ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 10, October 2023

Influence of physical and chemical properties of solid fuels on the gasification process

Murodjon Kavkatbekov, Rakhimjan Babakhodjayev, Lutfulla Eshkuvatov

Scientific researcher at the department of Industrial Thermal Power Engineering, Tashkent state technical university, Tashkent, Uzbekistan
Professor of the department Thermal Power Engineering, Tashkent state technical university, Tashkent, Uzbekistan
Associate Professor (PhD) of the department of Industrial Thermal Power Engineering, Tashkent state technical university, Tashkent, Uzbekistan

ABSTRACT: The article provides an overview of the influence of the properties of solid fuels on the process of efficient gasification. The variety of properties of solid fuels and the uniqueness of gasification methods require careful consideration of the properties of the fuel used when organizing the technological process. Otherwise, this may lead to an erroneous conclusion that the fuel is unsuitable for gasification or to an undesirable deterioration in the efficiency of the gas generator. Caking ability, ash content, slag-forming ability, mechanical and thermal strength, particle size distribution, moisture and sulfur content are qualitative indicators of the efficiency of gasification of a particular fuel.

KEY WORDS: intensification, efficiency, combustion, fuel size, moisture, slagging.

I. INTRODUCTION

The design of gas generators, the method and technology of the gasification process are determined based on the properties of the fuel [1]. When designing gasification installations, there are factors that determine the technical and economic feasibility of using a particular design. These factors are:

- ✓ gas generator intensification;
- ✓ heat losses during gasification process;
- ✓ gas quality and quantity;
- ✓ by-product recovery;
- ✓ fuel ash composition.

Each of these factors mainly depends on the type of fuel used in the gasification process.

The intensification of the gas generator in turn depends on several fuel characteristics.

Gasification intensity. The intensity of gasification is characterized by the weight of the fuel gasified per unit time, per unit cross-section of the gas generator shaft (kg/m^2 · hour).

The intensity of fuel gasification in the generator is determined by the following main factors that to a certain extent depend on each other:

- ✓ fuel (size of fuel pieces, nature of fuel, moisture, ash properties);
- ✓ generator design;
- ✓ load factor.

The same fuel size determines the resistance distribution over the layer, as well as the optimal height of the gasification layer. Large fuel sizes in relation to small ones require more time for gasification, at the same time, the latter creates a large resistance to the process. Thus, the efficiency of gasification depends on the size of the fuel, which determines the height of the gasification layer. Works [2-4] provide methods for effectively solving problems of the dependence of the efficiency of the gasification process on the size of fuel particles. Kolodtsev in [5] says that if the ratio of the diameter of the gas generator to the particle size is more than twenty, then the porosity of the layer does not depend on the size of the installation. In [6], the dependence of the gas yield per unit mass of fuel on the fuel size was established.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 10, October 2023

Numerical modeling of the pyrolysis process of solid fuel shows the dependence of the yield of volatiles on the size of fuel particles [7-8]. Also, other factors influencing the size of solid fuel on the gasification process are described in [9-11].

In table Figure 1 shows the dependence of the layer on the fuel size for average production conditions at maximum efficiency.

Table 1. Dependence of layer height on particle size for some types of solid fuels.

Fuel	Piece size, mm	Technically feasible fuel layer height, mm
Anthracite	10÷20 (small nut) 25÷40 (walnut)	300÷600 750÷900
Coke	20÷30 30 ÷50 50÷75	750 1150 1800
Coal	13 ÷19 (nut) Unsorted	550 1500÷2000
Firewood	Large logs Sawdust and shavings	1500÷2150 1 200÷1 500
Peat	Lump	2000÷300

It can be noted that the data given in Table 1 are general, which were taken from the practice of operating gas generators of various capacities. In practice, there are gas generators with a layer height of only 100 mm, or vice versa, there are gas generators with a layer height of more than 6000 mm. This is due to the fact that it is not possible to establish a specific rule for the required height. The optimal height value is achieved after experimental studies. In Fig. 1. The dependence of the efficiency of the gas generator on the particle size of the fuel used is shown.

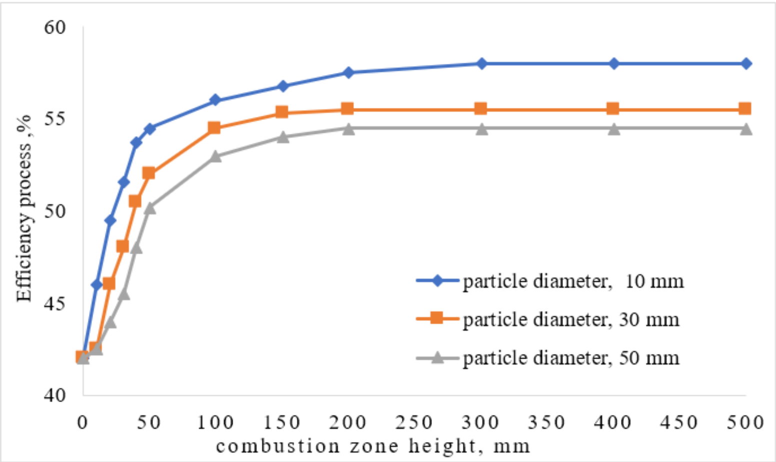

Fig.1. Dependence of gas generator efficiency on fuel particle sizes

The smooth surface of the fuel contributes to a more accelerated reaction of the gasification process. In gas generators with high productivity, this factor affects the overall efficiency of the process. The high content of fines in the gasified fuel is characterized by large entrainment of small particles, which reduces the overall efficiency of the installation.

