ISPITIVANJE RAZLIČITIH KINEMATSKIH PARAMETARA PROCESA
DEVOLATILIZACIJE ZA NUMERIČKO MODELRANJE SAGOREVANJA
SRPSKIH LIGNITA

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AN INVESTIGATION OF DIFFERENT DEVOLATILISATION KINETIC
FACTORS FOR NUMERICAL MODELING OF SERBIAN LIGNITE
COMBUSTION

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Abstract: Numerical modeling is well established tool for prediction of combustion processes. Computational Fluid Dynamics - CFD models utilize three different global chemical rates for description of the coal combustion processes: coal devolatilisation, volatile combustion and char combustion. Reported rates for coal devolatilisation vary considerably among the authors depending on the type of experimental procedure used in investigating the devolatilisation phenomenon. Accurate representation of devolatilisation process is necessary in order to conduct successful CFD simulations of pulverized coal combustion and gasification. The subject of this work is three-dimensional numerical simulation of Serbian lignite pulverized coal devolatilisation in drop tube type laboratory scale furnace. The aim of this study is to determine the influence of different devolatilisation kinetic factors on total devolatilisation time in numerical modeling of pulverized Serbian lignite devolatilisation. The influence of eight different devolatilisation kinetic rates mostly used in devolatilisation numerical modeling was investigated in the presented work.
Computational Fluid Dynamics (CFD) has gained widespread interest as a useful tool for investigation of pulverized coal flames characteristics. The use of CFD modeling enables the analysis of a system involving fluid flow, heat transfer, and combustion, and thus it can be used in coal burner design, investigation of boiler performance, and for pollutant emissions calculations [1–6], as well as for investigation of novel pulverized coal combustion technologies [7] and [8]. Devolatilisation process plays an important role during pulverized coal combustion and gasification processes. Because of this, accurate representation of devolatilisation process is necessary for successful CFD predictions of pulverized coal combustion/gasification.

Volatile species can account for up to 70% of the initial coal mass, significantly increasing the gas temperature surrounding the particle in short period of time as a result of released volatiles combustion. Devolatilisation impacts coal particle combustion from its injection to burnout. It influences particle ignition, trajectories, and eventual fragmentation as well as char intrinsic reactivity.

The two main theoretical approaches are used for devolatilisation modeling: network devolatilisation models and empirical devolatilisation models. Models from the first group are based on a physicochemical description of the coal structure and the processes the coal particle undergoes as it is heated and devolatilised. Although network devolatilisation models can give insight into detail information about volatile species evolution they are not commonly utilized in commercial CFD codes that become restrictively slow if large coal network matrix programs were included in main solver body [4] and [9]. The second group models are empirical devolatilisation models that employ global kinetics with Arrhenius type rates used for correlation of particle mass loss with temperature. Since empirical devolatilisation models require significantly lesser computational resources in compare with network devolatilisation models they are widely used in comprehensive CFD codes [10]. However empirical nature of these models makes them suitable only for use for fuels and heating rates for which Arrhenius parameters were derived. Detailed reviews of devolatilisation kinetic rates were reported by several authors [11]–[13].

However, no information’s were found about influence of different devolatilisation kinetic factors on overall combustion model for modeling of the Serbian lignite combustion. The subject of this work is numerical modeling of Serbian lignite pulverized coal devolatilisation in drop tube type laboratory scale reactor. The aim of this study is to evaluate the influence of different devolatilisation kinetic factors on total devolatilisation time in numerical modeling of pulverized Serbian lignite combustion.

2. MATHEMATICAL MODEL

ANSYS FLUENT version 12.1 [14] was used to model pulverized coal devolatilisation inside drop-tube furnace. The main model dimensions and geometry are shown in Figure 1 a). This code uses an unstructured, collocated, finite volume discretization scheme to solve the fluid transport equations in computational space. The Finite volume mesh was generated using ANSYS GAMBIT 2.4.1 pre-preprocessor. Special attention was given to the grid quality, since the numerical grid is very important in order to achieve reliable CFD results. Although triangular meshes are simple and time-efficient to construct, use of quadrilateral meshes is often preferred in order to minimize numerical diffusivity. Thus, computational grids consisting of 51200 all quadrilateral elements were used for all computational cases performed in the presented work, Figure 1 b).
The turbulent multi component flow field was described using Eulerian approach solving main transport equations in differential form, that is equations for continuity, momentum, turbulence kinetic energy, turbulent dissipation rate, enthalpy, and volatile species mass fraction. The standard $k$-$\varepsilon$ turbulence model with default model constants was used to describe turbulent behavior of the flow, based on previous experience [15]. Additional sources for kinetic turbulent energy $k$ and turbulent dissipation rate $\varepsilon$ are used to calculate the effects of particle-to-gas turbulence flow. Flow field in near wall region was solved utilizing standard wall-functions, which use Prandtl’s universal law-of-the-wall [16]. The following boundary conditions were set: adiabatic wall with no-slip condition for velocity magnitude at the wall and zero gradients for all flow variables at the outlet.

