RECONSTRUCTION OF THE AERO-MIXTURE CHANNELS OF THE PULVERIZED COAL PLANT OF THE 100 MW POWER PLANT UNIT

by

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After the last revitalization of thermal power block of 100 MW in TPP "Kostolac A", made in the year 2004, during the operation of the plant, pulverized coal deposition often occurred in horizontal sections of the aero-mixture channels. Deposition phenomenon manifested itself in places ahead of spherical compensators in the direction of flow of pulverized coal to the burners, due to unfavorable configuration of these channels. Coal dust deposited in the channels dried and spontaneously combusted, causing numerous damage to channels and its isolation as well as the frequent stoppage of the operation for necessary interventions.
The paper presents the original solution of reconstruction of aero-mixture channels which prevented deposition of coal dust and its eventual ignition. In this way the reliability of the mill plant is maximized and higher availability of boiler and block as a whole is achieved.

Key words: *fan mill, pulverized coal, aero-mixture channel*

Introduction

During the last revitalization of the 100 MW block No. 1 at the TPP "Kostolac A" which is composed of two identical steam boilers, realized in year 2004, among other things reconstruction of the aero-mixture channels on all eight mills (four mills per steam boiler) was performed.

The aim of reconstruction was to replace the existing mills with new fan mills. Regarding to the objective circumstances during the revitalization and shortened term-plan the existing fan mills are kept, type N 80.75, manufactured by Minel-Kotlogradnja, Belgrade. During exploitation and maintenance these mills are reconstructed several times in terms of raising the capacity of milling and more reliable operation.

Both steam boilers of block No.1 at TPP "Kostolac A" were projected for Kostolac lignite with lower heating capacity of 7600 kJ/kg with a moisture content of W = 38.5% and ash content of A = 27%. Boilers are Russian production type BK3 200-100 with characteristics:

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– nominal production of fresh steam	D =	55.56	kg/s,
– superheated steam pressure	p_s =	99	bar,
– superheated steam temperature	t_s =	540	°C,
– operating pressure	p_o =	109.8	bar,
– feedwater pressure	p_{fw} =	114.7	bar, and
– feedwater temperature	t_{fw} =	215	°C.

Four fan mills were installed at the corners around the boiler furnace, at different distances, to ensure the angle ignition and the complete combustion of used lignite. Their characteristics are:

– type of fan mill	N 80.75,
– milling capacity	5.83 kg/s (21 t/h),
– aero-mixture temperature	190-210 °C, and
– rest on the sieve of 90 μm	55 %.

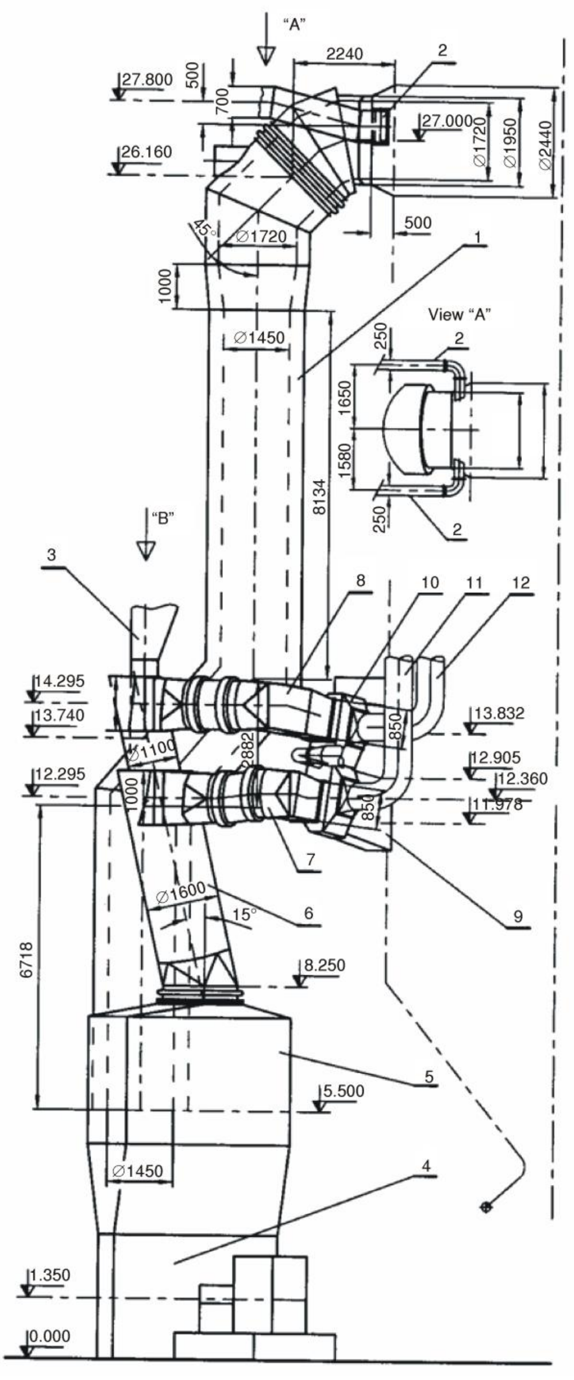
Disposition of a pulverized coal plant (for the fan mill No. 3), before the proposed aero-mixture channels reconstruction is shown in fig. 1.

