COMPOSITE CHIMNEYS

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Abstract

A lot of chimneys become dangerous because of corrosion. A composite chimney lining tube has been developed by Kompozitor Ltd. Its trade name is FuranFlex® and it is inserted into the chimney to be repaired, blown up by steam then irreversible hardened. The composite tube with 2 mm wall-thickness forms the shape, follows the path of the chimney. It is corrosion and heat resistant up to 220/350°C in flue gas. One of the advantages is that it can be used without breaking the wall as opposed to stainless steel. It is already used in 16 European countries in the diameter range of 60-900 mm until 80 m length.

Over the above mentioned dimensions FuranFlex® cannot be applied. A self supported, industrial chimney has been developed by Kompozitor Ltd for these large sizes. One has been already built with 1,250 mm diameter, 46.7 m height and 11,700 kg total mass in a hazardous waste incinerator environment.

1 Introduction

Kompozitor Co. Ltd. established in Budapest, Hungary, 1991. The profile of the company is R&D and manufacturing new products and machines in the field of reinforced plastics. Our philosophy is "Always unique solutions, never copying".

In this paper two types of chimneys made of composite material are presented.

2 FuranFlex® - Chimney Lining Technology

For several thousands of years mankind had no problems with chimneys. Wood and coal were used for heating and cooking, where the temperature of the flue gas was 400-500°C. At this temperature all of the combustion products left the chimney in the form of steam or gas. Spreading of oil and gas heating, modern, energy efficient boilers has affected the processes in chimneys radically.

In the past century wood and coal were given up for the more economical oil and gas heating where the flue gas temperature does not even reach 250°C (in case of wood or coal heating this temperature is above 450°C). This, however, had tragic results for chimneys. An acidic condensate precipitates out of the flue gas and corrodes mortar, concrete and sometimes even stainless steal. Due to this corrosion, carbon monoxide may enter rooms, and hence causes several deaths every year.

App. 300 people in France and app. 20 in Hungary die in carbon monoxide poisoning every year. A significant numbers of these cases are caused by wrong chimneys. In Fig. 1 an article about a Peruvian hotel can be seen where 57 people had to move to a hospital considering due to the suspicion of carbon monoxide poisoning caused by wrong chimneys.

Fig. 1 Carbon monoxide poisoning in a Peruvian hotel

To avoid this dangerous situation all gas and oil heated chimneys must be lined against corrosion in Europe. The most common technique used is to insert corrosion-resistant tubes into the existing chimney. In this case the following unsolvable problems arise:

- Rigid, thick-walled (0.6 mm) stainless steel tubes are corrosion-proof (10 years guarantee), but it is impossible to insert them into a long, faulty, crooked chimney without joints and breaking the walls.
- Flexible thin-walled (0.3 mm) stainless steel tubes can be pulled into a non-linear chimney with inclination, but their resistance to corrosion is not satisfactory.
- The cross-section of the inserted lining tube is always smaller than that of the existing chimney. This can result in less draft and less efficient heating.

The largest problem in the chimneys of gas and oil heating is corrosion. If one cubic meter gas is burnt, 1-2 liter water containing sulphuric, hydrochloric and nitric acid molecules as well is formed. Condensation occurs at 80°C. The more efficient is the boiler, the lower the temperature of flue gas is and the more condensate precipitates in the wall of the chimney. The acidity of this condensate is only pH 4-5 but its effect can be seen in Fig. 2 where these aluminum liner parts from the chimney were removed after 5 years of operation. Therefore industrial chimneys are designed in a way that the flue gas leaves the chimney over the dew-point temperature (160-180°C) to eliminate condensation. However, much energy is wasted in this case.

Fig. 2 Corroded aluminum chimney after 5 years of operation

The inner layer is a polyolefin based, extruded tube, while the middle section is a glass fiber reinforced composite (pre-preg) layer followed by a synthetic fabric layer.

The goal of the Kompozitor Ltd is to develop a composite chimney instead of aluminum, ceramic or stainless steel liners (Fig. 3) which changes the field of chimney lining radically. The structure of the FuranFlex® chimney liner can be seen in Fig. 4.

