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New Chimney Design (NCD). The long-term performance of the chimney type

New Chimney Design (NCD). Stan techniczny kominów po długoletniej eksploatacji

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(Studium przypadku)

Abstract. In 1998 Hadek Company commissioned the Expert Office Exponent to develop a chimney type based on the concrete shell protected by a Pennguard™ lining. The concept has become known as the New Chimney Design (NCD). It consists of a windshield with Pennguard™ blocks applied to the internal surface. The NCD chimneys have been built in power stations all over the world, also in Poland. Due to the growing success of NCD-Technology, Exponent was commissioned with case studies regarding the long-term performance of the Polish NCD--chimneys. The paper at hand contains the results of these studies.

Keywords: industrial chimneys; chimney lining; cracks in windshields; durability.

Streszczenie. W 1998 r. firma Hadek zleciła biuru eksperckiemu Exponent opracowanie nowego typu komina przemysłowego z wykładziną z bloczków Pennguard™. Rozwiązanie to stało się znane jako New Chimney Design (NCD). Polega on na naklejeniu wspomnianej wykładziny na wewnętrzną powierzchnię trzonu komina. Kominy NCD zostały zbudowane w elektrowniach w wielu krajach świata, również w Polsce. W obliczu rosnącego powodzenia tej technologi, Exponent otrzymał zlecenie wykonania badań dotyczących długoletniego zachowania się polskich kominów NCD po wieloletniej eksploatacji. Wyniki tych badań przedstawiono w artykule.

Słowa kluczowe: kominy przemysłowe; przewody spalin; rysy w trzonach; trwałość komina.

Research on NCD

The New Chimney Design consists of a concrete windshield with a Pennguard™ lining system applied to the internal surface (photo 1). This makes unnecessary all internal components such as independent flues, support slabs and corbels. The closed-cell borocilicate blocks of the Pennguard™ lining system are impermeable to acid gas and acid condensates. Therefore, the Pennguard™ lining protects the chimney from flue gas attacks including temperature.

The initial 1998 study [3] resulted in assessment of the differences between the NCD-chimneys and at that time very common chimneys with brick lining. In the following 17 years, the scene of the industrial chimneys experienced several distinct changes well reflected in papers [4 ÷ 9]:

- only three Chimney Types – Brick Flue, Steel/FRP Flue and NCD – remained on the market;
- NCD became used in Europe, both Americas and Asia under various operating conditions.

This welcome situation induced Hadek in 2015 to commission Exponent to determine the position of NCD in the current chimney market by comparing it with two other types of concrete chimneys dominating the current single flue scene. And so, within the research work [10] three 200 m high chimneys were designed and compared with each other by use of the same operating conditions (tabel). Based on the investigation results, the advantages of the NCD Chimneys can be briefly visualized by use of the following pro and cons presented also in [2, 11]:

Pro and cons of the different chimney types
Za i przeciw różnym typom komina

Chimney Type	Brick Flue	Steel/FRP	NCD
Designer qualifications	low	high	high
Structure arrangement	complex	complex	simple
Construction time	long	moderate	short
Construction cost [mln €]	12.4	15.0	11.2
Wet stack operation	not possible	possible	possible
Durability	low	high	high
Maintenance & repair	complex	moderate	simple
Earthquake resistance	poor	poor	good

Due to the growing success of NCD--Technology Hadek commissioned 2016 Exponent with case studies [1, 12] regarding the long-term performance of three chimneys located in Poland. The results of these special checks of the chimney condition are described in this paper.

Recently Hadek with participation of Exponent also induced research work regarding the provision of the NCD Chimneys with diffusers. The investigation results [13] prove the following two gains:

- significant cut of the operation costs without significant increase of the construction costs;
- avoidance of the damaging flue gas overpressure.

Performance of the NCD-Chimney Siekierki

The units of the combined PP (heat 2081 MW, power 622 MW) were only partially provided with FGD systems and the existing chimneys were not suitable for the mixed operation with average flue gas temperature of 140°C. The need for a new chimney has released studies on different alternatives which resulted in the decision to build in 2009 the following NCD chimneys (photo 2):

