

**ALTERNATIVE STEEL PRODUCTION
 DIRECT REDUCTION PROCESSES MIDREX DIRECT REDUCTION
 AT: ARCELORMITTAL HAMBURG**

Dr. Mohammad Safi
ArcelorMittal Hamburg
 Dradenastraße 33, 21129 Hamburg, Germany

1. FROM IRON ORE TO STEEL

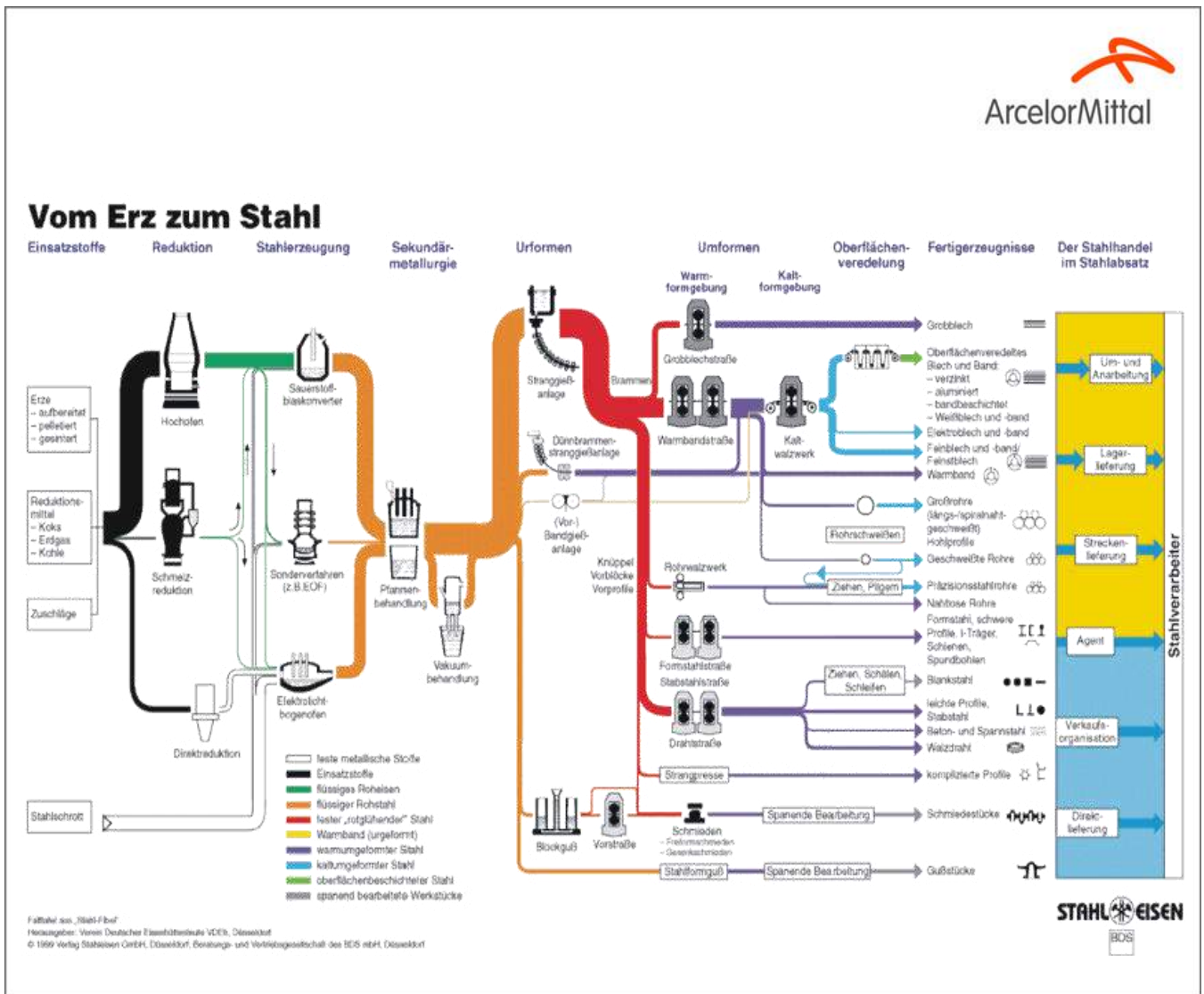


Fig. 1. From iron ore to steel

2. COMPARISON OF BF AND DR

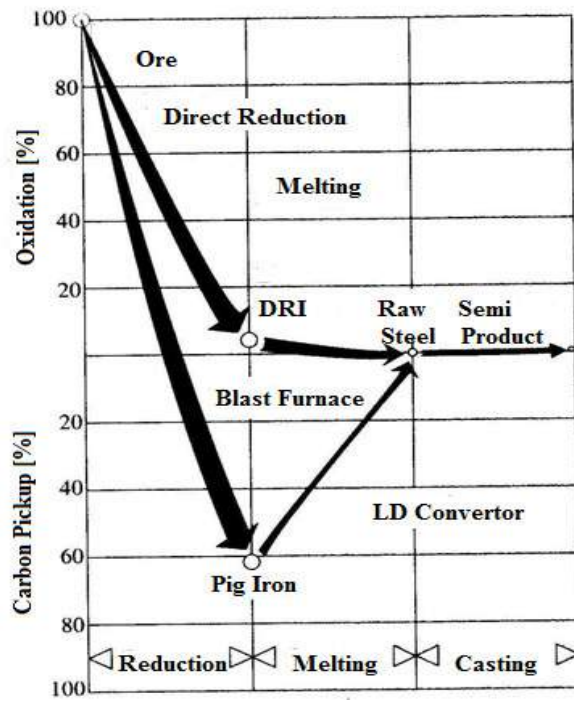


Fig. 2. Comparison of BF and DR

3. ARCELORMITTAL HAMBURG



