INITIAL RESULTS OF STUDIES AND POSSIBILITIES FOR BIOMASS GASIFICATION IN BULGARIA AND INDIA

I. Ivanov, A. Saravananakumar, K. Kumar, P. Kaleychev

Abstract. The use of biomass as energy source has high priority in order to comply with the Kyoto Protocol for global reduction of the greenhouse emission. As result of scientific contacts and studies of researchers from Bulgaria and India begin join work in the field of biomass energy utilization in particular with biomass gasification. The aim of the paper is to present the initial results from the studies and possibilities for biomass utilization and gasification in the both countries Bulgaria and India. The paper describes in brief some studies regarding biomass potential, the policy and legislation and some measures implemented in Bulgaria. On the other hand it presents the experience in India regarding biomass gasification and possibilities for utilisation of biomass at low investments and high efficiencies. The applied method of a very high temperature biomass gasification technology has technical advantages. In this connection are presented some results of experiments in pilot installations concerning gasification of solid agriculture waste. As results are presented temperature of the gas outlet, inlet air pressures measured in time of the experiments and some dependencies and conclusions.

Keywords: Biomass, biomass gasification, renewable energy sources

1. INTRODUCTION

Compared to other renewable sources the biomass represents a technically more feasible option with the potential of contributing to the energy supply meanwhile ensuring sustainable development. The EC has recognized the need of promoting the use of biomass as energy source with high priority in order to comply with the Kyoto Protocol for reduction of 8% of the greenhouse emission to 2012. Bulgaria has excellent natural conditions for development of the agricultural and forestry sector. The biomass potential for energy uses is large – the forests stands at about 3,6 million ha or 33 % of the total territory of the country. The Bulgarian Act on Renewable Sources of Energy and Biofuels encourages the development and use of technology for the production and use of energy generated from RES. More than 6 Mt/year solid agriculture waste could be use as biomass for energy production by direct combustion or gasification in Bulgaria. Over 75% of the Indian population is living in villages which are driven by agriculture. The scattered agriculture waste has enormous energy potential and can have large share in meeting the energy requirements of India. These conditions in the both countries are very good preconditions for research and practical collaboration of the biomass gasification.

The biomass as source of energy includes all of the derivable materials from the agricultural plants or domestic animals. Includes different products as wood, crop waste, agricultural and industrial waste, composts, organic and household solid waste, alcohol fuels, etc., that are appropriate for utilization for producing of energy. Biomass is a renewable energy source because it supply is not limited.

Wood and agricultural waste are used to generate electricity. Much of this electricity is utilized by the industries that make that waste. The paper and saw mills use a part of their product waste and generates steam and electricity for their own use. However, since they use much energy, there is needed to buy additional electricity. The power plants that use the garbage for energy are called waste-to-energy plants. They generate electricity as coal-fired plants.

The half part of the used biomass as fuel, comes from burning wood and wood scraps, as for example saw dust. Another part is from biofuels that use ethanol as a gasoline additive. The rest part comes from crops, garbage and landfill gas.

The biomass has some advantages, environment-tally, over fossil fuels, as petroleum and coal. It does not produce the pollutants that can cause acid rain, because contains little sulfur and nitrogen. The plants that use biomass, remove carbon dioxide which is one of the greenhouse gases in the atmosphere. The plants that use as biomass fuels help to keep carbon dioxide levels balanced.

The sources of biomass may be divided into three categories: forest, food and urban and the production of biomass may be divided as follows:

- Produced as a result of deforestation;
- Common organic industrial waste as paper;
- Agricultural residues from fruits and vegetables, residues from the food industry;
- The silviculture and wood processing forest residues;
- Organic household waste, etc.

2. POTENTIAL OF BIOMASS IN BULGARIA

In accordance with the Bulgarian National long-term program for encouraging the utilization of renewable energy sources [3], Fig.1 presents the expected consumption of biomass in ktoe, for 2005 – 2015 year.