Hot smoky gases are taken away from the top of furnace and by a recirculation channel (1) are leads to the fan mill (4). On the head of recirculation channel ducts are connected for the primary air (2), and on the slanted section of the recirculation channel connector for supplying row lignite was carried out (3). Coal and mixture of recirculated hot gases and primary air are brought in a mill (4) that performs simultaneous grinding and drying of coal. After separation of ungrinded particles in inertial separator (5) aero-mixture reaches aero-mixture splitter (6).

The splitter (6) divides the pulverized coal so that the level of its separations is g = 0.75, and the level of sharing of transport fluid is l = 0.5. From the splitter, primary flow of aero-mixture, with higher concentration of pulverized coal, is brought by the channel (7) to lower stage of the burner (9). Secondary flow, with lower concentration of pulverized coal, is brought by the channel (8) to the upper stage of the burner (10). The secondary air is brought in the lower and upper stage of burner by separate air ducts (11) and (12).

Behind the coal dust separator, in the direction of aero-mixture flow, the aero-mixture splitter (6) is set, inclined at 15° of the boiler in relation to its vertical (figs. 1 and 2). By this splitter a larger quantity of pulverized coal (about 75%) is blown in to the lower burner, which is located at level +11.978 m, and a smaller amount (about 25%) is blown in the upper burner, which is located at level +13.832 m. Transport fluid is divided by this splitter into two equal parts, and together with pulverized coal goes in the burners. Flows of secondary air per stage of burners are adjusted by the different amounts of pulverized coal.

In both horizontal sections of a mill, in the middle between the aero-mixture splitter and burner diffusers, a spherical dilatation compensator is set. This compensator is slightly larger in light cross-section than channel where it is located. The spherical compensator, as the designer of revitalization predicted, should compensate for the scroll of boiler furnace in relation to the mill and the burners. Channel configuration in front of the compensator, in the direction of aero-mixture flow, implies a transition piece from rectangular to circular cross-section of the channel. After the spherical compensator there is a similar transition piece, then a rectangular channel attached to burners diffuser and burner.



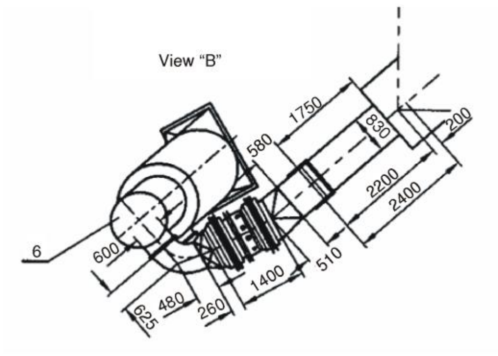


Figure 1. Disposition of existing mill plant
1 – recirculation channel, 2 – channel for primary air, 3 – connector for the coal, 4 – fan mill, 5 – mills separator, 6 – aero-mixture splitter, 7 – aero-mixture channel to the lower stage burner, 8 – aero-mixture channel to the upper stage burner, 9 – lower stage of burner, 10 – upper stage of burner, 11 – channel for secondary air to the lower stage of the burner, 12 – channel for secondary air to the upper stage of the burner

Figure 2. Photo of aero-mixture splitter and both horizontal channels

It is important to notice that the horizontal channels of the lower burners in the cold state at all fan mills are made and assembled with counter drop from furnace to the fan mill (fig. 1). The largest negative height difference in these channels is –103 mm at the mill No. 3, which is the farthest from the boiler. Horizontal channels of the upper burners in a cold state do not have such a prominent counter drop.

Measurements performed at the subject facility before reconstruction [1] gave the following results related to the aero-mixture splitter with milling capacity of 22 t/h:

– mass flow of lignite in the lower burner 16.5 t/h
– mass flow of coal in the upper burner 5.5 t/h
– separation of aero-mixture in the splitter 75:25
– separation of transport fluid 50:50
– concentration of pulverized coal
  – in the lower channel 0.25 kg/kg
  – in the upper channel 0.09 kg/kg
– the fineness of pulverized coal in the lower channel
  – the rest on the sieve of 1 mm, R1000 2.9 %
  – the rest on the sieve of 0,2 mm, R200 22.1 %
  – the rest on the sieve of 0,09 mm, R90 52.2 %
  – drop on the sieve of 0,09 mm, D90 47.8 %

Coal particles in the upper channel are smaller than the particles in the lower channel for ratio of redistribution of coal in the splitter .The rest on sieve of 1 mm is 0.08%, the rest on the sieve of 0.2 mm is around 13% while the rest on the sieve of 0.09 mm is around 33%. Drop through the sieve of 0.09 mm is around 67%.