Pure N$_2$ with the mass flow rate of 0.2 kg/s and static temperature of 1273 K, at atmospheric pressure was injected through inlet surface. Gaseous mixture transport properties (density, specific heat capacity, thermal conductivity, and viscosity) were calculated according to the ideal gas mixing law. Species diffusion coefficient was set to 2.88e-05 m$^2$/s as suggested in [14].

Secondary phase, pulverized coal particles, is solved in Lagrangian manner. In this approach, group of physical particles with the same features is represented with computational particles termed “parcels”. Parcels are tracked in the generated three dimensional reactive flow field. The initial density, $\rho = 1000$ kg/m$^3$, thermal heat capacity, $c_p = 1100$ J/(kg·K), and heat conductivity, $k = 0.1$ W/(m·K) of the Serbian lignite coal particles used in simulations are taken from [17]. Proximate and ultimate analysis of Serbian lignite on dry ash free (DAF) basis is shown in Table 1.

<table>
<thead>
<tr>
<th>Proximate analysis (without crude moisture)</th>
<th>Ultimate analysis Dry ash free (DAF) basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>[%]</td>
<td>[%]</td>
</tr>
<tr>
<td>Inherent Moisture</td>
<td>C</td>
</tr>
<tr>
<td>Ash</td>
<td>H</td>
</tr>
<tr>
<td>Fixed carbon (C)</td>
<td>S</td>
</tr>
<tr>
<td>Volatiles</td>
<td>N</td>
</tr>
</tbody>
</table>

Table 1. Serbian lignite coal proximate and ultimate analysis

Particle trajectory is solved integrating the force balance acting on the particle. The boundary conditions for computational parcels at each point in the computed particle trajectory are determined using gas properties from computational cell in which particle currently is. Appropriate sub-models are used to include particle mass loss rates due to vaporization and devolatilisation. Additional source terms are incorporated in the gas phase transport equations in order to account for the amount of mass, momentum, and energy loss/gain by the particle.
a. Main model assumptions

The following assumptions were used in the proposed numerical model:

- steady-state flow;
- incompressible flow;
- axisymmetric flow;
- the pulverized coal particles are spherical and have homogeneous chemical and physical properties (taken as above);

b. Devolatilisation modeling

Two different models, namely Single Rate Model (SRM) and Two Competing Rates Model (TCRM) were used to represent devolatilisation process in this work.

Single Rate Model assumes that devolatilisation rate is first-order dependent on the amount of volatiles remaining in the particle:

$$\frac{dm_p}{dt} = Ae^{-\frac{E_a}{RT_p}} \left( m_p - \left(1 - f_{v,0}\right) m_{p,0} \right)$$

(2)

where $m_p$ is the particle mass [kg], $T_p$ is the particle temperature [K], $f_{v,0}$ is the initial volatile mass fraction inside particle, and $m_{p,0}$ is the initial particle mass [kg]. $A$ [1/s] and $E_a$ [J/kmol] are Arrhenius type pre-exponential factor and activation energy, respectively.

Although TCRM falls in the same group (empirical devolatilisation models) as the SRM, it has additional capabilities. Namely, TCRM model can incorporate influence of heating rate to total volatile yield, by representing devolatilisation as a set of two competing global reactions. Kinetic rates for these reactions are:

$$k_1 = A_1 e^{-\frac{E_{a1}}{RT_p}}$$

$$k_2 = A_2 e^{-\frac{E_{a2}}{RT_p}}$$

(3)

where $k_1$ and $k_2$ are competing kinetic rates [1/s], $A1$ and $A2$ [1/s] are corresponding Arrhenius type pre-exponential factor, $E_{a1}$ and $E_{a2}$ [J/kmol] are Arrhenius type activation energies, and $T_p$ is particle temperature [K].