It is expected the consumption of biomass in 2015, to increase with almost 400 ktoe, in comparison to 2005 year.

The summary for the biomass potential in Bulgaria is presented in Table 1. The distribution of total potential of biomass is presented in Fig. 2 [3].

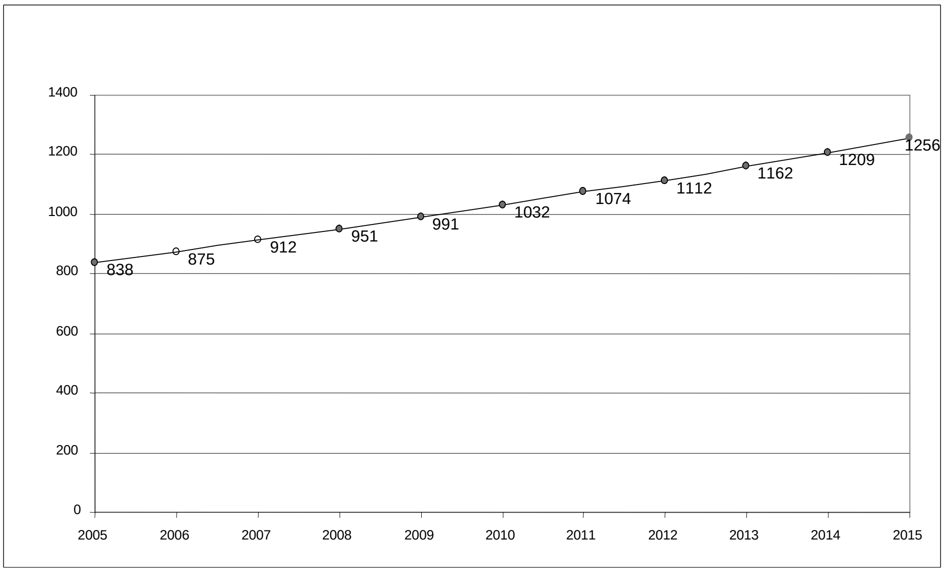

Fig.1 Expected consumption of biomass in Bulgaria: 2005 – 2015 year

Table 1

TYPE OF BIOMASS	POTENTIAL		
	Total	***Unutilized***	
	ktoe	ktoe	%
Wood waste	1 110	510	46
Industrial waste	77	23	30
Agricultural vegetable waste	1 000	1 000	100
Agricultural animal waste	320	320	100
Dung-hill gas	68	68	100
Rapeseed oil and waste fats	117	117	100
Total	2 692	2 038	76

The increasing energy utilization of wood waste in Bulgaria is in result to the low prices of this type of biomass and low invests for the simple utilities that are uses for the transformation of the biomass into a heat. The implemented policy concerning prices, as well the influence of the international markets, lead to the permanent increasing of the prices of the liquid fuels, natural gas, electrical and thermal energy. That leads to the stress over the consumers and increases the utilization of waste wood.

Bulgaria has a potential for utilization of waste and low rate biomass (up of 2 Mtoe), that at the moment is unutilized and may to be used for energy purposes. Technical and economical analyses present that the utilization of biomass in the urban areas and for producing of heat is competitive renewable energy source in comparison to the traditional fuels, except coals and has significant ecological priorities in comparison to the all traditional fuels.