Fig. 3 Conventional chimney liners

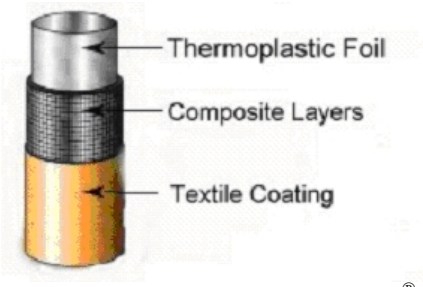


Fig. 4 Structure of the FuranFlex®

The applied resin contains a lot of components, additives and is excellent heat- and fire-resistant, corrosion proof and environmental friendly. FuranFlex® is delivered as a flat, soft, flexible tube (Fig. 5) folded into a compact pack less than 80 kg in a box (Fig. 6), and in case of bigger size (100-300 kg) in a wooden box. The matrix resin is in pre-polymerized state, while the FuranFlex® tube is tactile and not sticky, and can be stored under 18°C for several months.

Fig. 5 Folded FuranFlex® tube

Fig. 6 Packaging of the FuranFlex® tube

The FuranFlex® technology consists of the following steps:

- Examination and cleaning of the chimney to be lined;
- Insertion of the cross part (T) into the wall;
- FuranFlex® tube insertion into the chimney to be lined (Fig. 7.a);
- Closing the bottom and top part of the chimney with special devices;
- Connection of the steam generator at the bottom part of the FuranFlex® tube;
- Blowing up the FuranFlex® by steam at 0.2-0.4 bar pressure ;
- Hardening of the FuranFlex® for 0.5-3 hours (depends on the diameter and length);
- Cutting off the ends of hardened FuranFlex®;
- Insertion of condensed water tank/cleaning part;
- Insertion of the rain-hood (if required).

a) b)

Fig. 7 Installation of the FuranFlex® tube (a); The hardened chimney (b)

The completed, hardened FuranFlex® chimney can be seen in Fig. 7.b. and its technical properties are summarized in Table 1.

FuranFlex® tube follows the path of the chimney (until 30°declination) and takes up the shape of its cross-section. A few examples for this can been seen in Fig. 8.

FuranFlex® can be used for conventional gravity chimneys, standard (overpressure) and high efficiency, condensing boilers up to 5000 Pa according to the newest European standard (EN 14471) concerning plastic flue gas systems.

Table 1 Technical properties of hardened FuranFlex® tube

Property	Value
Wall thickness	2-5 mm
Diameter	60-900 mm
Permanent heat resistance	250-350°C
Cold resistance	-50°C
Tensile strength	100-250 MPa
Modulus of elasticity	12-15 GPa
Corrosion resistance	pH 1-pH 12
Environment protection	Does not emit toxic materials between 20 and 1000°C

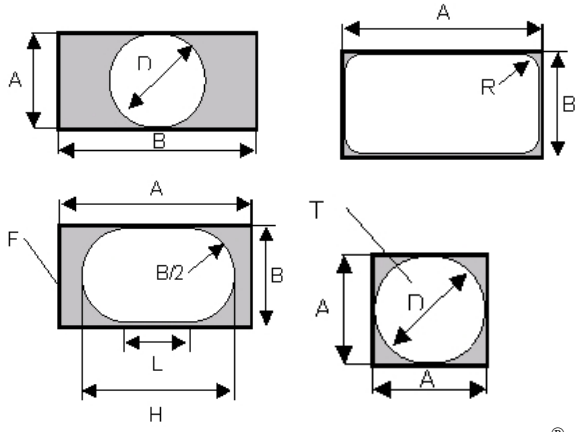


Fig. 8 Possible cross-sections of the FuranFlex® in the chimney

Here are some **advantages** of the FuranFlex®:

- Heat and corrosion resistant
- Thermally insulating
- Good mechanical properties
- Perfectly gas-tight
- Follows the path of the chimney
- Variable diameters in a single chimney
- Available in any length, various cross-sections
- Needs no junctions
- Smooth inner surface
- Short installation time
- Easy to handle
- No wall-breaking
- 25 years guarantee

Built-in quantity

850 km FuranFlex® tube has been built till now in Europe. The longest one was 80 m (France) and the largest diameter was 900 mm (Ukraine). FuranFlex® chimney lining system is exported by Kompozitor Ltd to European countries summarizes in Table 2.