Problems in the exploitation related to the aero-mixture channels

Since the horizontal aero-mixture channels belong to mill plant, they are connected on one side for the aero-mixture splitter and the other for the corresponding burners, so they dilate up. But these channels, of which the longest is around 3.5 m, dilate in the horizontal direction too, from burner to the aero-mixture separator of the mill. The shifts of aero-mixture channels in both directions, vertically and horizontally, are effectively compensated by mentioned spherical compensators placed in the middle of the horizontal sections. This complicated configuration of horizontal aero-mixture channels requires high-speed of pulverized coal.

During the operations of both steam boilers of 100 MW at unit No.1, during the first 4000 hours, there were often stoppage in work due to coal dust deposition in horizontal sections of the lower burner, at the elbow and transition piece in front of the spherical compensator (fig. 3), his self-ignition and the occurrence of fire.

Consequence of occurrence of fire was partially damaged channel and its isolation and the outbreak of coal in the boiler room. In the horizontal sections, in front of the upper burner, pulverized coal deposition did not appear or it was very rare. This problem of deposition and ignition of pulverized coal in power plant by 2008 was not resolved.

Figure 3. Place on the lower channel of the mill No. 3, which was repaired after damage

In the photos (figs. 4 and 5) the damaged and repaired places on the lower aero-mixture channels of the mills No. 3 and No. 4 are shown. Channel elbows and transition piece in front of the spherical compensator are usually repaired. From the subjected channels the isolation has been removed in order to help identify defects and carry out interventions.

Figure 4. Place on the lower channel of the mill No. 4, which was repaired after damage

Figure 5. Lower channel elbow repaired after damage

From an analysis of this problem it was necessary to propose a universal reconstruction of all 16 horizontal aero-mixture channels in aim to prevent the deposition of pulverized coal and its ignition in horizontal sections, to increase the reliability of pulverized coal systems and to achieve higher availability of boilers and block as a whole. It should be noted that the quality of lignite, with which the pulverized coal system operate nowadays, has been changed in relation to the guarantee coal for which the plant was designed and manufactured.

Pulverized coal system calculation

To achieve goals of these reconstructions it was necessary to perform a whole number of very complex calculations, as:

(1) material balance of the combustion process, in order to determine the volume of products of combustion, according to [2],
(2) heat balance of steam boiler, in order to determine coal consumption, according to [2, 3]
(3) thermal calculation of boiler furnace, to determine the temperature of flue gases at the end of the furnace, according to [2, 3],
(4) calculation of milling capacity, in order to determine the maximum capacity of the mill, according to [4-8],
(5) calculation of drying capacity, in order to determine the degree of flue gases recirculation from the top of the furnace and production of regulation diagram of mill, according to [3. 4],
(6) calculation of fan mill effort, more exactly the dependence of the effort in relation to capacity of the mill, according to [8, 9],
(7) calculation of pressure drop in the mill tract for the existing aero-mixture channel geometry (system resistance), in order to obtain aerodynamic characteristics of mill tract, according to [8-11], and
(8) calculation of pressure drop in the mill tract for the proposed aero-mixture duct geometry. Mill tract is divided into four sections according to the type and temperature of fluid (as in fig. 2 for the reconstructed aero-mixture channels), and sections are divided on elements according to the form and geometry.