Ch. Fushimi [12] experimentally determined the direct dependence of the rate of heating of particles on the size of the fuel, which consequently increases the reactivity of the coal residue during steam gasification.

The caking properties of coal are more typical for hard coals. The easy caking of coals has a positive effect on the gasification process if the coal contains dust or disintegrates when heated. In highly caking coals, a sharp decrease in gasification efficiency is observed due to the occurrence of mechanical underburning of sintered lumps of fuel with the

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 10, October 2023

formation of coke vaults, which create hang-ups and voids in the gas generator. To reduce the caking of fuels, gas generators with mechanical drilling are used [13].

The influence of moisture content in most cases is considered for lignite, brown coal, peat, firewood and other fuels of plant origin. When gasifying fuels with an operating moisture of more than 15%, high efficiency is achieved by using the actual heat of heated gases generated in the lower zone of the gas generator to remove moisture from the fuel in the upper zones and prevent moisture from penetrating into the combustion zone. This is achieved by providing a high fuel layer height, therefore, by increasing the layer height, the resistance to gas movement increases [14-19]. Also, additional resistance to gas movement is observed by increasing the volume of generator gas when using fuel with high moisture [20]. Figure 2 shows the dependence of the efficiency of the gas generator on the moisture of various solid fuels. Moisture equal to zero is given for comparison with the results of semi-empirical numerical models.

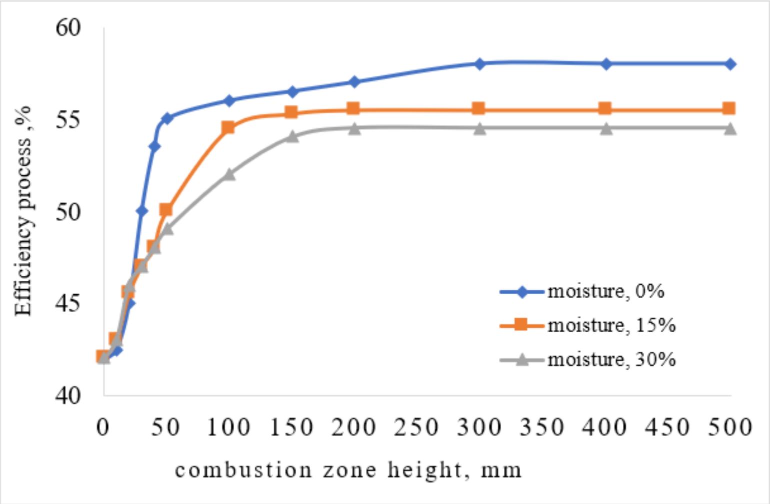

Fig.2. Dependence of gas generator efficiency on fuel moisture

One of the main tasks of the gasification process is to prevent the formation of ash slag. Slagging is formed as a result of contact of the liquid state of ash in the combustion zone with a gasifying agent, the temperature of which is much lower than the temperature of the ash. The ash turns into slag in the form of lumps or bark. In some cases, the slag is tightly welded to the brick insulation. Solid slag forms vaults and voids inside the fuel layer, therefore reducing the efficiency of the gas generator installation. To reduce the negative impact of slagging, it is necessary to break the slag mechanically (by screwing) and remove it from the gas generator [21]. The content of iron oxides, lime, magnesia and alkalis in the ash lowers the melting point of the ash, due to the fusibility of the resulting compounds with alumina and silica.

When developing gas generators to prevent the formation of slagging, the following conditions must be met [22]:

- ✓ determine the exact boundary for regulating the zone with the highest temperature so that it does not include areas where all the fuel has managed to turn into ash;
- ✓ regulate the supply of gasifying agent so that the temperature of the hot zone is below the melting or softening point of the ash.

  Operating characteristics that make it possible to minimize the negative impact of slagging for low-grade fuels are described in detail in [23-24].

II. CONCLUSION

Summarizing the above, we can draw the following conclusions:

Determining the optimal particle size for a particular solid fuel allows you to increase the reaction rate of the coal residue, the reactions of the reduction and pyrolysis processes. Diffusion restrictions of large solid fuels negatively affect the burnout rate of coal residue.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 10, October 2023

Knowledge of the comparative properties of the fuel in relation to the nature of free combustion, caking and swelling and other properties of the fuel helps to make the most of the technical capabilities of the gas generator plant. Carrying out experiments on laboratory equipment makes it possible to actually determine the above properties of solid fuels.