Kinetic rates (3) are weighted giving the volatile matter release as:

$$\frac{m_v(t)}{m_{p,0} - m_a} = \int_0^t \left( \alpha_1 k_1 + \alpha_2 k_2 \right) e^{-\int_0^t (k_1 + k_2)dt} dt$$

(4)

where $m_v(t)$ is volatile yield up to time $t$ [kg], $m_{p,0}$ is initial particle mass [kg], $\alpha_1$ and $\alpha_2$ are yield factors, and $m_a$ is particle ash content.

Although there are number of studies focused on deriving kinetic parameters for coal devolatilisation, the choice of Arrhenius kinetic parameters is still challenging task. Kinetic parameters in many studies are derived at low values of heating rates that are possible in Thermo Gravimetric Analysis – TGA (up to 50 K/s). Since devolatilisation during pulverized coal combustion occurs at much higher heating rates, values from these studies may not be appropriate because of different heat transfer mechanism and secondary reactions occurring at low heating rates. However, there are significant differences between reported values for kinetic rate, at temperatures around 1000 K which is crucial temperature for devolatilisation.
In the present work are compared eight different devolatilisation kinetics proposed by several author’s, presented in Table 2:

— rate suggested by S. Badzioch and P. G. W. Hawksley that is using Single Rate Model for pulverized coal devolatilisation modeling [18], based on investigation of 10 British bituminous coals and one semi-anthracite coal with high heating rates 25000 – 50000 K/s;

— two different pseudo-first-order devolatilisation rates calculated using network devolatilisation model FG-DVC as pre-processor by J. M. Jones et al. [19]. The coal studied was a medium volatile bituminous coal (Turon) from the north of Spain in near-laminar, entrained flow drop-tube reactor at 1273 K. One of these rates is based on total weight loss (FG-DVC) global rate, while the second is determined using tar mass loss as a result of devolatilisation;

— rate derived by Hu et al. who were investigated devolatilisation kinetics of of two Chinese lignite coals by means of TGA [20];

— devolatilisation rate of lignite coal based on single coal particles experiments in entrained flow reactor performed for 15 U.S. coals ranging from lignite to low-volatile bituminous in SANDIA laboratory [21];

— devolatilisation rate of Serbian lignite coals derived by D. Stojiljkovic using TGA techniques [22];

— devolatilisation rates for two step model proposed H. Kobayashi et al. Reported devolatilisation rates of U.S. lignite and a bituminous coal were measured in a flow furnace at high heating rates (10^4÷2×10^5 K/s) for temperatures of 1000÷2100 K [23];

— Ubhayakar et al. have also reported devolatilisation rate parameters for two step model [24]. Lignite coal devolatilisation is investigated at temperatures from 973 to 2100 K, residence times from 0.001 to 10.0 s and heating rates from 180 to 1×10^6 K/s. Their parameters are especially attractive since they were derived for the case of rapidly heated pulverized lignite combustion.

<table>
<thead>
<tr>
<th>Kinetic Model</th>
<th>A [s⁻¹]</th>
<th>Eₐ [J/kmol]</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Rate Model - SRM</td>
<td>3.82×10⁵</td>
<td>7.4×10⁷</td>
<td>S. Badzioch and P. G. W. Hawksley [18]</td>
</tr>
<tr>
<td></td>
<td>2.36×10³</td>
<td>5.47×10⁷</td>
<td>FG-global [19]</td>
</tr>
<tr>
<td></td>
<td>2.75×10¹²</td>
<td>1.9×10⁸</td>
<td>FG-tar [19]</td>
</tr>
<tr>
<td></td>
<td>1.36×10¹³</td>
<td>2.194×10⁸</td>
<td>Hu et al. [20]</td>
</tr>
<tr>
<td></td>
<td>2.3×10¹⁴</td>
<td>2.29×10⁸</td>
<td>SANDIA [21]</td>
</tr>
<tr>
<td></td>
<td>2.5×10⁶</td>
<td>8.771×10⁷</td>
<td>Stojiljkovic et al. [22]</td>
</tr>
<tr>
<td>Two Competing Rates Model - TCRM</td>
<td>A₁, A₂ [s⁻¹]</td>
<td>α₁, α₂ [-]</td>
<td>Eₐ₁, Eₐ₂ [J/kmol]</td>
</tr>
<tr>
<td></td>
<td>2.0×10⁶</td>
<td>0.3</td>
<td>1.046×10⁸</td>
</tr>
<tr>
<td></td>
<td>1.57×10⁷</td>
<td>1.0</td>
<td>1.672×10⁸</td>
</tr>
<tr>
<td></td>
<td>3.7×10⁶</td>
<td>0.39</td>
<td>7.357×10⁸</td>
</tr>
<tr>
<td></td>
<td>1.46×10¹³</td>
<td>0.8</td>
<td>2.5×10⁸</td>
</tr>
</tbody>
</table>