Table 1. Extract from the calculation results for steam boiler and mill plant

No.	Title	Symbol	Unit	Guaranteed coal			Better coal		
				$\bar{D}$			$\bar{D}$		
				1.00	0.85	0.70	1.00	0.85	0.70
1	Low heat value of the coal	HL	kJ/kg	7600			8142		
2	Boiler efficiency	η_{sb}	%	85.34	85.62	85.94	85.87	86.16	86,41
3	Fuel consumption	B	kg/s	21.289	18.037	14.801	19.761	16.742	13.750
4	Temperature of primary air	t''_{zvl}	°C	150	150	151	149	148	147
5	The temperature of the secondary and tertiary air	t_{ha}	°C	326	310	292	323	307	289
6	Adiabatic furnace temperature	t_{ad}	°C	1336	1320	1298	1362	1346	1323
7	Degree of flue gases recirculation	r_1	–	0.326	0.342	0.365	0.312	0.328	0.351
8	Flue gases temperature at the top of the furnace	t''_f	°C	953	919	876	959	924	880
9	Maximum capacity of the mill	$B_{max.}$	kg/s	5.646	5.646	5.646	5.656	5.656	5.656
10	Number of mills in operation	m	–	4	4	3	4	4	3
11	Mill operating capacity	B_m	kg/s	5.322	4.509	4.934	4.940	4.186	4.583
12	Minimum capacity of the mill	$B_{min.}$	kg/s	3.579	3.053	3.181	3.425	2.925	3.028
13	Temperature of transport fluid at the entrance to impact wheel	t'_m	°C	461	442	440	447	428	427
14	Fluid flow for drying at the mill operating capacity B_m	$\dot{V}_m$	m^3/s	14.044	12.590	14.056	13.740	12.359	13.788
15	Carbon dioxide content in dry transport fluid at B_m	CO_{2m}	%	6.44	6.34	6.66	6.16	6.05	6.40
16	Aero-mixtures temperature	t_2	°C	210	210	210	210	210	210
17	Fan mill head in operating conditions	h_m	Pa	1461	1539	1486	1494	1569	1518

All these calculations were performed for three operating loads of steam boiler: 100, 85, and 70%. Calculations were also carried out for two coal quality: guaranteed coal (H_L = = 7600 kJ/kg, W = 38.50%, A = 27.50%) and coal of better quality with which the plant recently usually works (H_L = 8142 kJ/kg, W = 38.66%, A = 25.31%).

It is clear that for such a large number of complex and extensive calculations the support of appropriate computer programs developed for this purpose was required.

Extract from the calculation results, shown in detail in [11], is given in tab. 1 for all three referential steam boiler loads and using both coal quality. The table shows the value of major values related to the boiler operation and coal consumption as well as the capacity of milling. Also the temperature of working mediums and mill effort are given.

When a steam boiler operating with a load of 70%, for both coal qualities, one off the mill is turned off and the boiler plant is working with three mills. Working capacity of a mill, in this case increases, also increasing the flow of drying fluid. In that way flow of drying fluid, while working with guaranteed coal, is 14.056 m^3/s and is similar to the flow of drying fluid at a boiler load of 100%; when the boiler operates with 4 mills (14.044 m^3/s). The same conclusions can also be made for the work of the boiler with better quality lignite.

Reconstruction of the aero-mixture channels

After perceiving the problem and executed calculations of pulverized coal preparation plants, a new geometry of horizontal aero-mixture channels with minimal reconstruction of the existing elements of the plant is proposed (fig. 2).

Reconstruction of the vertical aero-mixture channel

In order to annul the counter fall of the horizontal aero-mixture channels, it is virtually proposed to straighten aero-mixture splitter for 10°, from 15° to the 5°. The reason why this small slope of the 5° is left, is two-sided: first is to distribute partially the vertical dilatations, primarily dilatations of the splitter, in horizontal direction too, and second is to achieve with its straightening for 10° the same slope of the upper and lower generatrix line of output opening 600 × 1000 mm for aero-mixture, and as well the slope of burner diffusers (slope of 10° to furnace hopper). In this way easier design is allowed and installation of channels linking these two elements. Straightening up splitter also shortens the length of the channel (fig. 6).

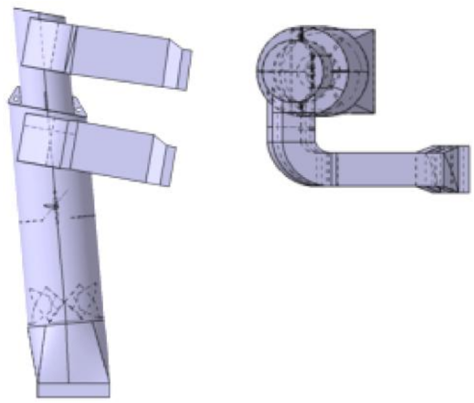


Figure 6. Reconstruction of the aero-mixture splitter – change of the angle from 15° to 5° and reduction to circular cross-section

Additional rising of the output opening 600 × 1000 mm for pulverized coal in the aero-mixture splitter is achieved with the reconstruction of link – splitter with separator (figs. 7 and 8). This is done in order that lower generatrix line of lower aero-mixtures channel would have the corresponding decrease in direction of burner (slope of 4°). Upper horizontal channels, due to higher altitudes, have certainly steeper slope.