Fig. 3. ArcelorMittal Hamburg

4. PRODUCTION FLOW

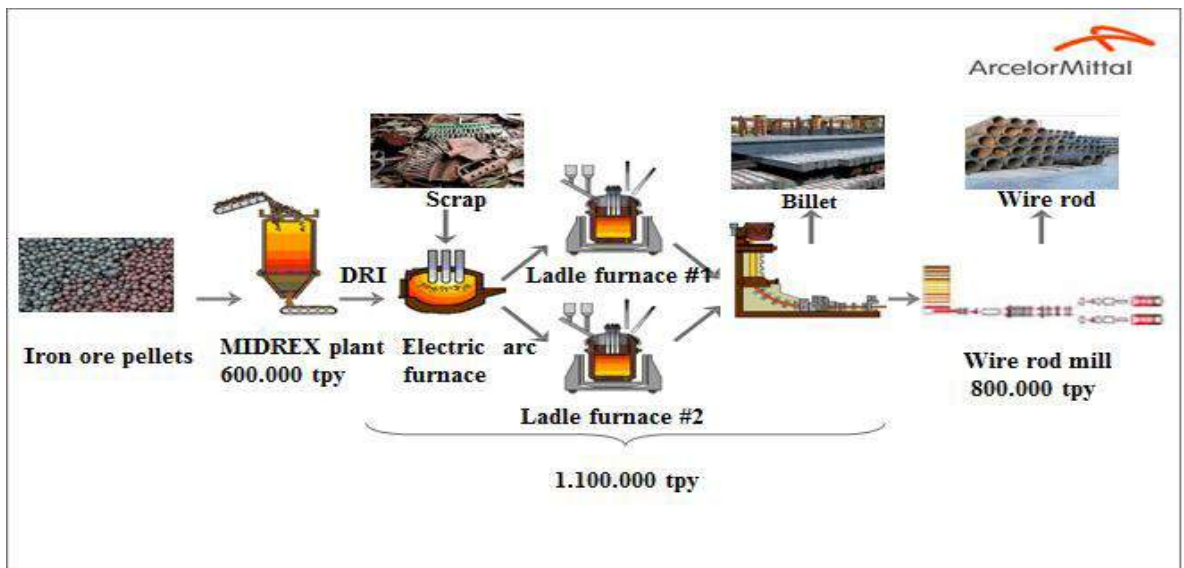


Fig. 4. Production flow

5. WIRE ROD SHIPMENT (2015)

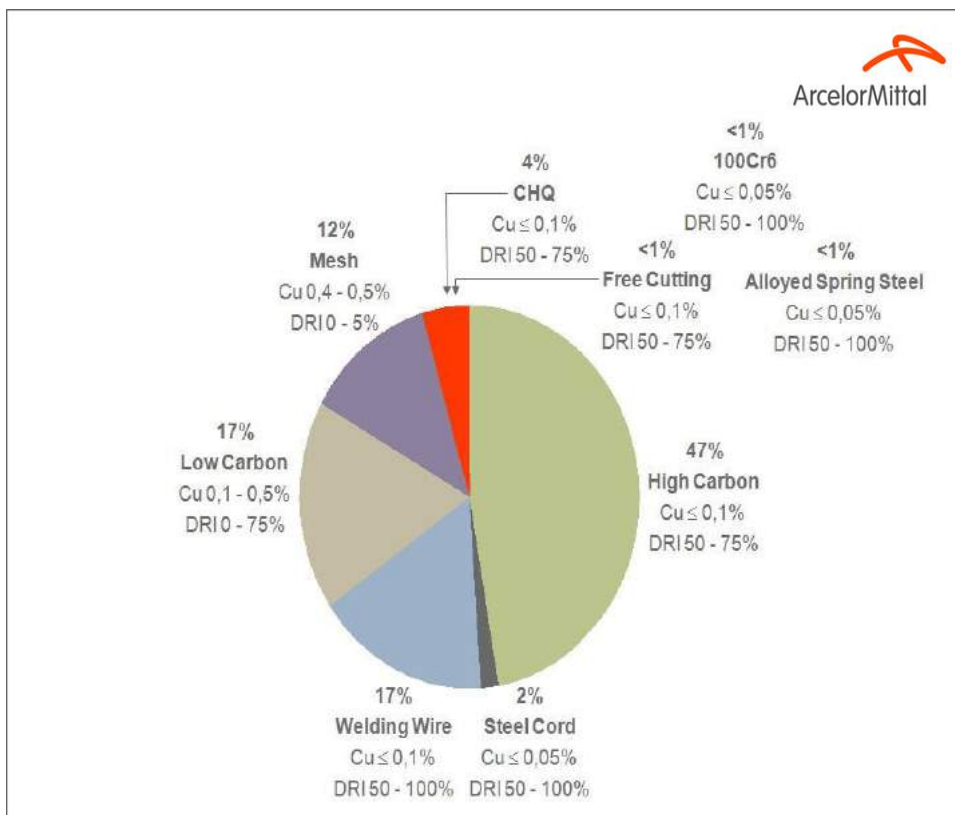


Fig. 5. Wire rod shipment (2015)

