Chimney for Wet Stack Operation

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Hermann Hoffmeister has been the Chimney Director of KARRENA since 2003 and the Chimney Business Leader of the BEROA Technology Group.

Hermann's interest in CICIND grew with the discussions at his first CICIND meeting in Amsterdam in 2003. He was elected to the Governing Body in 2007 at the meeting in Athens

Albert de Kreij

Albert de Kreij joined Hadek Protective Systems in 1989. He has been closely involved in a number of projects with the use of Borosilicate Glass Block Linings especially in wet stack operation conditions.

1. Introduction

In central Poland 150 km westwards of the capital Warsaw one of the biggest Power Plants of Poland produces 2,457 MW of electric energy: PAK – Patnow-Adamow-Konin.

To meet European Union environmental standards the existing 4 lignite fired units with a capacity of 200 MW each had to be retrofitted.

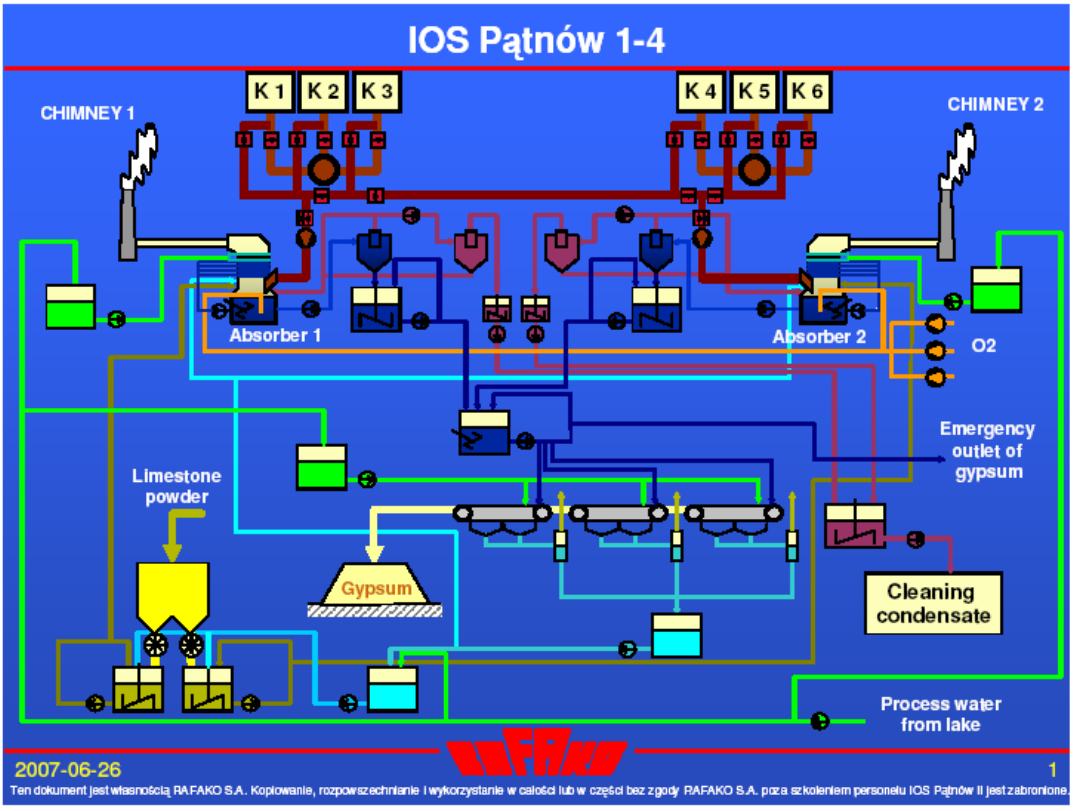
RAFAKO, a leading EPC contractor to the Polish Power Industry was awarded to construct two wet limestone FGD plants with 4 x 200 MW lignite powered units.