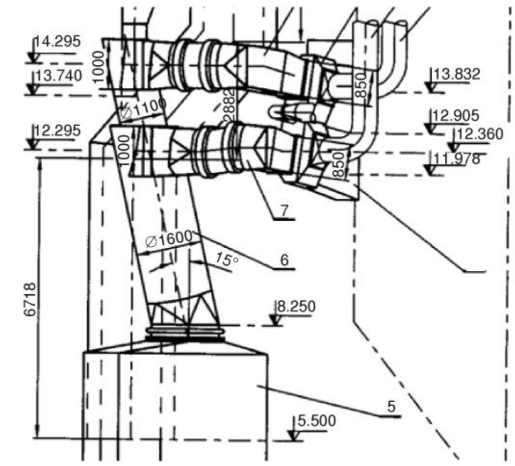


Figure 7. Transitional piece between the separator and splitter – reduction

Figure 8. Transition piece – the reduction to a circular cross-section

Reconstruction of the horizontal aero-mixture channel

Considering that the existing configuration of the horizontal section of the aero-mixture channels created interference of pulverized coal flowing and allowed its deposition and ignition, certain requirements for solving this problem during their reconstruction are set: elimination of the counter slope at the horizontal sections of the channels and their leaning towards burner, achieving optimal velocity of pulverized coal flow through the ducts, reducing the pressure drop in the subject ducts, reduction and prevention of dilatations and excessive wear out, and so on.

The first request, the counter slope reset at horizontal sections of the channels, is solved with aero-mixture splitter straightening, as explained in previous paragraph and presented on fig. 6.

Into aero-mixture channel, from splitter toward the burner, the cross-section of the outlet 600 × 1000 mm is retained. After the turn of 90°, long, slightly sloping section exist, without changing the cross-section in which the optimal flow velocity of 20-25 m/s is achieved.

In front of the burner itself the reduction to the higher section is made, which is 830 × 850 mm, with intention to reduce the upper generetrix line of channel from 1000 mm to 850 mm, and the lower generetrix line keeps its existing slope, fig. 9. All horizontal channels are, after reconstruction, shorter for 670 to 1020 mm.

New wavy compensator, with the same cross section, is placed in front of the burner and with transitional piece is connected to the input section of its diffusers, also dimensions 830 × 850 mm. In this way the higher angles of rotation of this compensator are avoided, which primarily has to compensate the horizontal dilatations of the channel.

With mentioned reconstruction lower generatrix line of horizontal section of the channel has a constant drop towards to the burner, of at least 4°, as the coal dust would not be held up and deposited in the channel, especially in the lower aero-mixture channels where its concentration is increased.

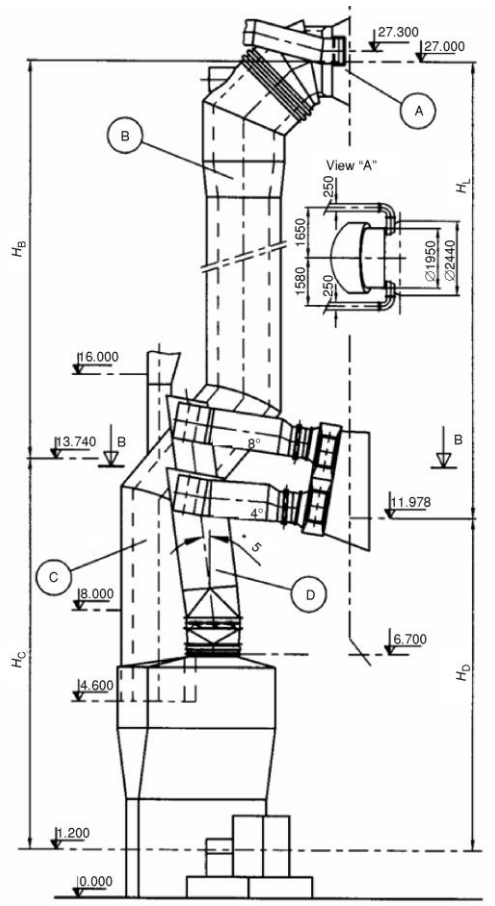


Figure 9. Reconstructed aero-mixture channels of mill plant No. 3 with classification in the sections and elements

(A) recirculation channel head from entry to primary air channel connection,
(B) recirculation channel next to connection for the coal,
(C) recirculation channel from coal connection to the fan mill,
(D) channel from fan mill to the air-mixture exit to the furnace

