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# EXPERIENCE WITH LOW TEMPERATURE VORTEX COMBUSTION OF DIFFERENT FUELS AT BKZ-210-13,8 BOILER OF KIROV CHP-4 AND POSSIBILITIES OF ITS USE AT BALKANS

**K.A. Grigoryev*, V.E. Skouditskiy**, R.G. Anoshin**,**

**V.V. Osmanov*, S.V. Djekic**

***Saint-Petersburg State Polytechnical University**

29 Polytechnical street, St.-Petersburg, 195251, Russia, e-mail: kg1210@mail.ru

****Company „NTV-energo“**

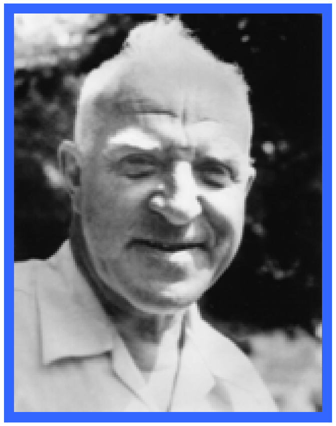
29 Polytechnical street, St.-Petersburg, 195251, Russia,

e-mail: info@ntv-energo.spb.ru, http://www.ntv-energo.spb.ru

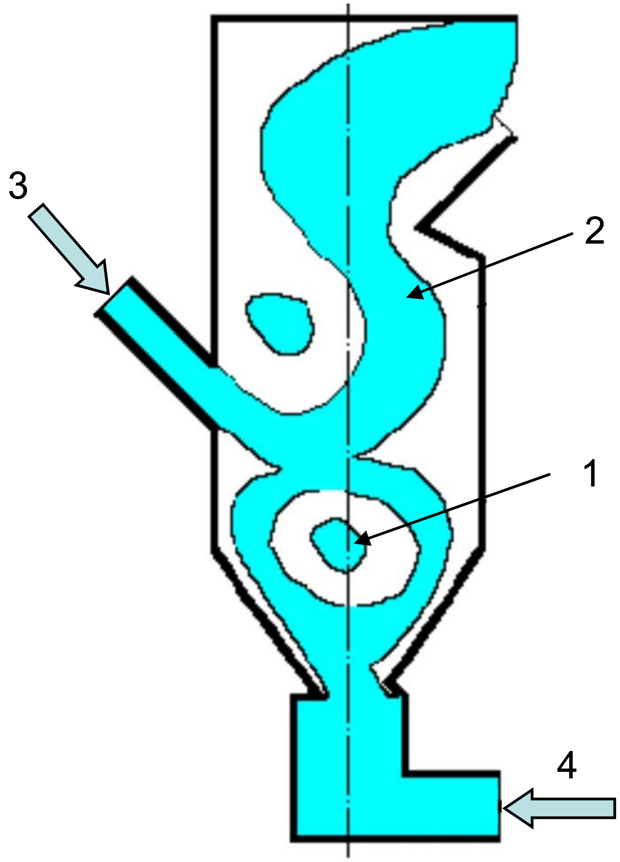
# LOW-TEMPERATURE VORTEX COMBUSTION

Low-Temperature Vortex Combustion is a modern and effective method of solid organic fuel combustion.

Main principles of Low-Temperature Vortex Combustion and furnace design had been developed by Prof. Viktor Pomerantsev, the outstanding Soviet scientist in domain of heat-and-power engineering, within Department of Reactor and Steam Generator Manufacture, headed by him at Leningrad Polytechnic Institute (now St.-Petersburg State Polytechnic University – SPbSPU).