6. APPLICATION FIELDS

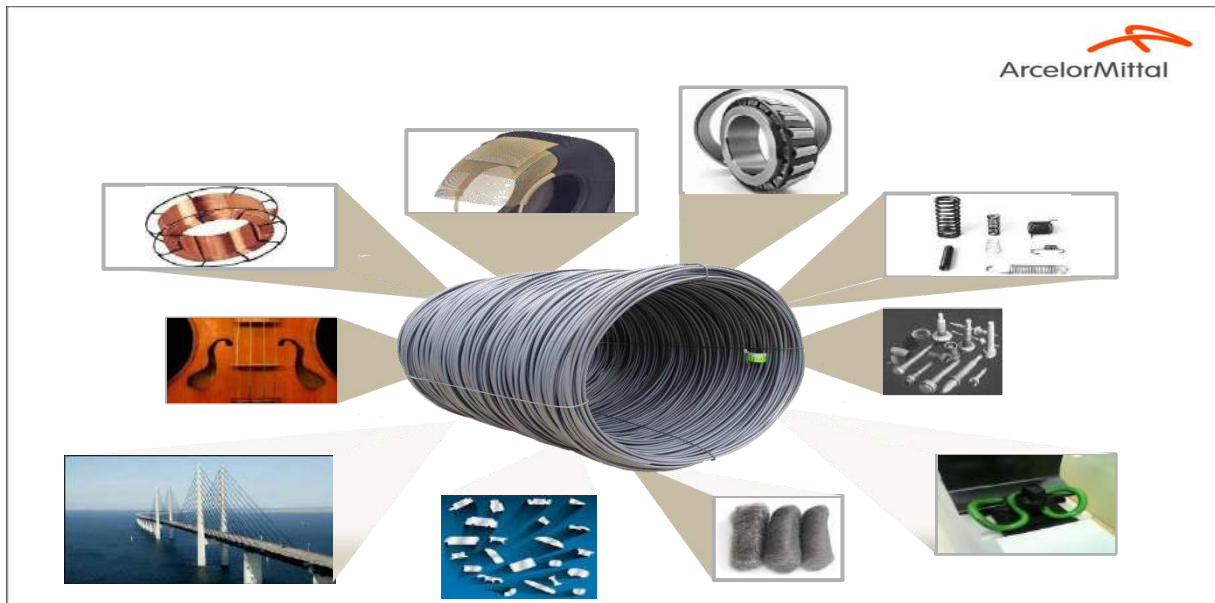


Fig. 6. Application fields

7. DIFFERENT DR PROCESSES

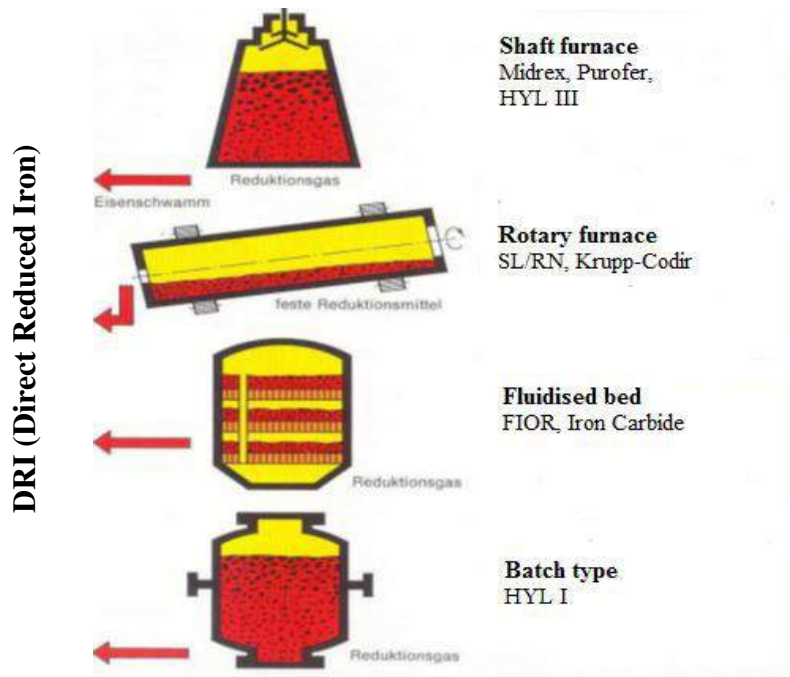


Fig. 7. Different DR processes

8. WORLD DRI PRODUCTION BY PROCESS

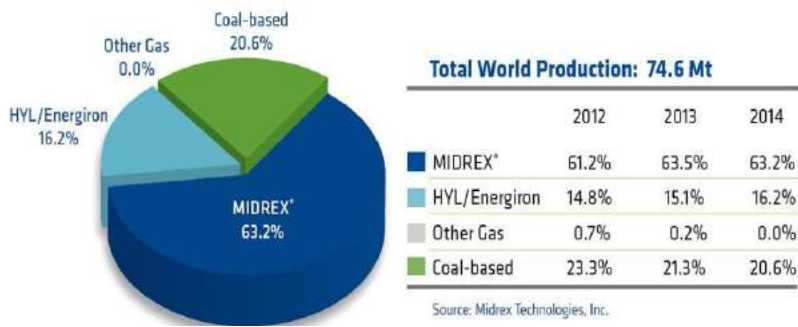


Fig. 8. World DRI production by process