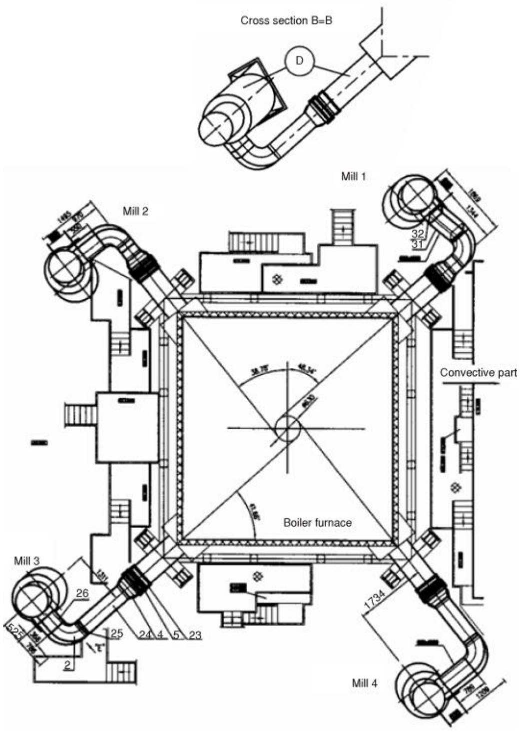


Figure 10. The cross-section of boiler furnace and burners with belonging fan mills – recirculation channels

Replacing spherical compensator with the wavy one and its setting with a burner diffuser, the unfavorable configuration of the channel was changed and problematic transition piece was removed. In this way, the pressure drop in reconstructed horizontal channels is reduced (see tab. 2). Also, with the iron plate, elbow and bottom of the channel is reinforced, places at the channel that have highest abrasion, in order to prolong time of its exploitation.

Drawing of the reconstructed channels is shown in fig. 9, and the disposition of fan mills around the boiler and the lay-out of reconstructed channels in fig. 10. Photo of reconstructed aero-mixture splitter with the corresponding channels of the lower and upper burners of the mill No. 3 is given in figs. 11 and 12.

Figure 11. Reconstructed aero-mixture splitter

Figure 12. Reconstructed channel – connection with aero-mixture splitter

Dilatation of aero-mixture splitters and horizontal channels

Horizontal aero-mixture channels are connected on one side to the aero-mixture splitter and on the other to their burners (lower and upper) so that can not move in relation to the boiler furnace. At the temperature of aero-mixture they dilate on one side, together with the mill, mill separator and its aero-mixture splitter, up and on the other side, in the horizontal direction, along with the burner.

Temperature of drying fluid at the entrance of the mill, in the most unfavorable case, is t'_{m} = 461 °C, while the temperature of the transport fluid (aero-mixture) is constant and equal to t_2 = 210 °C. Hot air temperature at the entrance of the burner, also in the most unfavorable case, is equal to t_{ha} = 326 °C.

Dilatations of the highest point of the aero-mixture splitter in a vertical direction, on level +16.0 m, are approximately equal to 60 mm. Existing wavy compensator, placed at the top of the separator, between the separator and the splitter, should compensate a part of these dilatations between two fixed points. The rest of the vertical dilatations is received by sliding support placed on top of the aero-mixture splitter, on level +16.0 m, and is linked to the nearest boiler gallery.

Horizontal dilatations of upper aero-mixture channel of the mill No. 3, in the total length of around 5.9 m including the burner and its diffuser, are approximately 25 mm, which represents the most unfavorable case considering that the channels in other mills are shorter.

It is predicted that the new wavy compensator (instead of spherical compensator) will be placed on both channels, between the horizontal aero-mixture channel and burner diffuser, right next to the burner. In this way it would offset the horizontal dilatations of the aero-mixture channel together with the elbow of 90°, which is located close to the splitter, immediately after aero-mixture is flown from it. This compensator should also compensate small rotations of the horizontal channel, provoked by aero-mixture splitter top rising. In the most unfavorable case, these rotations do not exceed an angle of about 0.75°.

Flow simulations of pulverized coal particles of different dimensions at the reconstructed channels

Requirements regarding to the recommended speed of aero-mixture and for possible reduction of pressure drop in the reconstructed channels, during the flow of pulverized coal with increased concentration, are resolved on the basis of the recommendations and 3-D flow simulation of coal with various granulation.

The velocity in horizontal inclined channels should amount from 20 to 25 m/s (recommendation given in [12]) and the configuration of the horizontal section of the channel should be made with as little as possible turns and reductions of cross-section.

When considering the deposition of coal dust particles in the lower reconstructed aero-mixture channel, in the 3-D flow simulation, we analyzed the flow of coal particle dimension of 1 mm, 0.6 mm and 0.1 mm. Finely milled coal particles, of smaller sizes are directed, by the aero-mixture splitter into the upper horizontal channel (fig. 6) and are not the subject of these considerations.