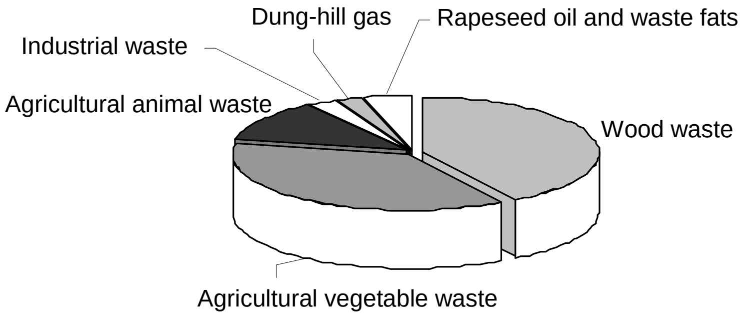

Fig. 2. Distribution of the total potential of biomass in Bulgaria

Therefore, the possibilities for utilization biomass, respectively by gasification for energy purposes are:

- Preprocessing of low rate wood and agricultural waste;
- Start using modern installations for combustion of low rate wood and agricultural waste;
- Priority building of installations for co-generation of biomass;
- Utilization of industrial waste;
- Increasing of the efficiency of the utilities for combustion of woods;

3. POLICY AND LEGISLATION CONCERNING BIOMASS IN BULGARIA

In connection to the Bulgarian National long-term program for encouraging the utilization of renewable energy sources 2005 – 2012 years, the main aims are:

- Production of electrical energy from renewable energy sources - the share of renewable energy sources in 2010 year, to be 8% of the total production of electrical energy and till 2015 year, to be 9%.
- Replacement of the conventional fuels and energies that are uses for heating and biofuels with total energy equivalent not less then 1300 ktoe/year.
- The consumption of liquid biofuels - the market share of the biofules to correspond to the actual conditions in the country.

The Low for renewable and alternative energy sources and biofuels regulates the public relations in connection to encouraging production and consumption of electrical, thermal energy and biofuels. Some of the measures for encouraging the producing energy from renewable energy sources are:

- To buy up the produced electrical energy in appropriate prices;
- Contracts and obligatory buying up of electrical energy from renewable energy sources;
- Obligatory connection to electrical grid of every producer of electrical energy, etc.

There are some other lows and mechanisms for encouraging the producing and consumption of energy from biomass, as: Environmental Protection Act (State Gazette 86/2003) [4], Waste Management Act (State Gazette 86/2003, last amended SG 27.09.2005) [5], etc.

4. POTENTIAL OF BIOMASS IN INDIA

At the moment India is one of the leading countries of utilization biomass energy. Biomass contributes over a third of primary energy. The biomass power potential in the entire country is 19,500 MW. Biomass delivers most energy for the domestic use (rural - 90% and urban - 40%). Wood fuels contribute 56 percent of total biomass energy. Estimates of biomass consumption remain highly variable since most biomass is not transacted on the market. The reported biomass energy is: dry fuel wood for domestic sector - 218.5 million tons and crop residue - 96 million tons (estimate for 1985). A recent study estimates demand in India for fuel wood at 201 million tons. Over 75% of the Indian population is living in villages which are driven by agriculture. The agriculture waste has large energy potential and can have large share in energy requirements of India.

India is the largest producer of cane sugar and has 465 sugar mills scattered all over. Sugar cane and the energy crop offers great number of byproducts in large quantities in addition to its main product sugar – bagasse, molasses, press mud, leaves and trashes, etc. Only very little bagasse finds its use in paper industries. The vast source of byproducts gives the opportunity for the development of large scale gasifier plants and also looks promising for the establishment of chemical plants for the production of value added chemicals in addition to energy and thus strengthening its economical viability.

By the series of measures the government of India encourages strongly the utilization of energy from biomass. The renewable energy sources in India are under jurisdiction of MNES - Ministry of Non-Conventional Energy Source. MNES encourages researches, resource assessment, technologies and biomass system modeling, with aim to obtain the maximum utilization of the potential of the renewable energy sources.

In India, there are rather advantages in biomass gasification and energy utilization, such as possibilities for utilisation of large quantities of biomass at low investments and high efficiencies. There is need to researching to biomass technologies, for the incensing of the quality, improvement of the applications and the technologies, achieving the market base, biomass gasification development and commercialization. One of the aims is to improve the biomass technologies and biomass gasifiers in particular. The efforts are toward identification and reducing of the possible health, safety and environmental hazards.