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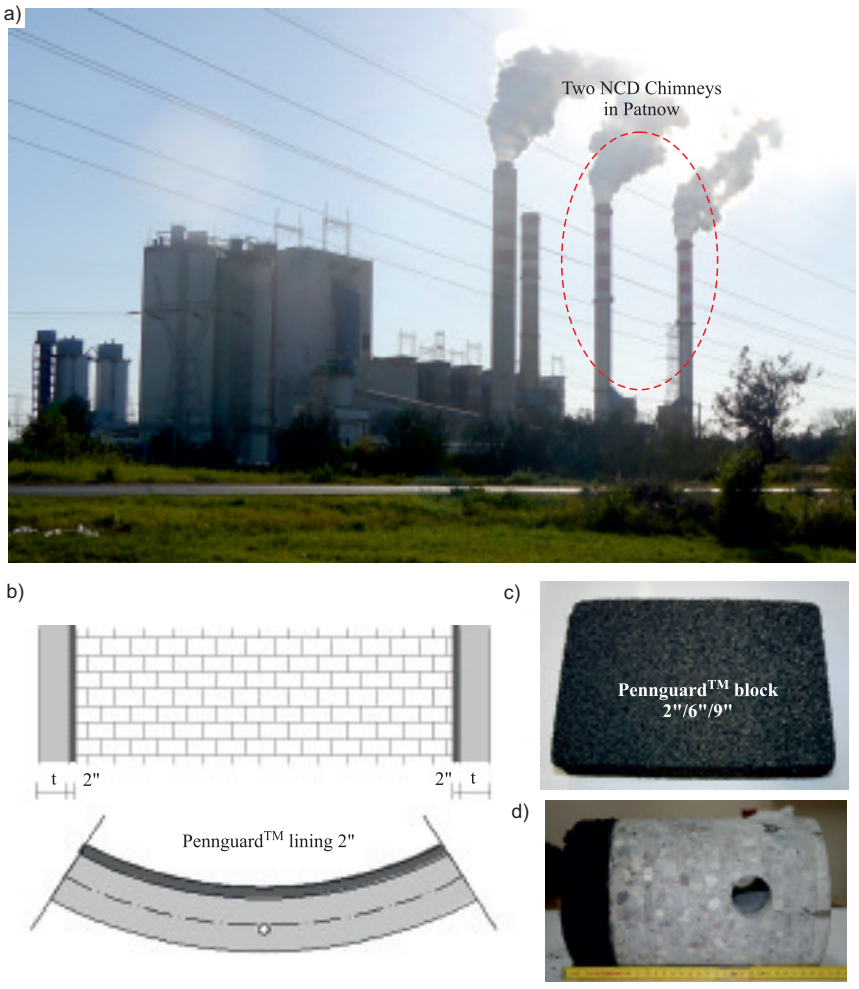

Photo. 1. Basics of the New Chimney Design: a) view on NCD Chimneys in Patnow; b) vertical and horizontal arrangement; c) individual Pennguard™ block; d) drilling core with Pennguard™ lining

Fot. 1. Podstawy New Chimney Design: a) widok na kominy NCD w Pątnowie; b) pionowy i poziomy przekrój trzonu; c) bloczek Pennguard™; d) odwiert z wykładziną Pennguard™

● mixed operation with average flue gas temperature of 140°C;
● height 170 m;
● conical shape with bottom diameter of 10 m.

After 7 years of operation the structure was subjected to condition checks by Exponent to determine the long term performance. The investigations provided the following findings:

■ **Windshield:**
– flawless windshield surface with hardly cracks on the surface;
– generally normal results of the thermo-vision measurements;
– local hot spot at the duct bottom indicating a small washing out;

■ **Pennguard™ lining**
– flawless lining surface and tight joints;
– partial washing out at the duct of 20 mm, 0.2% of the entire lining surface (photo 2f).

These results indicate that the chimney is in a good condition after 7 operation years.

Performance of the NCD-Chimney Patnow

Construction of two new wet limestone FGD plants (2 x 400 MW) required erection of chimneys capable to take over desulfurized flue gas without reheating (temperature of 65°). This released studies regarding the following two alternatives:

Alternative 1: Single twin flue Chimneys. Need of internal flues, slabs and corbels. Two long flue gas ducts. High concrete consumption of 3250 m^3.

Alternative 2: Two NCD Chimneys. No need of internal flues, slabs and corbels. Two short flue gas ducts. Low concrete consumption of 2640 m^3.

In view of these, the decision was made to build in 2006 the following two NCD chimneys:

● wet stack operation with flue gas temperature 65°C;
● height 150 m;
● cylindrical shape with bottom diameter of 9.0 m.

After 10 years of operation the structure was subjected to condition checks by Exponent to determine the long-term performance. These investigations provided the following findings:

■ **Windshield:**
– flawless windshield surface;
– narrow but numerous cracks indicating a former action of a high temperature difference;
– leakage of an aggressive condensate eating concrete to which Pennguard™ is resistant;

■ **Pennguard™ lining:**
– flawless lining surface and tight joints.

These results indicate that the chimney is in a good condition after 10 operation years (photo 3).

Conclusions

The general flawlessness of the chimney after 7 respectively 10 years of operation confirms that the NCD Chimneys designed and erected by qualified experts are durable. Since the findings were partially gained by thermo-vision measurements, the simplicity of such condition checks constitutes a substantial advantage of the NCD technology. The general experiences on the New Chimney Design so far [2, 3 ÷ 10, 11] allow the following statements:

● structural design – demanding due to the slender windshield and relative high temperatures;
● construction costs – low in any country due to the simple arrangement;
● construction time – approx. 10 months thanks to the simple arrangement;
● construction area – small due to the simple arrangement and correspondingly easy installation;
● maintenance – simple due to the possibility of using the infrared cameras;
● durability – high thanks the durable Pennguard™ blocks;