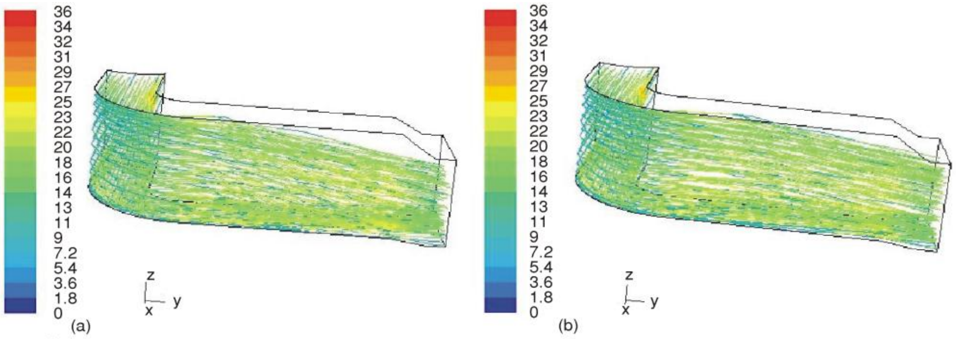
At the steam boiler load of 70% and work with 4 mills, which represents an unfavorable operating case (in tab. 1 for that load one mill is turned off and a boiler plant is working with 3 mills), the average speed of the aero-mixture in the lower channel would be around 16 m/s. In fig. 13(a) the separated stream of the largest particles of coal is shown, with dimensions of 1 mm. At these speeds the largest particles show a tendency to greater separation from the upper generatrix lines of the channel, but the particles are not deposited in the channel. In fig. 13(b) the separated stream of larger particles of coal is shown, with dimensions of 0.6 mm. Particles of this size are just beginning to separate from the upper generatrix lines of the channel. The smallest particles in the lower channel, particles diameter of about 0.1 mm, fig. 13(c), with the cited aero-mixture speed, load of the boiler and mill, have not started to separate from the upper generatrix lines and are properly arranged through cross-section of the channel.

At the steam boiler load of 100% for guaranteed coal and work with 4 mills, average speed of aero-mixture is 20.705 m/s (tab. 2). In fig. 14(a) and 14(b) the flow of pulverized coal particle of all sizes in the lower channel is shown. In fig. 14(c) the separate stream of the largest particles of coal is shown, dimensions of 1 mm, which will certainly first begin to deposit. At these speeds and boiler load, particles of this size are regularly distributed through cross section of channel and tendency to flow downwards is not noticed.

At a steam boiler load of 85% and work with 4 mills, average speed of aero-mixture is 18.561 m/s (tab. 2). In fig. 15(a) the streaming of pulverized coal particles in the lower channel is shown. In fig. 15(b) the separate streaming of the largest coal particles is shown, dimensions of 1 mm. At these speeds the largest particles show a tendency of slight separation from the upper channel generatrix lines [13] and show no tendency to deposition.

At the calculated speed of aero-mixture flow and its solid phase (tab. 2), which amounts from 18.222 m/s to 20.722 m/s for both coal qualities, it will not come to deposition of the largest particles of coal dust in the lower horizontal channels. In real working conditions, due to increased suck – in of surrounding air in the mill plants, the speed of aero-mixture at the specific channels will be increased by around 20%. In tab. 2 is also given comparative review of speed and pressure drop in the existing and reconstructed mill plant.

With such reconstruction, 6.0% increase in the speed of aero-mixture in the new aero-mixture channels is achieved, in relation to the place where pulverized coal was deposited, and pressure drop in it was reduced by an average of 30 to 40 Pa.



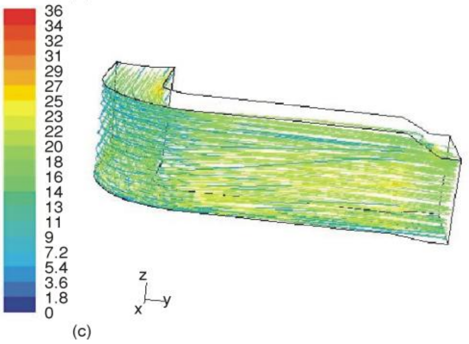
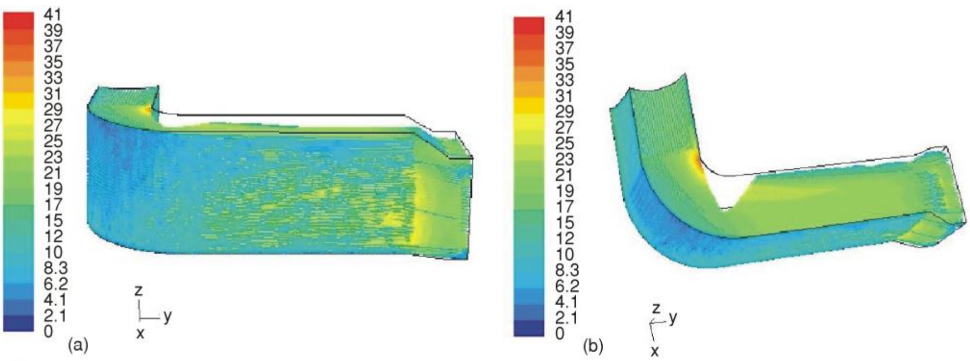