KARRENA was asked to work out a proposal for the chimney arrangement of this plant, to evaluate the best material and to find out the most economical solution. The given data was the height of the chimney with 150 m, the soil conditions of the site.

The basis for the considerations of different material options was the analysis of the flue gas data:

Flue gas volume:	MIN 574,500 Nm³/ h;	T = 65.50°C
	NOM 2,330,300 Nm³/ h;	T = 66.60°C
	MAX 2,429,300 Nm³/ h;	T = 66.50°C.
Design temperature:	80 / 210°C, max 78 h, max 340 h/year	
Diameter:	8400 mm	
Draft min./max:	32 Pa / -367 Pa	
Critical Gas Velocity:	17 m/s	

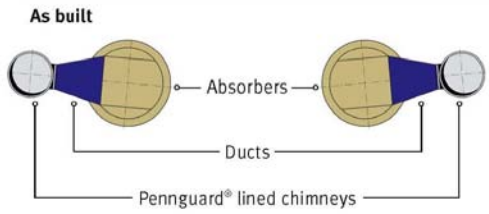
Because RAFAKO decided not to reheat the flue gases only partially, the chimney had to be operated as a Wet Stack Chimney. Besides an option for bypass operation at 210 °C was requestet.



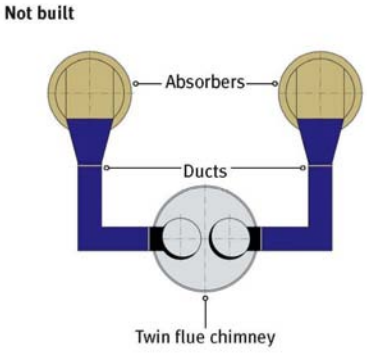
The general arrangement of the power plant with the new absorbers is shown in the following sketch:

As a design solution for the plant's best needs two different options for the chimney arrangement generally had been considered:

a) Two separate chimneys (single flue stacks)
   - Very short duct lines
   - Small area each



b) One central chimney (twin flue stack)
   - Long duct lines
   - Bigger area



The advantages of the required area and the lower costs of two separate chimneys led to the decision to build two single flue stacks.

2. Material Options

To conform to the client's requirements such as the arrangement of absorber and chimney under wet stack operation, a bypass with 210 °C, as well as a short erection time, maintenance conditions and life time, different material options for the chimney were examined.

- Stainless Steel liner
- Steel Liner + Pennguard
- Steel Liner + Flake
- FRP-Liner
- Lattice Girder Chimney
- New Chimney Design.

Analysing the most reasonable solutions for the wet stack operation the key data of each option were compared (see Table below).

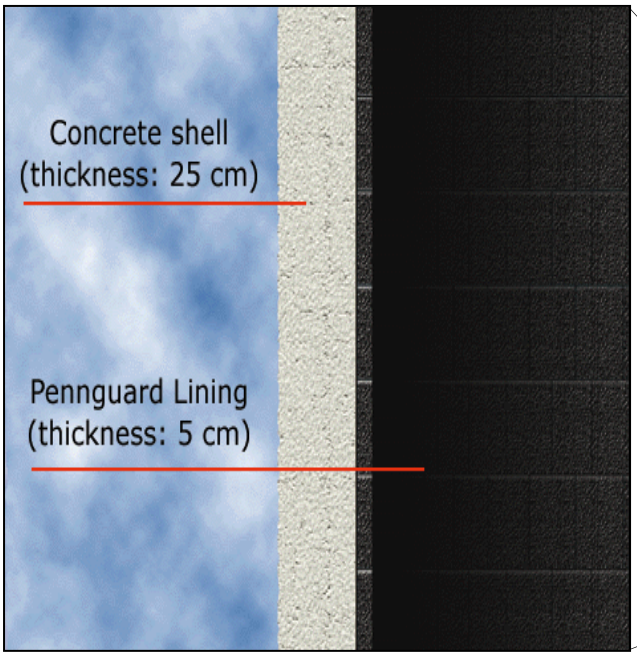
As a result of all advantages and disadvantages of the different material options and while considering the best performance with regard to e.g. acid resistance, condensate, etc., as well as the site activities, RAFAKO decided to contract the New Chimney Design to KARRENA as the most economic solution.