Table 2. Kinetic parameters used for Serbian lignite devolatilisation modeling
3. EXPERIMENTAL INVESTIGATION – USED FOR MODEL EVALUATION

Two different sets of experimental data were used for comparison with numerical results. The first one are taken from [25]. In their work authors investigated combusting behavior of isolated brown coal particles under rapid heating conditions. Single coal particles at room temperature were inserted to the experimental furnace preheated to temperatures 1200 – 1400 K. Significant temperature difference between entrained particle and surrounding gas ensures rapid particle heating rates which are similar to those inside full scale furnaces. Reactor was able to operate with different mixtures of O\textsubscript{2} and N\textsubscript{2}. Experiments were undertaken for more than 150 samples with diameters between 0.1 – 1 mm at for three different gas temperatures (1200 K, 1400 K, and 1600 K). Whole process was recorded by high speed video camera.

Camera recorded images enabled to determine time intervals for different phases during particle combustion: inert heating, devolatilisation, combustion of volatiles, and char combustion. Time period between start of inert heating and start of volatile combustion is called ignition time delay. The first visible sign of flame on camera recorded images was taken criteria for particle ignition. The following theoretical expression for ignition delay time was derived based on the obtained experimental results:

\[
\Delta t_{\text{ignition}} = 2.5 \cdot 10^{15} \cdot \frac{1}{T_g} \cdot d_p
\]

Where \(\Delta t_{\text{ignition}}\) is time necessary for particles to heat up to ignition temperature, where \(T_g\) is bulk gas temperature and \(d_p\) is particle diameter.

The second set of experimental results was taken from [26]. In their paper authors presented results obtained from devolatilisation tests of domestic Serbian lignite coal performed on a hot wire screen reactor in inert gas atmosphere. Investigated coal samples (approximately 10 mg) was spread in the few particle thin layers over electrically heated stainless steel wire mesh. After connecting of thermocouples the reactor was closed, evacuated, and purged with nitrogen. The sample was heated with the predetermined heating program to desired reaction temperature. Temperatures of reactions were maintained in range from 573 K to 1073 K, with reaction times 3 s – 28 s, thus leading to relatively low heating rates (for common pulverized coal combustion conditions) between 120 – 270 K/s. The reaction temperature dependence of maximum volatile yield was derived as result of performed experimental tests.

4. RESULTS AND DISCUSSION

Calculated ignition delay times, according to Eq. (5), for different Arrhenius kinetics together with experimental values [25], for different particle sizes are shown in Figure 2.

It can be seen that faster devolatilisation models, [18] – [21], produce rates which agree fairly well with experimentally derived devolatilisation rates. This behavior can be explained by the fact that these models’ parameters were derived for similar conditions, i.e. rapid heating rates, to those under which experiments were carried out. The best agreement between numerical results and experimental values was reached using rates suggested by S. Badzioch and P. G. W. Hawksley [18] and Hu et al [20], as can be seen in Figure 2.

Significant difference between experimental data and numerical results is obtained using devolatilisation kinetics derived by J. M. Jones (FG-global) [19] and H. Kobayashi and coworkers [23]. Results obtained using these two Arrhenius kinetics sets can be explained by the fact that they predict slow devolatilisation rates which are more likely to occur at low temperatures and low particle heating rates. In the contrast, experiments used for model validation were carried out under rapid heating rates at high bulk gas temperatures. Although devolatilisation kinetics parameters suggested by D. Stojiljkovic et al., [22], are also based on experimental technics which involve slow heating rates (TGA analysis) they produce higher devolatilisation heating rates then two previously mentioned models. This difference is probably coming from the coal samples used for determining
devolatilisation kinetics. While J. M. Jones and H. Kobayashi used mainly bituminous coals, D. Stojiljkovic carried out experiments with low-grade Serbian lignite coals which have higher volatile content and lower devolatilisation temperatures and thus produce faster devolatilisation. However, it should be noted that in case of all three slow devolatilisation models described in this paragraph it was not possible to obtain stable devolatilisation for particles bigger than 200 μm.