5. TECHNOLOGIES FOR GASIFICATION OF BIOMASS

There are various technologies that are use for gasification of solid fuels. The classification takes into account the applied basic reactor principles [1]:

- entrained flow systems
- fixed-bed systems
- fluidized-bed systems

Gasification in entrained flow

In this case, the flow of small parts of solid biomass (smaller than 0.1 mm) passes in the reactor. The reactor has the gasification medium. The time of retention is a few seconds, and the gasification is applied for temperatures from 1200 to 1500°C. By the high temperatures is ensured a complete conversion of the hydrocarbon compounds in result to the pyrolysis of the fuel.

Gasification in a fluidized bed

Fluidized-bed reactors use a fluidized mix of bed material and biomass. The gasification medium flows in the nozzle bottom and fluidize the bed material. The medium can be inert, (quartz sand) or catalytically active. That depends to the conversion of organic contaminants in the crude gas and after-reactions in the gas phases.

The temperatures for operation for ligneous biomass are around 950°C and may be reduced down moderately to lower temperatures, for i.e. short rotation crops (or straw) which possess ash that lower the temperatures to around 800°C.

Gasification in fixed-bed reactors

In case of fixed-bed reactors, there is a fuel bulk filling in the reaction chamber. The biomass is fed in the upper part of the reactor, by opening or sluice on the reactor head. The biomass sinks slowly down in the reactor by gravity in the term of fuel-conversion process, depending to the various manners of operation of fixed-bed reactors, results to the relative direction of gas stream and fuel bed movement (up and downdraft).

The gasification medium and the produced wood gas in the updraft gasification, flow through the gasification reactor in the opposite direction to the fuel bed. If the reactor is fed on the upper part, the gasification media as for example air, oxygen, steam, enters in the reactor in the area of the grate.

The gasification medium in the downdraft gasification flows through the gasification reactor in the direction of the sinking bulk filling. The drying or pyrolysis zone is above the oxidation zone and is supplied with the necessary heat for the process through the thermal conduction in the bulk filling.

Gasification in a double fire gasifier is a combination of downdraft and updraft gasification.

In the staged systems for biomass gasification all the processes are separate to the partial processes of thermo-chemical conversion, for example: drying, pyrolysis, oxidation, and reduction. These processes are applied in reactors separated. The process separation leads to a greater influence on the partial steps and those results for example to little load in the form of the condensable hydrocarbon compounds.

Another classification concerns the individual process steps of biomass gasification technology - [1] and [2].

Fuel, fuel storage, transport and feeding

From the fuel storage, transport and feeding depends the quality of the fuel, as for example the drying processes. They influence the process stability, for example the quality of the producer gas and the stability of heat and power production.

Storage of fuel and auxiliary fuel

Fuel storage concerns the fuel delivery and fuel treatment during the storage period. The stored amount of fuel is dependent on the configuration of the plant.

Fuel conveyance

Fuel conveyance covers the transportation of the fuel from the fuel depot to the fuel feeding system in sufficient volume and quality.

Feeding fuel into the reactor

The fuel feeds into the gas generating reactor by conveyance systems, activated by the output regulation of the exploited system. Fuel feeds by the tight transfer canal that prevents gas leakage as well as the aspiration of the leakage air.

Gasification reactor

The conversion of solid biomass into raw produced gas is realized in the gasifier - gasification reactor. The biomass passes to the steps of drying, pyrolysis, partial oxidation and reduction and the input mass flow of solid biomass is converted into an output mass flow of producer gas that consist desired gas products as H_2, CO, C_xH_y, CO_2, N_2, and undesired products as particulate matter, dust, soot, inorganic pollutants and organic pollutants (tars) as well as ash.

Gas cooling

The gas cooling lower the temperature of produced gas and then achieves the requirements of the optimal operation conditions. There are demonstration facilities where the reactor that discharge in the temperature interval 500-800°C is cooled down to around 600-100 °C, to achieve dry particle filtration with ceramic or fabric filters.