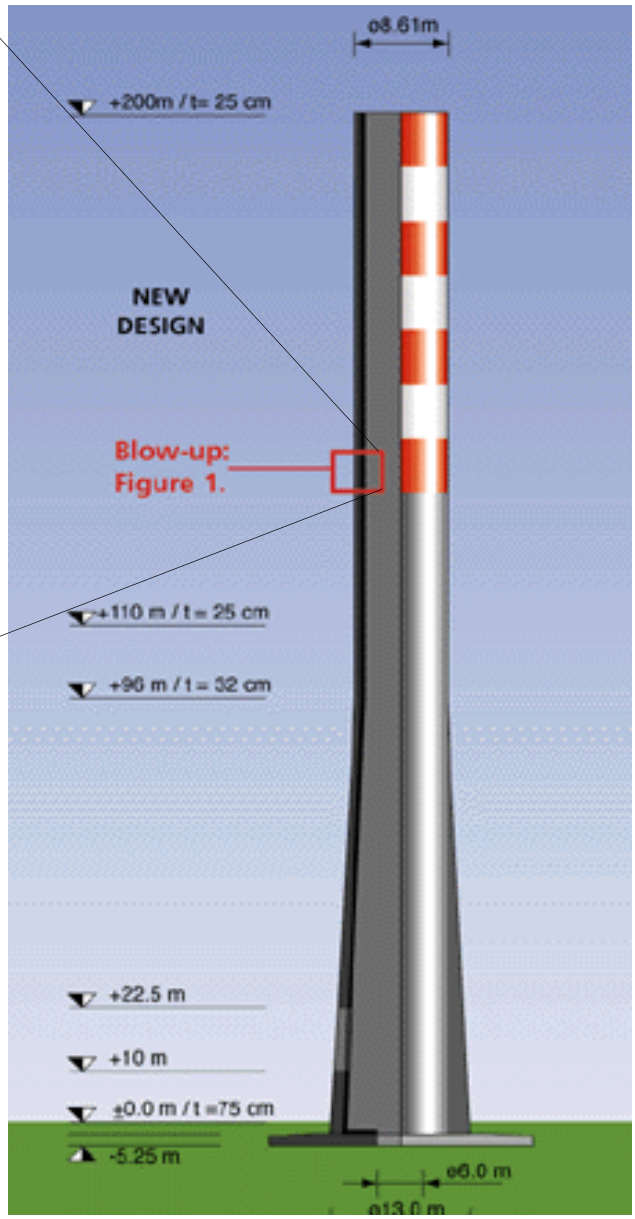
3. New Chimney Design

The analysis for the New Chimney Design for the requested chimneys at Patnow Power Plant was done by KARRENA.

	R/C Steel liner Flake	**R/C FRP-Liner**	**Lattice Girder FRP-Liner**	**New Chimney Design**
Acid resistance	+	++	++	++
Heat resistance	--	-	-	++
Condensate quantity	+	+	-	++
Liner substitution	-	-	-	+
Long term performance	-	++	+	++
Maintenance	-	+	+	+
Erection time	33 weeks	30 weeks	26 weeks	25 weeks
Required working area	7500 m	7500 m	8900 m	3500 m
Structural analysis (gate opening at the bottom)	-	-	O	+
Safety area required	13 weeks	13 weeks	20 weeks	12 weeks
Costs	++	O	+	+