In order to verify model behavior under slower heating conditions experimental results by G. Jankes et al. [26] were used. Their data enabled to compare total volatile yield obtained at different temperatures (i.e. at different heating rates) for different devolatilisation rates and particle diameter $d_P = 90 \mu m$.

![Figure 2](image_url)

**Figure 2.** Computed ignition delay time for different Arrhenius rates together with experimental data for different pulverized coal particle size

Slower devolatilisation models show much better agreement in compare with the fast. All models under-predict total volatile yield at the lowest investigated temperature of 573 K. All fast devolatilisation models predict sudden release of total amount of volatiles with temperature increase. The fastest devolatilisation model suggested by S. Badzioch and P. G. W. Hawksley predicts that all volatiles are released as early as at 623 K. Similar trend is also present in case of the other fast devolatilisation models. However, complete volatile release is shifted to higher temperatures corresponding to somewhat slower devolatilisation rates predicted by these models. The smallest difference in comparison with experimental results was achieved using single rate devolatilisation model with D. Stojiljkovic’ s parameters which is consistent with the fact that these parameters were derived at low heating rates for similar coals as in G. Jankes experiment (low-grade Serbian lignite).
Figure 3. Comparison between computed (for different Arrhenius constants) and experimentally determined total volatile yield reaction temperature dependence.

Figure 4. Particle volatile fraction along reactor length for class of particles, S. Badzioch and P. G. W. Hawksley kinetic rate [18].

Particle volatile mass fraction change along reactor length for different devolatilisation kinetic parameters is shown in Figures 4 – 10.

Particle volatile fraction change during devolatilisation for S. Badzioch and P. G. W. Hawksley kinetic rate is shown at the Figure 4. It can be seen that for 90 µm and for 200 µm volatiles are rapidly released from particle. All volatiles are evaporated at distances 0.25 m and 0.52 m from inlet surface for 90 µm and 200 µm particles respectively. With particle size increase volatile release is delayed further downstream reactor. Total volatile release is located at 2.05 m for 500 µm particles. In case of the largest particles (dp = 1000 µm) only about 20% of all volatiles initially present in particle are released.
Particle volatile fraction change in a case of devolatilisation modeling using FG-DVC global rate is shown at the Figure 5. It can be seen that produced devolatilisation rates are significantly slower in comparison with previous case. Total volatile release is located at about 3.2 m from inlet surface for particle sizes 90 μm and 200 μm. Complete devolatilisation wasn’t achieved for particles with diameters greater than 500 μm. In case of 1000 μm particles devolatilisation is just at the beginning, due to low predicted devolatilisation rate.
Devolatilisation rates based kinetics obtained from tar mass loss in FG model are much higher than those obtained using FG-global kinetic data, Figure 6. 90 μm and 200 μm size particles are completely devolatilized at 0.125 m and 0.4 m after injected into reactor. Devolatilisation rate for 500 μm is somewhat slower to those obtained using S. Badzioch and P. G. W. Hawksley kinetics. However, in case of 1000 μm particles there is almost no devolatilisation (less than 0.1% of volatiles released from particle).

Devolatilisation rates produced using single rate model with Arhennius parameters derived by Hu and coauthors are shown in Figure 7. Obtained rates for 90 μm, 200 μm, and 500 μm particles are very similar to those based on FG-tar global kinetics. Again, in case of the biggest (1000 μm) coal particles, almost no volatiles are released inside reactor.
Particle diameter $d = 90$ [microm]  
Particle diameter $d = 200$ [microm]  
Particle diameter $d = 500$ [microm]  
Particle diameter $d = 1000$ [microm]

Figure 9. Particle volatile fraction along reactor length, D. Stojiljkovic’s kinetic rate [22]

Figure 10. Particle volatile fraction along reactor length, Kobayashi et al. kinetic rate [23]
Devolatilisation rates calculated using single rate model together with kinetic parameters suggested by SANDIA national laboratory are very similar to those calculated using single rate and S. Badzioch and P. G. W. Hawksley kinetic parameters. This similar devolatilisation behavior can be explained by the fact that in the both cases authors have used similar experimental procedure (drop tube reactor with rapid heating rates) and similar sample coals (low quality brown coals), Figure 8.