# LOW-TEMPERATURE VORTEX COMBUSTION

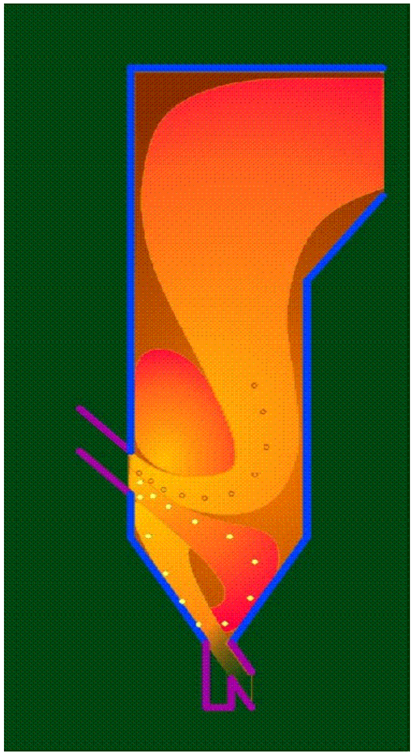



**1 – vortex combustion zone**
**2 – one through flow flame zone**
**3 – fuel&air mixture**
**4 – furnace bottom air introduction system**

## Principles of LTV-type Furnace Operation:

- Combustion of coarse fuel particles at multiple circulation
- Two combustion zones along the furnace height: vortex (1) and straight flow (2)
- "Active combustion zone" occupies complete vortex zone of the furnace
- Interaction of organized flows of pulverized coal and air mixture (3) and bottom air (4) at vortex zone (1)

# Advantages of Low-Temperature Vortex Combustion



## 1. Coarsening of coal milling

- simplify the system of pulverized fuel preparation and increase its efficiency;
- provide explosion safety;
- reduce expenses for fuel preparation;
- increase of life time of the milling equipment

- increase of ash collection efficiency

## 2. Intensive mixing in fire chamber volume

- stabilize ignition and combustion
- cancel need for the “fire support” by gas or fuel oil even at combustion of difficult low-heating value fuels

## 3. Heat exchange intensification

- the possibility to increase steam capacity by 15–20 %

## 4. Low-Temperature

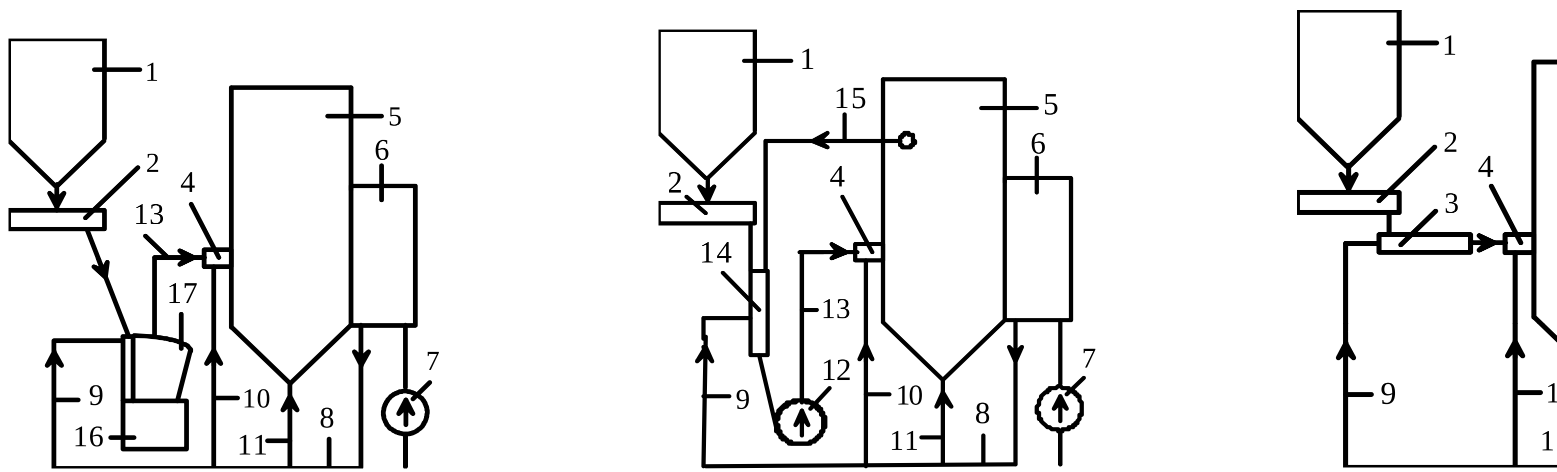
- excludes a slag formation and clogging of furnace and convective heating surfaces;
- provides reduction of nitrogen oxides emissions NOx by 20–70 %;
- provides reduction of sulfur oxide emissions SOx by 20–70 %,