++ Very good *+ good* *O sufficient* *- not sufficient* *- - Very bad*





3.1 Thermal analysis

Ambient conditions

- Summer T_{out} = 35°C
- Winter T_{out} = -25°C

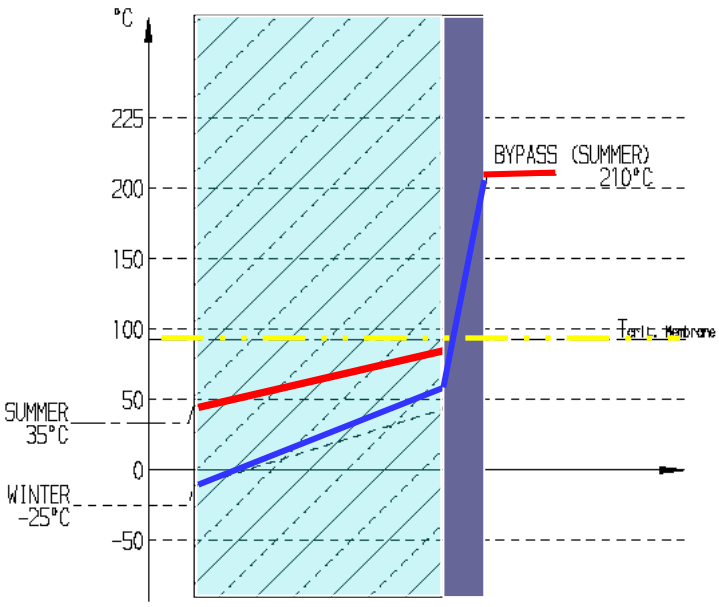
Gas temperatures

- Operation 66 °C
- Bypass 210 °C

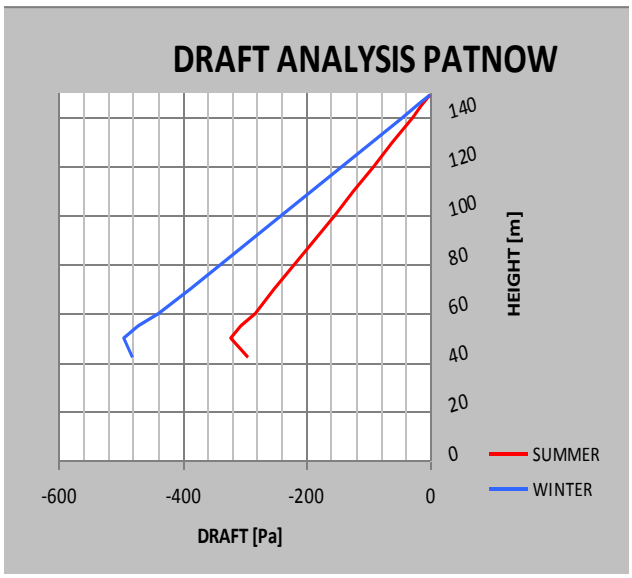
Wall construction,

- R/C wall 350 mm
- Membrane 3 mm
- Pennguard 51 mm

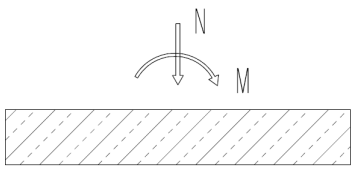
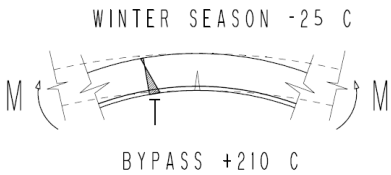
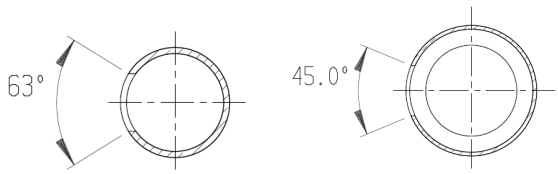
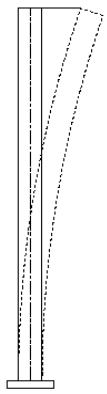
The given data based in the following calculation:



3.2 Draft analysis



3.3 Structural analysis

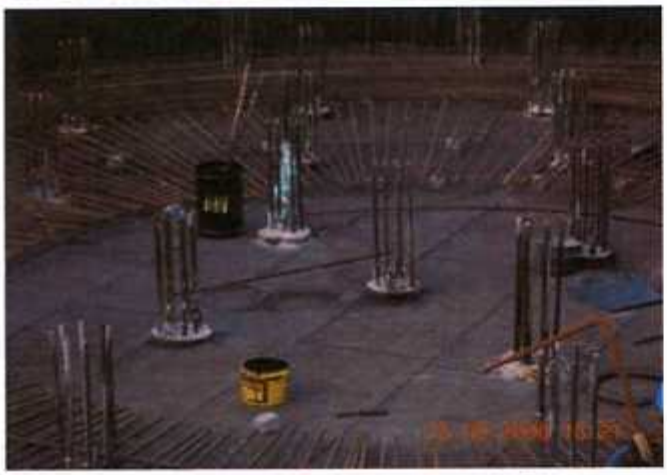
	New Chimney Design		Standard Design
	$e_{NCD} = M_{NCD}/N_{NCD}$	>	$e_{STD} = M_{STD}/N_{STD}$
	$a_{s,hor.\ NCD}$	>	$a_{s,hor.\ STD}$
	α_{NCD}	>	α_{STD}
 Vertical reinforcement	$a_{s,vertical\ NCD}$	>	$a_{s,vertical\ STD}$

4. Execution of the works

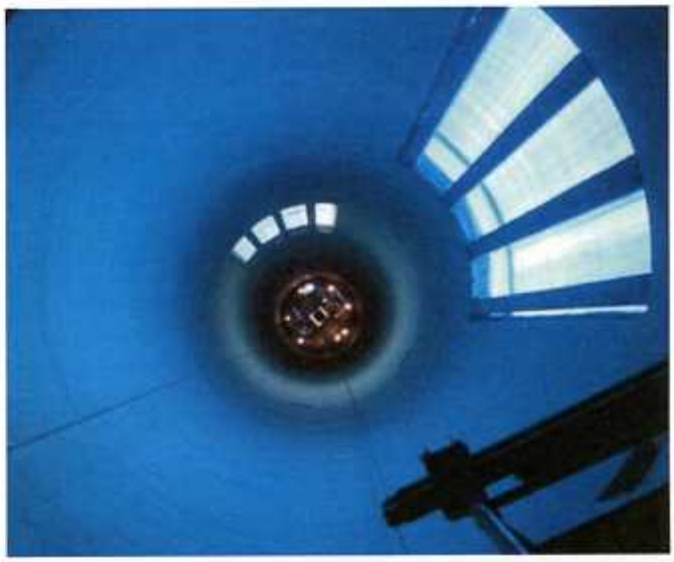
The chimneys could be completely built in just seven months each.