9. WORLD DRI PRODUCTION BY REGION

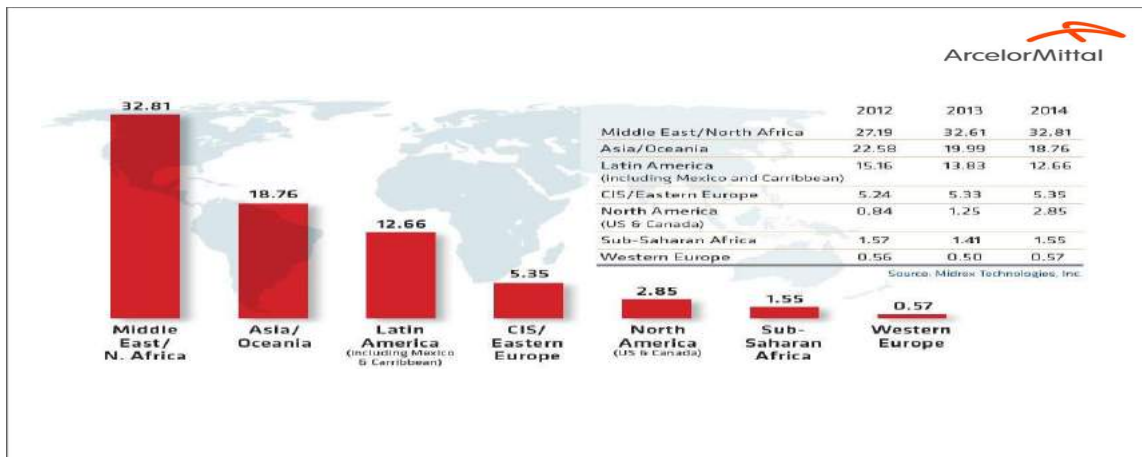


Fig. 9. World DRI production by region

10. MIDREX PROCESS FLOW SHEET

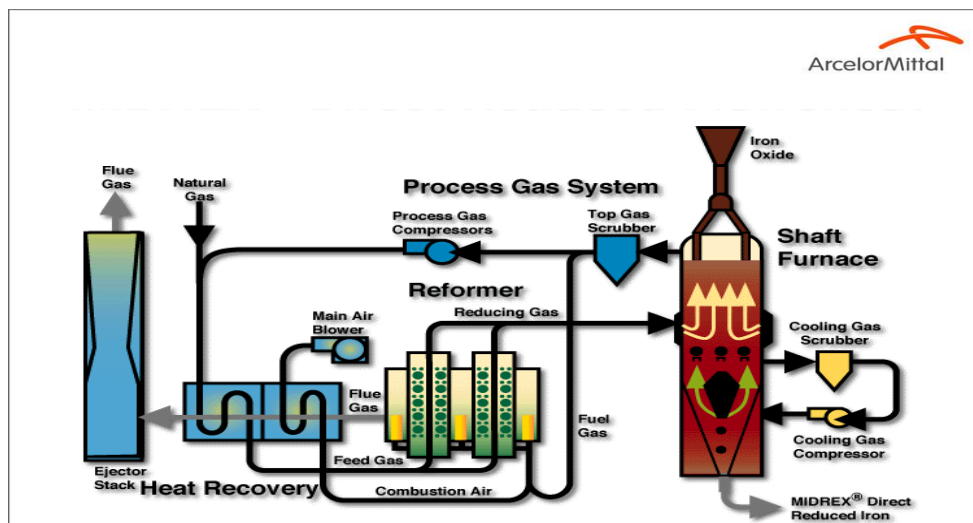


Fig. 10. Midrex process flow sheet

11. CHEMICAL REACTIONS

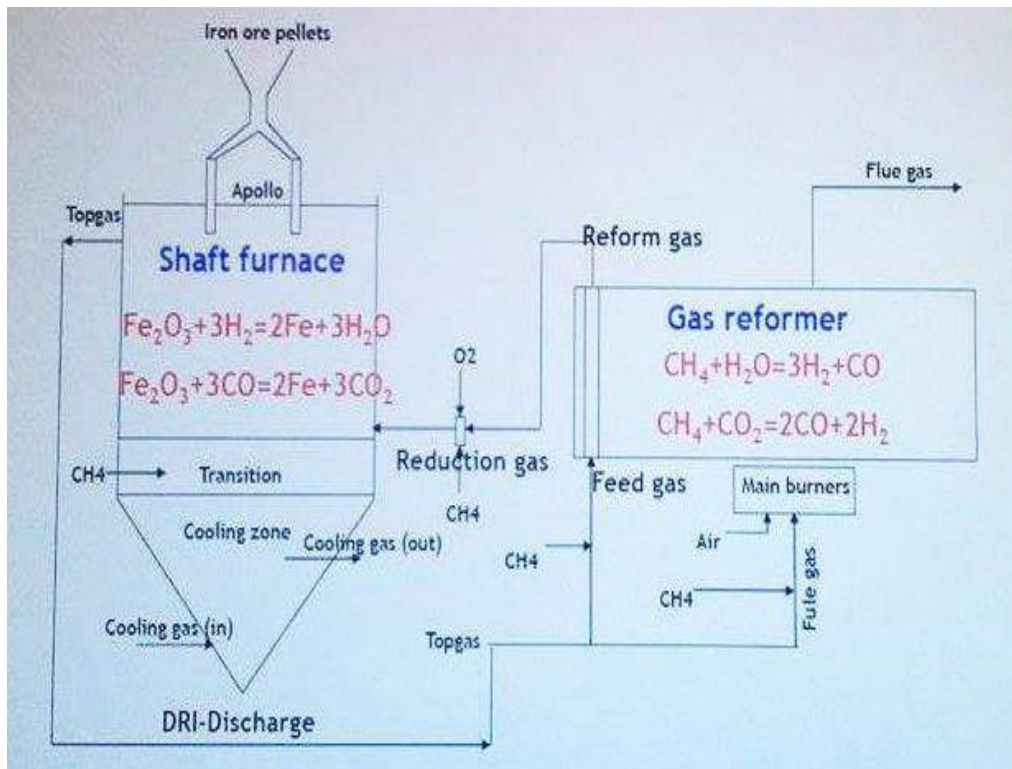


Fig. 11. Chemical reactions

12. QUALITY OF DRI

$$Fe_T = \frac{Iron_{total}}{Oxide} \times 100$$

$$Fe^\circ = \frac{Iron_{metallic}}{Oxide} \times 100$$

Metallisation: $Met = \frac{Fe^\circ}{Fe_T} \times 100$

Reduction rate: $RD = \left[1 - 2,327 \left(\frac{\%O}{\%Fe_T} \right)_{DRI} \right] \times 100$