Table 2 Present exported European countries

Austria	France	Romania	Italy
Belgium	Netherlands	Slovakia	Sweden
Norway	Finland	Spain	Estonia
Poland	Ukraine	Greek	Russia

There are few “big” partners in the given countries who have used FuranFlex® for 5-7 years, and in some countries it is only started to be used.

Licenses

The introduction of FuranFlex® (and all new chimney lining technologies as well) requires permit in all countries. This usually contains the following measurements:

- Permanent heat resistance
- Corrosion resistance
- Pressure-tightness

Fig. 9 shows a cyclic-diagram of a standard heat resistance measurement for chimney liners, while Fig. 10 presents the testing laboratory.

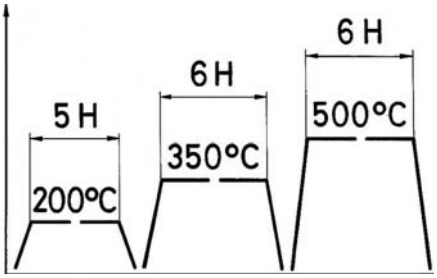


Fig. 9 Cyclic-diagram of heat resistance

Fig. 10 Testing laboratory

Installation devices of the FuranFlex®

Top and bottom closing pieces (Fig. 11) are used to pre-blow up the chimney, to carry in and out the steam and to remove the condensed water. The pre-blow up is carried out by a self-designed Fastblower (Fig. 12). A self-designed steam generator (36 kW performance, 93% efficiency) is applied for steam generation (Fig. 13).

Fig. 11 Top and bottom pieces of the FuranFlex®

Fig. 12 Fastblower

Fig. 13 FuranFlex® KNK 36 type steam generator

Quality assurance

Courses are organized by Kompozitor Ltd for those who would like to use the FuranFlex® technology. Fig. 14 shows the training chimney used in a course.

Awards

The FuranFlex® material and technology won the following international awards:

- Throphées de l’innovation, Intercliama, Paris
- Award Special, International building exhibition, Kiev (2004)

- Gold medal, Internationale Ausstellung Idéen, Erfindungen, Nürnberg (2004)
- Palmares de l'innovation, Paris (2004)
- Genius Europa Grand Prix, International exhibition of inventions, Budapest (2004)
- Gold medal with mention, 53rd world exhibition of innovation, Research and new technology, Bruxelles (2004)

Fig. 14 Training chimney

Polykamin

Industrial chimneys are also damaged by corrosion; e.g. the chimney of the hazardous waste incinerator of the French company, ONYX in Hungary. This chimney made of steel-plate (6 mm), with an abrasion- and corrosion-proof vulcanized inside rubber liner (5 mm), thermal-insulation (80 mm) and aluminum trapezoid plate (1.5 mm) as the outside cover. The inner diameter of the steel chimney was 1,100 mm. The total mass of the steel chimney was 18,000 kg.

The the steel chimney can be found in Fig. 15.a. After 8 years operations steam and flue gas flew out the thermal insulation since corrosion tracks formed on the chimney wall (Fig. 15.b). The collapse of the chimney was a real risk.

The first idea was to build and line a new steel chimney with FuranFlex technology, but it had to be rejected. On the one hand there was not any experience to line such a big chimney with FuranFlex® technology. On the other hand the thermal-expansion-coefficient of the FuranFlex® material is 2.5 times higher than that of the steel which could cause damage in the structure in the long run.

a) b)

Fig. 15 Steel chimney (a), Steam escape (b)

Therefore Kompozitor Ltd. Developed a self-supported composite chimney (trade name: Polykamin). Polykamin corresponds to the following requirements:

- Permanent heat-resistance up to 125°C
- Excellent corrosion-resistance in pH 3 range
- High mechanical strength
- Abrasion-resistance
- UV-resistance
- Self-quenching property

Vinyl-ester and isophtalic-acid polyester were applied when producing Polykamin. The raw resins were modified with different additives considering to the strict requirements and the processes in the chimney.

Production data are shown in Table 3.