Figure 13. Display of the coal dust particles flow in the lower horizontal aero-mixture channel at the boiler load of the 70% while working with 4 mills
(color image see on our web site)
(a) particle dimension of 1 mm; (b) particle dimension of 0,6 mm; (c) particle dimension of 0,1 mm



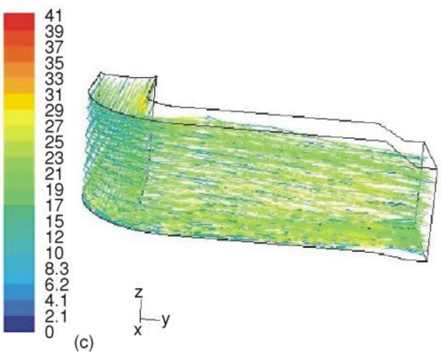


Figure 14. Display of coal dust particles streaming in the lower horizontal aero-mixture channel at the boiler load of 100% and work with 4 mills
(color image see on our web site)
(a) all dimensions of the particles; (b) all dimensions of the particles – a top view; (c) particles dimension of 1 mm

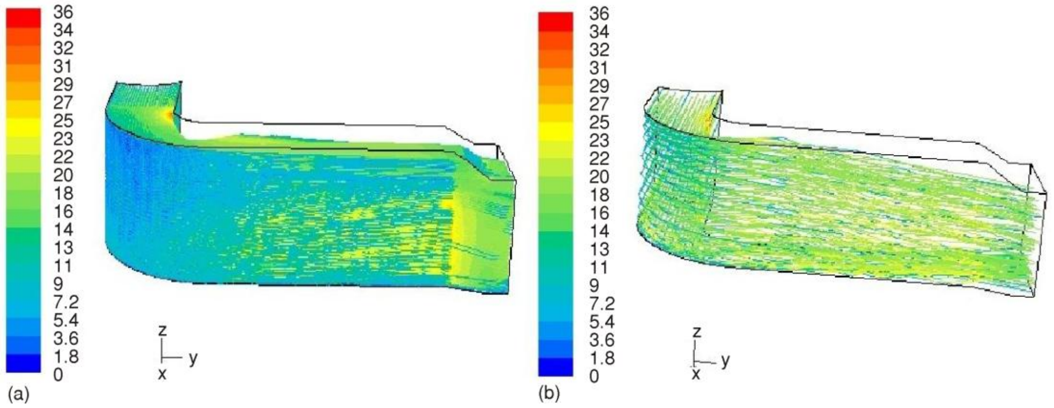


Figure 15. Display of coal dust particles streaming in the lower horizontal aero-mixture channel at the boiler load of 85% and work with 4 mills
(color image see on our web site)
(a) all dimensions of the particles (b) particles dimension of 1 mm

Table 2. Relevant value of existing and reconstructed mill plant

No.	Title	Symbol	Unit	Guaranteed coal			Better coal		
				$\bar{D}$			$\bar{D}$		
				1,00	0,85	0,70	1,00	0,85	0,70
				Number of mills that operate					
				4	4	3	4	4	3
1	The concentration of coal dust in the aero-mixture	μ	kg/kg	0.316	0.298	0.292	0.298	0.279	0.274
2	Aero-mixture flow in a lower duct	$\dot{V}$	m^3/s	12.423	11.137	12.433	12.154	10.933	12.197
3	Speed of aero-mixture in the spherical compensator	w	m/s	19.533	17.510	19.549	19.110	17.190	19.178
4	Speed of aero-mixture in the lower channel	w	m/s	20.705	18,561	20.722	20.257	18.222	20.328
5	The total pressure drop in the existing mill plant	Δp	Pa	1230	987	1223	1171	946	1171
6	The total pressure drop in reconstructed mill plant	Δp	Pa	1190	956	1184	1133	916	1134
7	Reduction of pressure drop due to reconstruction	Δ	Pa	–40	–31	–39	–38	–30	–37

Conclusions

After a comprehensive calculation and 3-D simulation for the different steam boiler loads and the different quality of coal the shown solution is proposed for the optimal reconstruction of the aero-mixture channels of pulverized coal plant of 100 MW steam unit No. 1 at TPP "Kostolac A". Reconstruction of the aero-mixture channels of pulverized coal system, according to the proposed solution, was made at the end of summer in 2008.

The transport of aero-mixture to the burner works perfectly after reconstruction. To date, no malfunction of the plant due to pulverized coal deposition and the occurrence of fire in the horizontal sections wasn't noticed, which previously was often the case. In this way the reliability of pulverized coal plant is maximized and higher availability of the boiler plant as a whole is achieved.

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