Gas cleaning

By the gas cleaning is achieved constant qualities for gas, independent of fluctuating of the produced gas contamination of the processes in the gas generation or fuel feeding, which leads to fluctuations in the quality of the raw gas. The task of gas cleaning is to de-dust the producer gas and to ensure suitable purity.

6. EXPERIMENTAL

In connection to the process of biomass gasification, there are two main approaches for tar cracking. The first is thermal cracking and the second is catalytic cracking. The Renewable Energy R&D Division of the Spray Engineering Devices Limited (SEDL), in India, researches first approach - thermal cracking. SEDL gasification team had experience in developed and testing of pilot installations on scale level during their earlier tenure in the MNES project.

The activities of SEDL includes technical issues related to scaling up of down draft biomass gasifiers and develop scalable Bagasse based very high temperature (>1200°C) down draft gasifiers using ceramic and refractory materials. By using of air and oxygen as oxidants which eliminates tars or drastically reduce the load on catalysts in gas cleaning systems. Then is received thermally cracked very high quality producer gas and synthesis gas. The experiments and research concerns basic designs that deal with burning of pyrolytic products to maintaining constant bed porosity and achieving very high temperature in the intermediate zone.

The applied method of a very high temperature biomass gasification technology has significant advantages, for instance the technical reliability overcomes the major flaw of converting tar into useful fuel which can reduce the load on the gas cleaning systems and to extend the life of it. This increases the efficiency and improves the performance of the systems. The method influences to the polluting of inefficient large scale direct combustion of biomass fuels. It eliminates the risk of safe disposal of process waste which may otherwise require treatment to avoid any negative impact on the environment. In connection to power generation it also makes it possible the pumping of gas into the large village networks, where the current practices of direct combustion is inefficient.

In connection to the activities of SEDL, there are presented below some experimental results for biomass gasification received during 2009.

For the experiment is used 820 kg wood chips and 1000 kg charcoal. The total time of ignition is 20 min. Gasifier starting time is 7:30 pm and gasifier shutdown time is 9:00 pm. Ignition starting time is 7:33 pm, ignition stopping time is at 7:53 pm. There are two modes - up draft and down draft. After 8:33 pm air flow rate was reduced for both the modes. At 8: 45 pm updraft mode of operation was completely stopped. The temperature of the gas outlet and inlet air pressures is measured in time of the experiment.

7. RESULTS AND DISCUSSION

The picture of ignition for start-up is presented in Fig.3. Fig.4 presents the flame after 15 minutes and Fig.5 - the flame after 60 minutes.

The temperature on the gas outlet in interval 8:00 to 9:00 pm is shown in fig.6. The lower temperature is 124°C at 8:00 pm and the maximum temperature is 308°C at 8:50 pm.

In the fig.7 is presented the inlet air pressures P_1 and P_2 in kgf/cm^2 by the measuring points for up draft and down draft modes. The up draft P_1 pressure is highest then others pressures, as the maximum value is 0,989 kgf/cm^2 in 8:20 pm.

