)

A preliminary evaluation to determine the descalability threshold value is conducted through visual analysis of the samples after descaling.



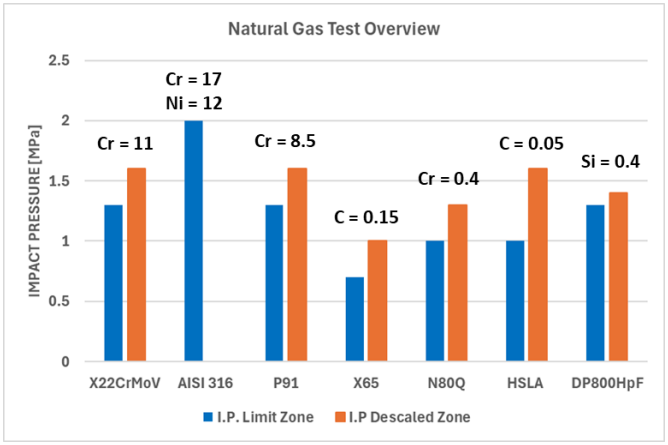
Preliminary evaluation to determine the descalability threshold by visual analysis

Descalability, or the threshold limit, defined through visual analysis, is verified through metallographic section analysis



Metallographic section analysis

An important result is the increase in impact pressure required to obtain an adequately descaled surface in H_2 combustion atmosphere compared to NG.



Impact pressure required to obtain an adequately descaled surface in H2 combustion atmosphere compared to NG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