# Characteristics of fuels being used at Low-Temperature Vortex Combustion

Method of Low-Temperature Vortex Combustion has been tested on the wide range of solid fuels such as: peat, brown and black coal, oil shell, microbiological and wood waste.

| Solid fuel characteristic | Range |
|---|---|
| Humidity on working mass $\mathbf{W}^r$, % | **14…75** |
| Ash content for working mass $\mathbf{A}^r$, % | **5…50** |
| Volatile matter content on dry ash free bases $\mathbf{V}^{daf}$, % | **15…90** |
| Specific Lower Heating Value $Q^r_i$, kJ/kg (kcal/kg) | **4,200…25,960 (1,000…6,200)** |
| Sulfur content on working mass $\mathbf{S}^r$, % | **0,2…3,0** |
| Nitrogen content on working mass $\mathbf{N}^r$, % | **0,4…2,0** |

# Diagrams of boiler plants with Low-Temperature Vortex Combustion




*a)* *b)* *c)*

1 – fuel hopper;
2 – fuel dosing unit;
3 – fuel feeder;
4 – burner;
5 – boiler;
6 – air heater;
7 – forced draft fan;
8 – hot air;
9 – primary air;
10 – secondary air;
11 – furnace bottom air;
12 – fan type pulverizer;
13 – pulverized fuel pipe;
14 – solid fuel feeding duct;
15 – hot flue recirculation gas;
16 – pulverizer of hammer type;
17 – separator-classifier of pulverizer

# Implementation of Low-Temperature Vortex Combustion
## Problems before reconstruction

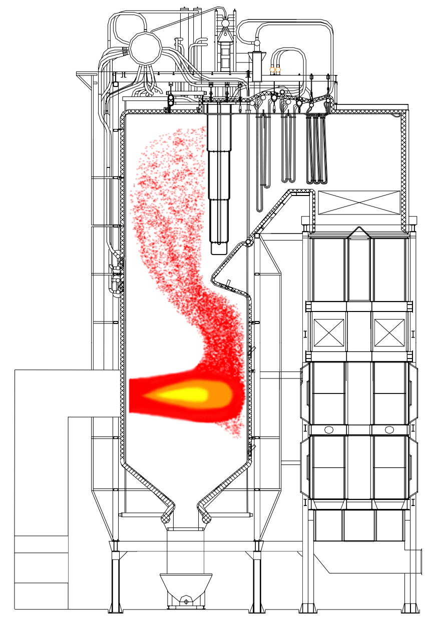
### BKZ-210-13,8 BOILER OF KIROV CHP-4

**Design parameters:**
steam capacity – 210 t/h,
pressure – 13,8 MPa,
temperature – 540 °C

**Fuels:**
Peat (design)
Black Coal
Natural gas

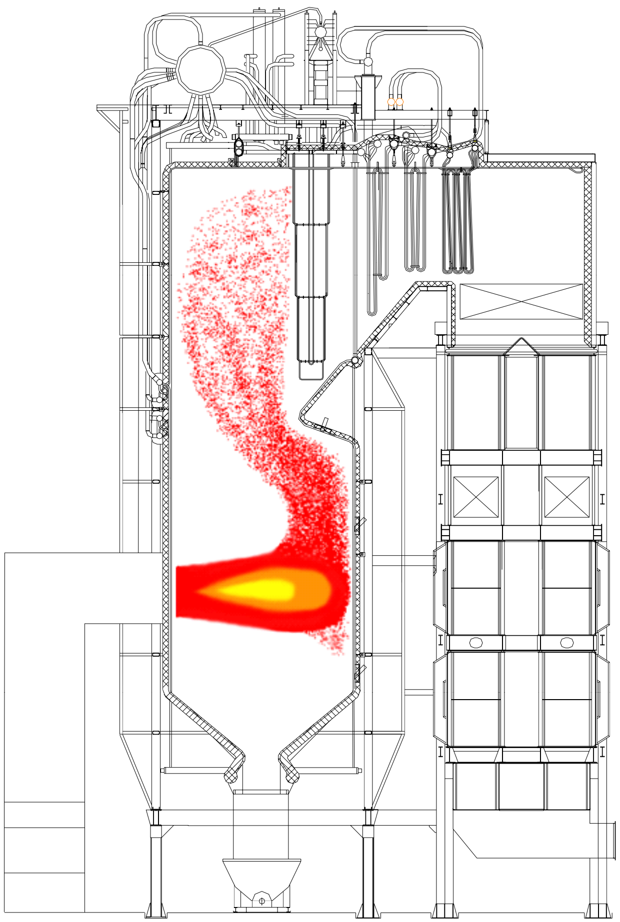
### Main problems before the reconstruction:

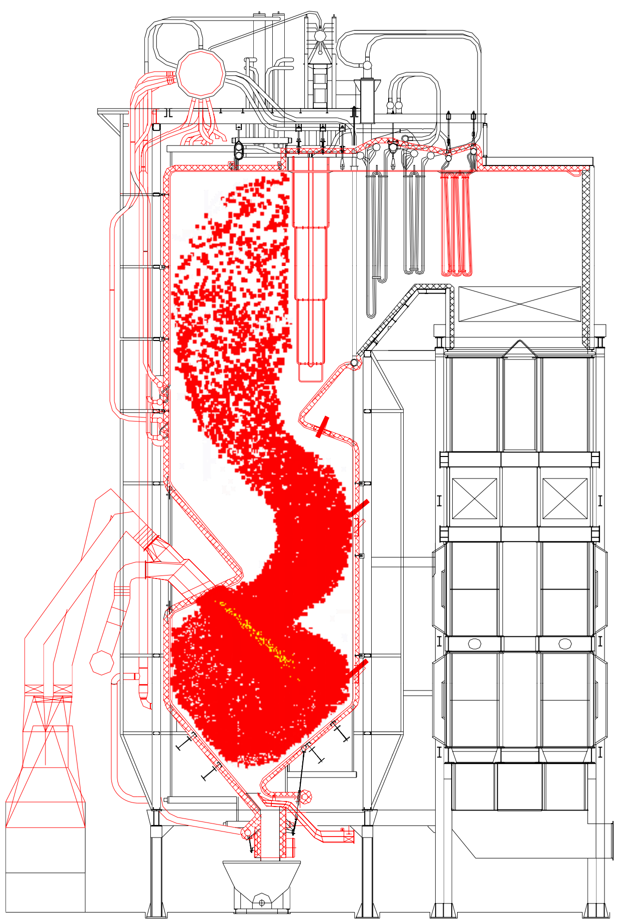
- Impossible combustion of peat without firing support with natural gas.
- Intensive slagging of boiler heating surfaces.
- Limitation of the boiler load up to 180-185 t/h (slagging condition).
- Extensive nitrogen oxides and sulfur oxides emissions.