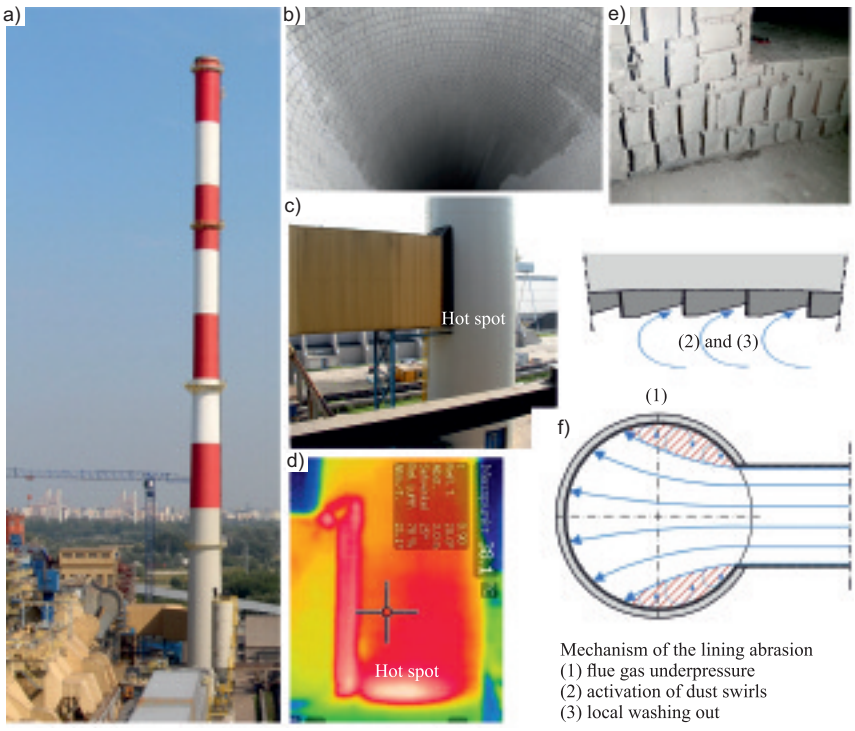

Photo 2. Chimney Siekierki: a) view on the NCD Chimney; b) flawless surface of the regular Pennguard™ lining; c) view on the external duct area; d) thermo-vision photo with a hot spot due to a local lining abrasion; e) view on the lining surface at the duct with visible lining abrasion; f) explanation of the local and partial lining abrasion

Fot. 2. Komin Siekierki: a) widok na komin NCD; b) bezbłędna powierzchnia wykładziny Pennguard™; c) widok na trzon przy czopuchu; d) zdjęcie termowizyjne z hot spot spowodowanym lokalnym ubytkiem wykładziny; e) widok na wykładzinę z lokalnym ubytkiem przy wlocie; f) mechanizm lokalnego ubytku wykładziny Pennguard™

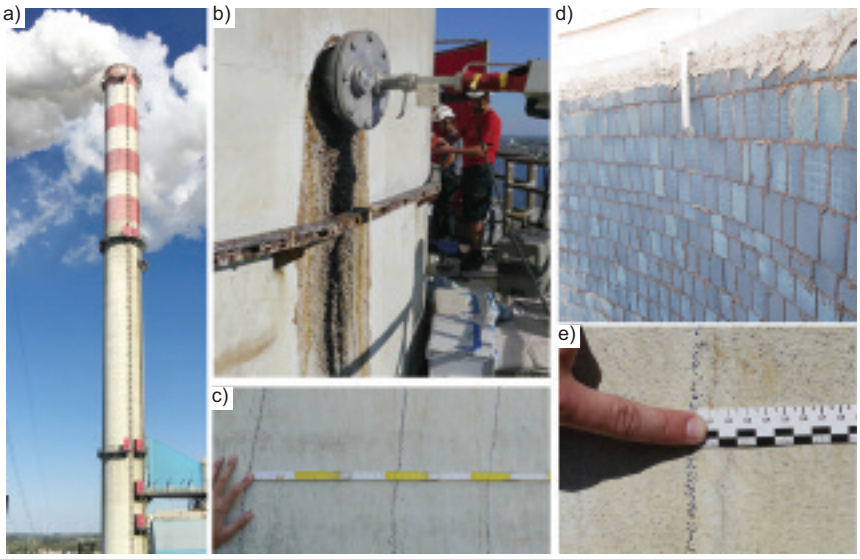

Photo 3. Chimneys Patnow: a) view on one of the two existing NCD Chimneys; b) leakage of an aggressive condensate eating concrete to which Pennguard™ is resistant; c) numerous vertical cracks indicating a former action of a high temperature difference; d) typical narrow crack width of 0.1 mm in the summertime indicating sufficient hoop reinforcement; e) flawless surface of the Pennguard™ lining

Fot. 3. Komin Pątnów: a) widok na jeden z dwóch kominów NCD; b) wyciek agresywnego kondensatu „zżerającego" beton a nienaruszającego Pennguard™; c) liczne rysy wskazujące na wcześniejsze wysokie różnice temperatur; d) typowa mała rysa w lecie o szerokości 0,1 mm wskazująca na wystarczające zbrojenie obwodowe; e) bezbłędna powierzchnia wykładziny Pennguard™

- earthquake resistance – excellent due to the light windshield top;
- wet operation – possible thanks to both tightness and no inclination to spitting.

Fot. – P. Noakowski

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