Devolatilisation rates calculated using single rate model and kinetic parameters derived for Serbian lignite coals by D. Stojiljkovic are presented in Figure 9. Total volatile mass loss is observed at distances 1.4 m and 1.8 m from inlet surface for 90 μm and 200 μm size particles respectively. This somewhat delayed devolatilisation compared with rates obtained using SANDIA, S. Badzioch and P. G. W. Hawksley, and Hu et al. kinetic parameters can be explained by different experimental methods employed. While above mentioned authors have used vertical reactors able to achieve rapid heating of entrained particles, D. Stojiljkovic utilized thermo-gravimetric analysis to derive devolatilisation parameters. About 15% of volatiles remain in particle in case of 1000 particles.

The slowest devolatilisation is noticed in case of two step model with Kobayashi kinetic parameters, Figure 10. In this case there is no complete devolatilisation even in case of the smallest \((d_p = 90 \mu m)\) particles. Approximately about 30 – 35 % of all volatiles initially present inside particle are released in case of small size (90 μm and 200 μm) particles. Only small part of particle mass is lost due to devolatilisation in case of 500 μm particles (up to 5%).

Devolatilisation rate values obtained using two step model and Ubhayakar and coauthors derived kinetic parameters are close to those based on D. Stojilkovic work, although somewhat higher, Figure 11. However attraction in using two step devolatilisation model with Ubhayakar et al. suggested Arhennius constant lies in ability of this model to predict influence of heating rate to total volatile yield.

5. CONCLUSIONS AND FUTURE WORK

— Sensitivity analysis of influence of different devolatilisation kinetic factors on pulverized coal particles devolatilisation and ignition time was conducted.
In total, eight different devolatilisation kinetics and two different devolatilisation models were compared against experimental data.

Inspection of obtained numerical results pointed out that different kinetic parameters strongly influence coal devolatilisation behavior.

The quickest devolatilisation rates were achieved using S. Badzioch and P. G. W. Hawksley devolatilisation constants. Similar, rapid devolatilisation rates were also obtained using other fast devolatilisation models (SANDIA, FG-tar, and Hu et al.). These high devolatilisation rates are influenced by the experimental conditions in which coal particles were examined, i.e., vertical reactor with rapid heating of entrained coal particles. Somewhat slower devolatilisation rates were produced using Ubhayakar et al. and D Stojilkovic’s kinetical constants. In case of Ubhayakar and coauthors work, slower devolatilisation rates are probably produced due to assumption under which kinetic parameters were derived. Namely, it was assumed that devolatilisation starts at relatively high temperatures ~ 700 K. Slower devolatilisation rates obtained using D. Stojiljkovic Arhennius kinetics can be explained by influence of slow heating rates conditions utilized in her work. The slowest devolatilisation rates were obtained using Kobayashi kinetics. In this case it was almost impossible to achieve stable devolatilisation, even for the smallest particles. This is likely caused by authors’ assumption that devolatilisation starts at quite high temperatures (more than 850 K).

The performance of numerically investigated devolatilisation models was checked against two different sets of experimental data, one obtained at rapid heating rates (ignition delay time) and the second set obtained at low to moderate heating rates (total volatile yield at different devolatilisation temperatures).

The best agreement with experimentally obtained ignition delay time is obtained using fast devolatilisation models, [18 – 21] and [24], developed for high heating rates similar to those used in experiments. It should be mentioned that experimental values were obtained investigating single particle devolatilisation, while in reality, as well as in the proposed numerical model coal particle devolatilise in clouds.

Slow rate devolatilisation models, [22 and 23] produce total volatile yield were close to experimentally determined, as it is expected since experimental data used for comparison were obtained using slow to moderate heating rates as already stated above.

In order to further investigate Serbian lignite coals devolatilisation it was decide to build entrained flow combustor able to operate at high heating rates and with desired oxidizer composition at desired gas temperatures.

Newly built reactor will also enable investigation of Serbian lignite coals combustion characteristics using valuable conclusions from this work.

Literature