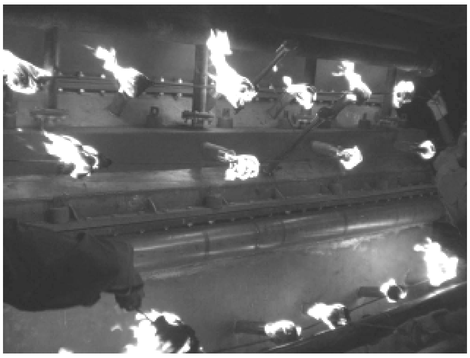

Fig. 3. Start-up of ignition

Fig. 4. Flame after 15 minutes

Fig. 5. Flame after 60 minutes

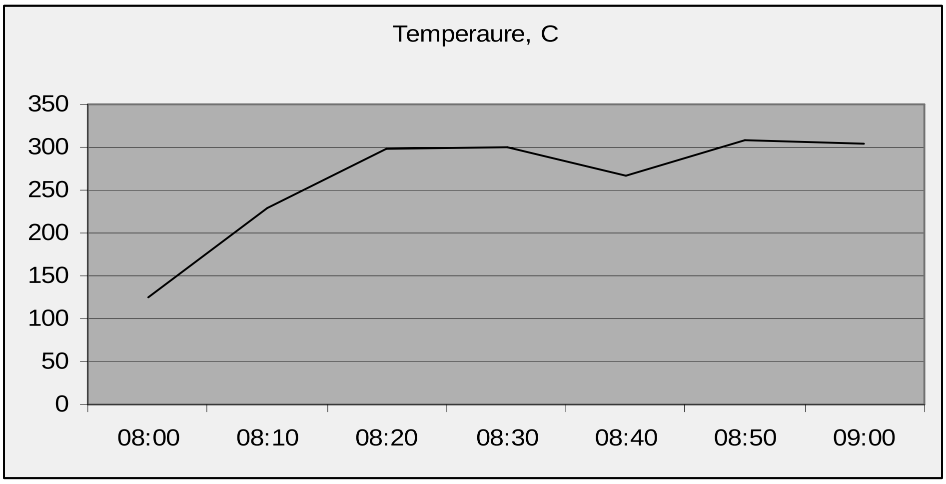

Fig.6. Temperature on the gas outlet

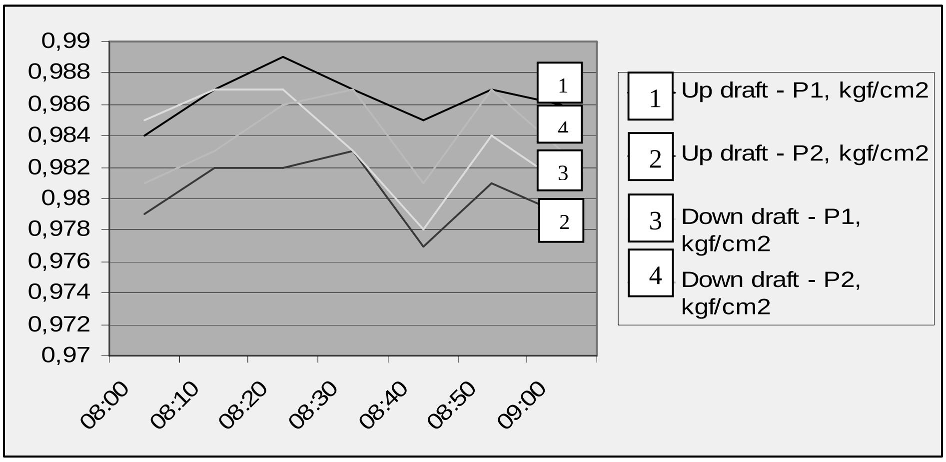

Fig.7. Inlet air pressures - for up and downdraft modes

The values of the pressures and temperatures in times 8:20 pm and 8:50 pm are maximal for the experiment. The pressures in the up and downdraft modes, and the temperature of the gas outlet increase from the beginning of the experiment (at 8:00 pm) to the next 20 minutes, when the screw conveyers and grate motors stops. The pressures at 8:00 pm are between 0,979 and 0,985 kgf/cm^2. At 8:20 pm, the pressures in the up and downdraft modes are between 0,982 and 0,989 kgf/cm^2. As is present to the fig. 7, the difference between upper and down pressure for the time 8:00 and 8:20 pm is similar. This dependency is same to the end of the experiment, for example for time 8:50 pm, when the maximum of the pressures (fig. 7) and of the temperature (fig. 6) is appeared.