Table 3 Production data

Quantity of flue gas and steam	50,000 m3/h
Reflowing condensed water	4,000 kg/h
Acidity	pH 5
Speed of the flue in the chimney	60 km/h
Speed of the flue in the dropseparator	120 km/h

The features of the Polykamin are summarized in Table 4.

Table 4 Features of the Polykamin

Inside diameter	1,250 mm
Length of the vertical tube	40.4 m
Diameter of the water drop separator	2,500 mm
Height of the water drop separator	5 m
Weight of the vertical tube	9,300 kg
Weight of the water-drop separator	1,700 kg
Weight of the elbow	700 kg

Prefabricated parts of Polykamin

The vertical section is produced with filament winding technology. Its lay-up corresponds to the requirements of operation. The joint of the parts assures a perfectly smooth inner surface of the pipe.

The 90 degree elbow of the bottom part made of two parts glued and screwed together externally.

The diameter of the water-drop separator is 2,500 mm. The 120 km/h velocity flue gas is forced to circular path in it thus the acidic water-drops are "centrifuged". According to high abrasion load Kevlar fibers were also applied.

The vertical section of the plastic chimney was inserted in one part together with the elbow (Fig. 16.a). This was 10,000 kg in total. The water drop separator was assembled later in 70 m height (Fig. 16.b). It was prepared according to new principals, the purpose of which is not to let acidic water drops into the environment, with the best effectiveness

The disassembling of the steel chimney took 2 days, and the assemblage of the plastic chimney lasted for 2 days as well. Waste incinerator was in operation during the assembly, flue gas was exhausted through a temporary chimney.

POLYKAMIN plastic chimney (Fig. 17) was commissioned in October, 2005. Kompozitor has taken a 30 year corrosion warranty for the assembled chimneys.

Experiences:

- After one year of continuous operation neither corrosion, nor erosion signs were observed in the chimney.
- The water drop separator perfectly selects water drops; "acidic rain" has disappeared in the environment.
- Resistance of the chimney is lower than it was of the steel chimney, thus power consumption of fans has significantly decreased and quantity of burnt waste could be increased.

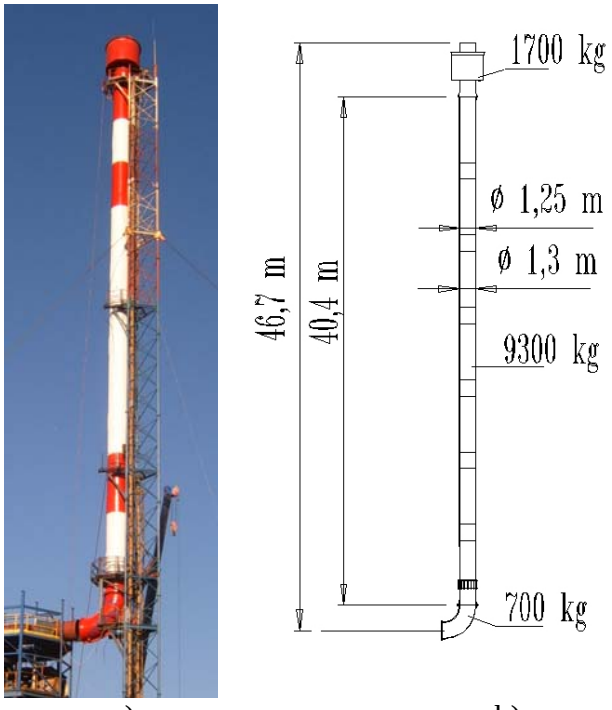
Advantages of Polykamin

A few advantages of PolyKamin are the follows:

- Heat and corrosion resistant
- Excellent mechanical properties
- Withstand for the abrasive and corrosive effect from high quantity condensate (~4,000 kg/h)
- Perfectly gas-tight
- Smooth inner surface
- Paintable
- 30 years guarantee

a) b)

Fig. 16 Elbow (a); Water drop separator (b)



a) b)

Fig. 17 Polykamin: the chimney of a waste incinerator (a); Scheme of the chimney (b)

Applications of the Polykamin

PolyKamin can be used for any industrial chimneys such as oil-refineries, (hazardous) waste incinerators and chemical companies.