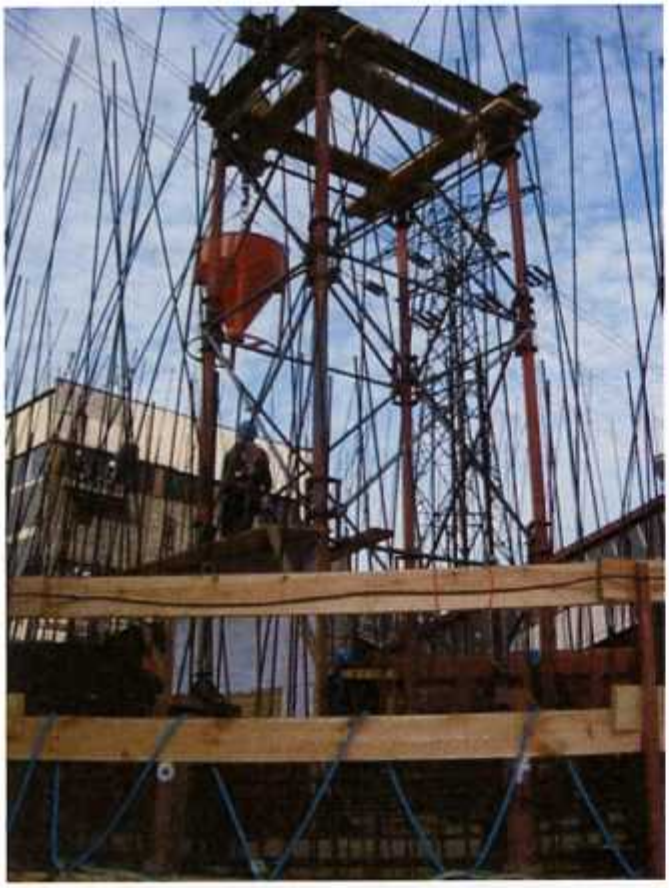
4.1 Piling

4.2 Foundation



4.3 Slipform erection / start





4.4 Surface treatment during slipforming

Surface treatment during slipforming – STEP 1 Smoothing the concrete surface

Surface treatment – STEP 2 Primer application directly to the fresh concrete

Composite Floors

4.5 Pennguard® Installation - Chimney

4.6 Pennguard® Installation – Flue opening

4.7 Quality procedure Pennguard®

- PHASE 1
  Inspection of object / jobsite
- PHASE 2
  Inspection of material
- PHASE 3
  Inspection of substrate preparation and primer application (pull off tests)
- PHASE 4
  Installation of Pennguard® block lining system
- PHASE 5
  Act of „FINAL ACCEPTANCE"

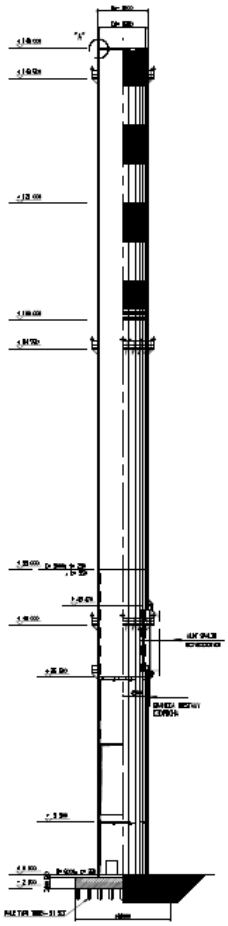
4.8 Execution of quality procedure

Phase 3 - Inspection of substrate preparation and primer application

Phase 4 – Installation of Pennguard® block lining system

Phase 5 – Act of final acceptance

5. Conclusion



The decision by RAFAKO had been made to build two separate concrete chimneys with a Pennguard® lining: **the New Chimney Design** (NCD).

One major aspect was the very tight site area for the realization of the project. The New Chimney Design was the concept with the most space savings by shortening the flue gas ducts. This arrangement minimized the pressure losses to the lowest level which had a positive effect on the fan capacity.

Of course the short duct further reduced the overall costs against one twin flue chimney placed in the middle of the arrangement.

For the performance on site the short construction schedule was very attractive for the overall works. The works at the absorber could start directly after shell erection and the installation of the Pennguard® lining could be done without any interference at the tight site conditions. So far the short time period for the necessary safety area was a significant advantage to the construction process. The influence on other site activities could be reduced to a minimum.

The Pennguard® System can be used for the scheduled bypass operation with 210 °C and for wet stack operation with a high condensate production. The creation of condensate appearance during wet stack operation was investigated by the Alden Institute for different materials: The Pennguard® System produces the lowest quantity of condensate in comparison to other materials.

The Pennguard® System has a long expected lifetime; therefore a 10 year guarantee was given. The concrete windshield for the New Chimney Design has a scheduled life time of 50 years.

The maintenance of the Pennguard® System is on a very low level. Repair works can be done easily by using a cradle or a working platform. The New Chimney Design finally was the most economic solution for the given conditions.