# Implementation of Low-Temperature Vortex Combustion
## Reconstruction

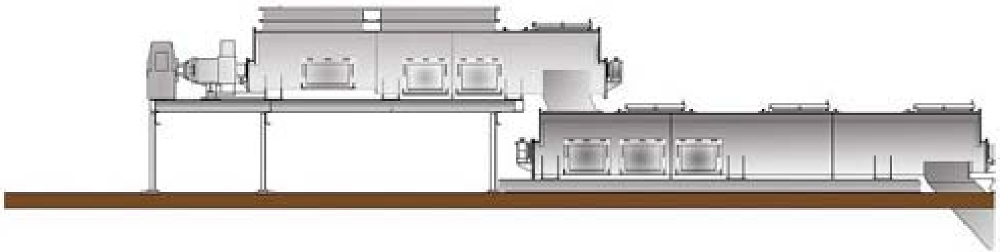
**Before** | **After**



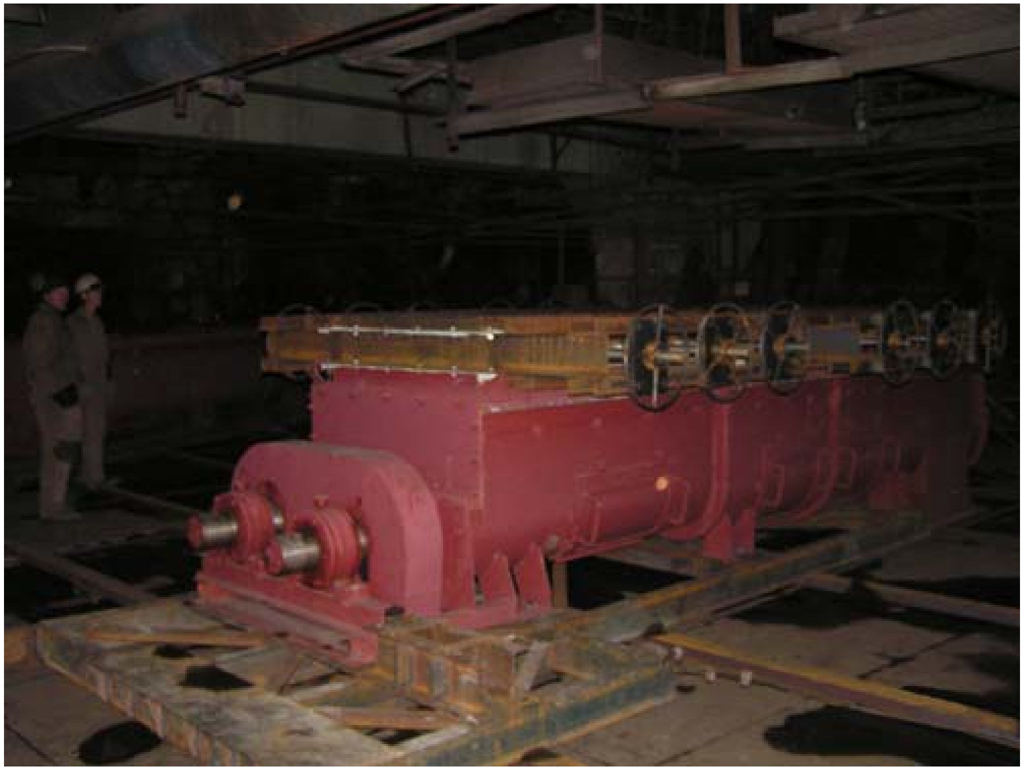


# Implementation of Low-Temperature Vortex Combustion

**Reconstruction** of coal feeding system

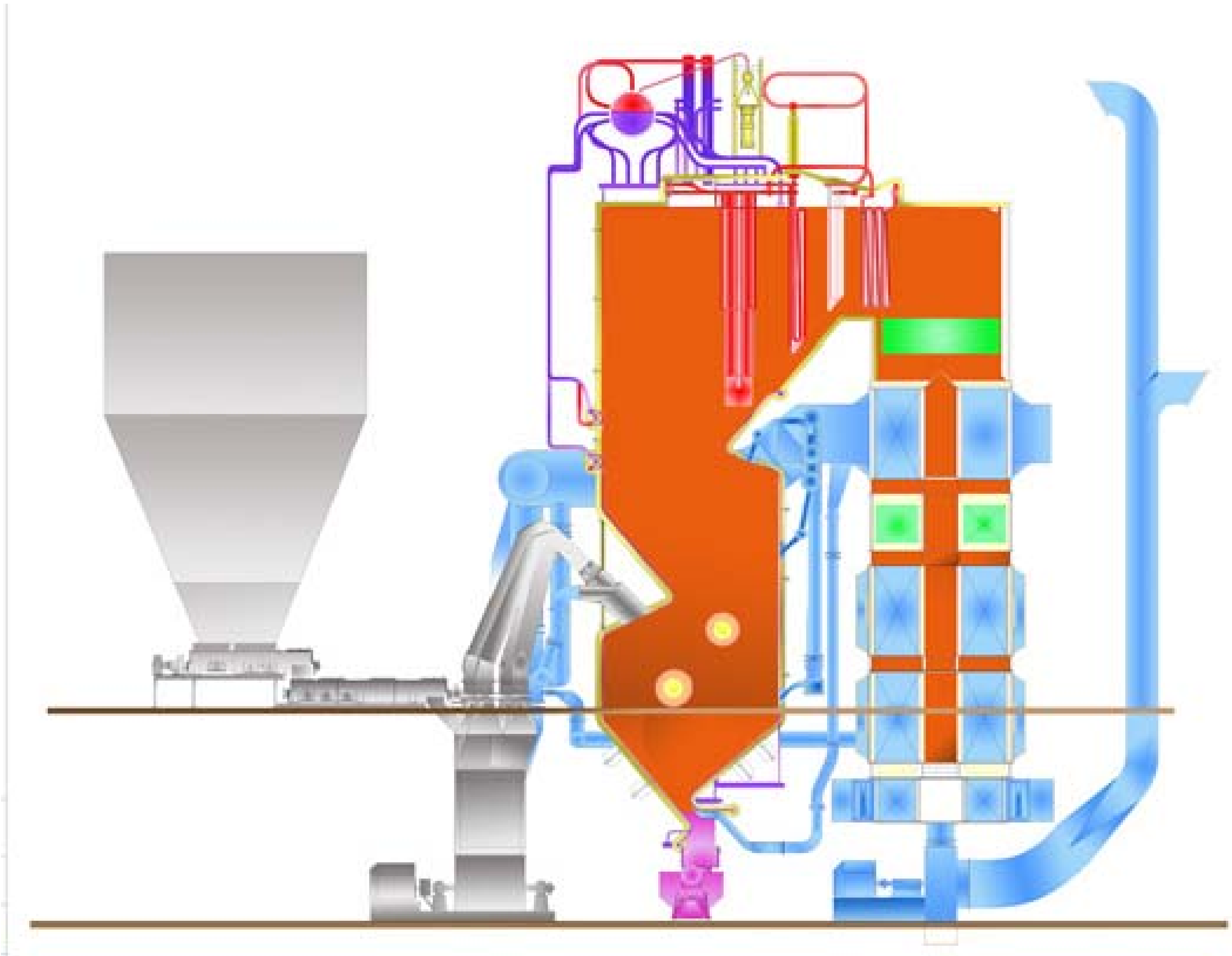


Design capacity:
Coal – 16 t/h,
Peat – 40 t/h



# Implementation of Low-Temperature Vortex Combustion
## Reconstruction of I&C system

# Implementation of Low-Temperature Vortex Combustion
## Boiler plant after reconstruction



## Implementation of Low-Temperature Vortex Combustion

**Main results of reconstruction**

| Boiler characteristic | Peat | | Coal | | Natural gas | |
|---|---|---|---|---|---|---|
| | Before* | After | Before | After | Before | After |
| Capacity $D_{max}$, t/h | 180 | 210 | 185 | 250 | 210 | 250 |
| Loss of heat with outlet gas, % | 9.9 | 7.6 | 8.2 | 6.2 | 6.5 | 4.4 |
| Loss of heat with unburned, % | 3.0 | 0.8 | 11.05 | 1.5 | 0.0 | 0.0 |
| Boiler Efficiency, % | 86.4 | 90.4 | 79.6 | 91.9 | 92.9 | 95.1 |
| Nitrogen oxides emissions $NO_x$, $mg/m^3$ | 700 | 550 | 1 500 | 450 | 370 | 125 |

*- operation result with firing supported with gas

## Potential use at Balkans

Developed LTVC technology can be used at modernizing and reconstruction of existing boiler as well as at new boiler installation at Balkan countries.

Liquid fuel burning boilers (heavy fuel) could be also subject of reconstruction to solid fuel combustion using LTVC technology.

Following plant boilers could be subject of a deeper investigation of potential reconstruction into LTVC boilers:
- TPP "Kostolac"-A2 and TPP "Morava" at Serbia
-TPP "Tuzla"-3 (boiler no. 4), TPP „Ugljevik" and TPP „Gacko" at Bosnia & Herzegovina
- TPP "Bitola" and TPP "Negotino" (transfer from oil to coal) at Macedonia
- as well as many boilers at TPP and CHP in Bulgaria and Romania.

Suggested modernizing of boilers including life extension for additional 15- 20 years of operation with increase of efficiency and environmental parameters  is feasible for 4-5 time smaller investments compared to new boiler plant.