Carbon content

Example: Metallisation : 94 %
Carbon content 2,4 %

Fig. 12. Quality of DRI

13. SHAFT FURNACE

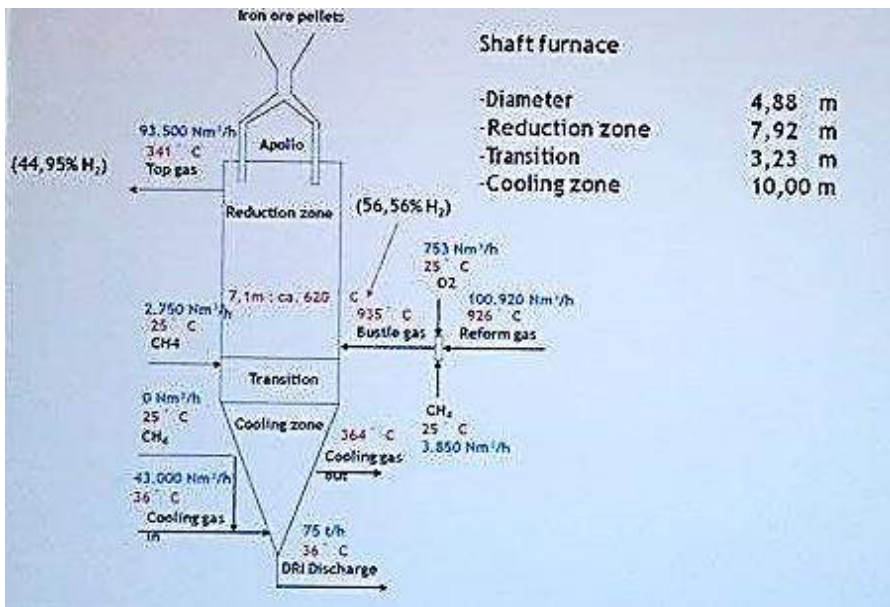


Fig. 13. Shaft furnace

14. BUSTLE - AND TOP GAS TUBES



Fig. 14. Bustle - and top gas tubes

15. BUSTLE GAS RING

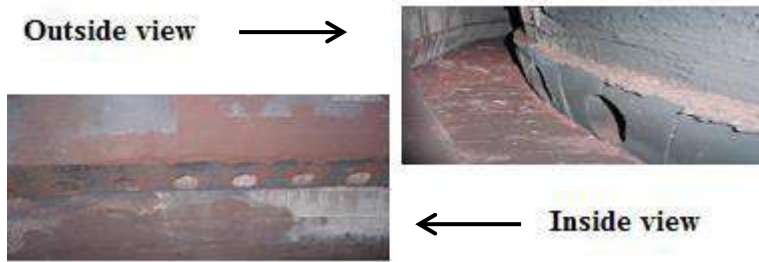


Fig. 15. Bustle gas ring

16. CHARGING OF THE FURNACE



Fig. 16. Charging of the furnace

17. GAS REFORMER



Fig. 17. Gas reformer

18. PRODUCTION OF REDUCING GAS FROM NATURAL GAS IN GAS REFORMER

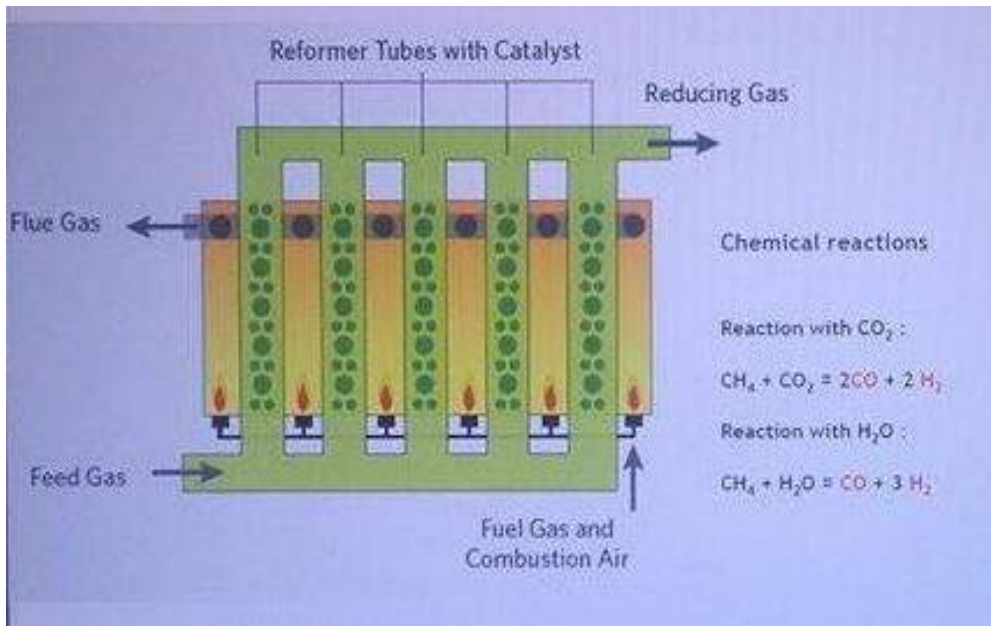


Fig. 18. Production of reducing gas from natural gas in gas reformer

19. HEAT AND ENERGY RECOVERY

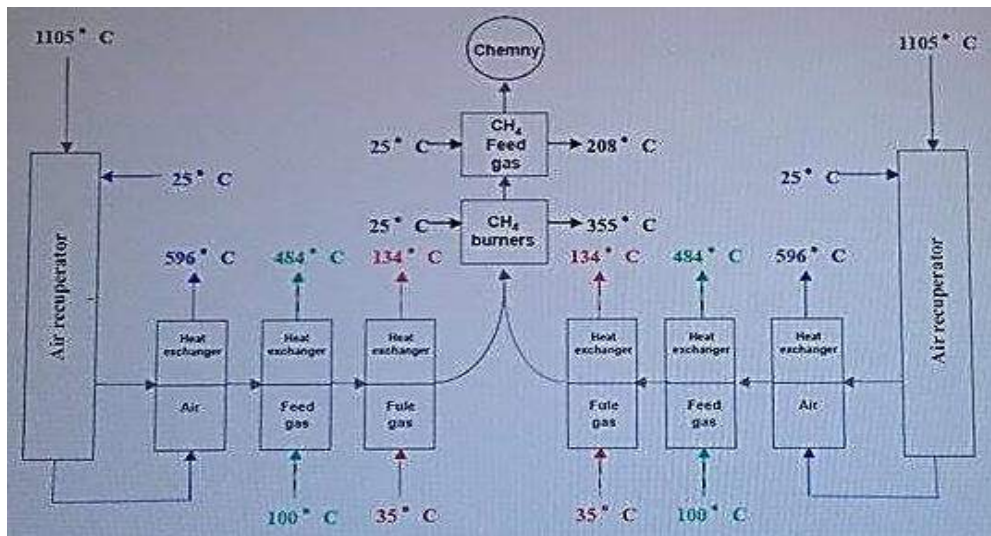


Fig. 19. Heat and energy recovery

20. CHEMICAL COMPOSITION OF DIFFERENT GAS CIRCUITS

Table 1. Chemical composition of different gas circuits

	Erdgas	Bustlegas	Kühlgas	Prozeßg.	Feedg.	Reformg.	Topgas	Brenng.	Sperrgas
H ₂		56,56	21,62	43,99	44,87	57,94	44,95	43,45	
O ₂									0,96
N ₂	1,98	3,04	1,87	2,31	1,63	2,02	1,53	1,33	83,84
CH ₄	91,35	3,22	65,81	2,69	15,49	1,28	2,65	3,08	
CO		34,33	7,47	31,98	19,66	36,27	30,69	30,91	
CO ₂	0,89	2,85	0,96	19,03	17,20	2,49	20,18	21,23	15,20
C ₂ H ₆	4,61		2,27		0,97				
C ₃ H ₈	1,17				0,18				

21. ENVIRONMENT



Fig. 20. Environment

- ArcelorMittal Hamburg: 824 kg CO₂ / t wire rod (mean value 2015)
- 65% compared to the German steel industry (1360 kg CO₂ / tsteel) in 2010.