8. CONCLUSIONS

Bulgaria has a large potential of biomass and possibilities for development of energy utilization by application of the good practices for biomass gasification. In Bulgaria energy utilization of wood waste increasing in result to the low prices of this type of biomass and low invests for the simple utilities that are used to produce a heat from biomass. The aim is Bulgaria to reach till 2015 year total production of 9% of electrical energy from renewable energy sources.

The governmental policy in India encourages researches with aim to obtain the utilization of the potential of the renewable energy sources. The Renewable Energy R&D Division of the Spray Engineering Devices Limited (SEDL), researches thermal cracking related to scaling up of down draft biomass gasifiers. The presented initial experimental results of the pilot installations and the conditions in the both countries are very good preconditions for research and practical collaboration of the biomass gasification.

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НАЧАЛНИ РЕЗУЛТАТИ ОТ ИЗСЛЕДВАНИЯ И ВЪЗМОЖНОСТИ ЗА ГАЗИФИКАЦИЯ НА БИОМАСА В БЪЛГАРИЯ И ИНДИЯ

И. Иванов, А. Саравананакумар, К. Кумар, П. Калейчев

Резюме. Употребата на биомаса като източник на енергия има висок приоритет за изпълнението на Протокола от Киото за глобално намаляване на емисиите на парниковите газове. В резултат на научни контакти и проучвания на изследователи от България и Индия е започната съвместна работа в областта на оползотворяването на биомаса, в частност чрез газификация на биомаса.

Целта на статията е да представи първоначални резултати от изследвания и възможности за оползотворяване и газификация на биомаса в България и Индия. Статията описва накратко потенциала на биомасата, съответната политика и законодателство, и мерките в тази насока, които се прилагат в България. От друга страна е представен опита на Индия от гледна точка газификация на биомаса и възможностите за оползотворяване на биомаса при ниски инвестиции и висока ефективност.

Приложеният метод на високотемпературна газификация на биомаса има технически предимства. В тази връзка са представени някои резултати от експерименти в пилотни инсталации за газификация на твърда селскостопанска биомаса. Като резултати са показани температурата на изходния газ, наляганията на входящия въздух, измерени по време на експериментите, някои зависимости и заключения.

Доц. д-р инж. Иван Иванов

България, Технически университет – София,
София 1000, бул. Кл. Охридски 8, бл.12
e-mail: ivec@tu-sofia.bg
тел.: +359 2 965 2043

Dr. Ayyadurai Saravananakumar

Spray Engineering Devices Limited, C-82,
Industrial Area, Phase-VII, Mohali-160 055
Punjab, India
e-mail: a.saravanakumar@sedl.in

Dr. Kandasamy Vinoth Kumar

Spray Engineering Devices Limited, C-82,
Industrial Area, Phase-VII,
Mohali-160 055 Punjab, India
e-mail: vinoth.kumar@sedl.in

Ст. ас. д-р инж. Петър Калейчев

България, Технически университет – София,
София 1000, бул. Кл. Охридски 8, бл.12
e-mail: kaleychev@tu-sofia.bg
тел.: +359 2 965 2113

Assoc. Prof. Dr. Ivan Ivanov

Bulgaria, Technical University - Sofia,
Sofia 1000, Kl. Ohridski 8, bl.12
e-mail: ivec@tu-sofia.bg
phone: +359 2 965 2043

Dr. Ayyadurai Saravananakumar

Spray Engineering Devices Limited, C-82,
Industrial Area, Phase-VII, Mohali-160 055
Punjab, India
e-mail: a.saravanakumar@sedl.in

Dr. Kandasamy Vinoth Kumar

Spray Engineering Devices Limited, C-82,
Industrial Area, Phase-VII,
Mohali-160 055 Punjab, India
vinoth.kumar@sedl.in

Assist. Prof. Dr. Petar Kaleychev

Bulgaria, Technical University - Sofia, Sofia
1000, Kl. Ohridski 8, bl.12
e-mail: kaleychev@tu-sofia.bg
phone: +359 2 965 2113