REFERENCES

[1] Altshuler V.S. New processes for gasification of solid fuels. - M.: Nedra, 1976. – 280 p.
[2] Folk R.L. A handbook for small-scale densified biomass fuel pellets manufacturing for local markets / RL Folk, RL Govett . – DIANE Pub., 1993. – 46 p.
[3] Hartmann H. Herbaceous biomass – fuel characteristics and pretreatment / H. Hartmann, I. Lewandowski // Biomass gasification and pyrolysis: State of the art and future prospects. – CPL Press, 1997. – P. 79-88
[4] Bowyer J.L. Forest products and wood science: An introduction / JL Bowyer, R. Shmulsky , JG Haygreen . – Blackwell Pub., 2007. – 568 p.
[5] Carbon combustion: experience in constructing the physical and chemical foundations of the process / A.S. Predvoditelev [and others]. – M.-L.: Publishing house Acad. Sciences of the USSR, 1949. – 407 p.
[6] Biomass air-steam gasification in a fluidized bed to produce hydrogen-rich gas / P. Lv [el al.] // Energy and fuels. – 2003. – Vol. 17. – No. 3. – P. 677-682.
[7] Hanson S. The effect of coal particle size on pyrolysis and steam gasification / S. Hanson, JW Patrick, A. Walker // Fuel. – 2002. – Vol. 81. – No. 5. – P. 531–537.
[8] Babu B.V. Pyrolysis of biomass: improved models for simultaneous kinetics and transport of heat, mass and momentum / BV Babu, AS Chaurasia // Energy Conversion and Management. – 2004. – Vol. 45. – No. 9-10. – P. 1297-1327.
[9] Experimental investigation and modeling study of long stick wood gasification in a top lit updraft fixed bed gasifier / A. Saravanakumar [et al.] // Fuel. – 2007. – Vol. 86. – No. 17-18. – P. 2846-2856.
[10] Air Gasification of Biomass in a Downdraft Fixed Bed: A Comparative Study of the Inorganic and Organic Products Distribution / I. De Bari [et al.] // Energy & Fuels. – 2000. – Vol. 14. – No. 4. – P. 889-898.
[11] Moilanen A. Gasification reactivity of large biomass pieces / A. Moilanen, J. Vepsalainen , E. Kurkela // Science in thermal and chemical biomass conversion. – Vol. 1. – CPL Press, 2006. – P. 509-518.
[12] Effect of Heating Rate on Steam Gasification of Biomass. 1. Reactivity of Char / C. Fushimi [et al.] // Industrial & Engineering Chemistry Research. – 2003. – Vol. 42. – No. 17. – P. 3922-3928.
[13] Lipovich V.G., Kalabin G.A., Kalechits I.V. and others. Chemistry and coal processing. – M: Chemistry, 1988. -336 p.
[14] Gasification of biomass/high density polyethylene mixtures in a downdraft gasifier / P. García- Bacaicoa [et al.] // Bioresource Technology. – 2008. – Vol. 99. – No. 13. – P. 5485-5491.
[15] Mukunda HS Fixed bed gasification for electricity generation / HS Mukunda [et al.] // Biomass gasification and pyrolysis: State of the art and future prospects / M. Kaltschmitt , AV Bridgwater eds. – Newbury: CPL Press, 1997. – P. 105-116.
[16] Tokarev G.G. Gas generating vehicles. – M: MASHGIZ, 1955. – 275 p.
[17] Mezin I.S. Transport gas generators. – M: OGIZ SELKHOZGIZ, 1948. – 248 p.
[18] García- Bacaicoa P. Downdraft gasification of high moisture biomass / P. García- Bacaicoa , C. Uson, R. Bilbao // 1st World conference on biomass for energy and industry. – Sevilla, Spain, 5-9 June 2000. – P. 1562-1565.
[19] Prins MJ More efficient biomass gasification via torrefaction / MJ Prins, KJ Ptasinski, F. Janssen // Energy. – 2006. – Vol. 31. – No. 15. – P. 3458-3470.
[20] Babrauskas V. Ignition of Wood: A Review of the State of the Art / V. Babrauskas // Journal of Fire Protection Engineering. – 2002. – Vol. 12. – No. 3. – P. 163-189.
[21] Yudushkin N.G. Gas generator tractors. Theory, design and calculation. – M.: MASHGIZ, 1955. – 244 p.
[22] V. A. Munts, E. Yu. Pavlyuk. Combustion and gasification of organic fuels: textbook. manual /— Ekaterinburg: Ural Publishing House. University, 2019. - 148 p.
[23] Keiko A.V. Promising modes of gasification of low-grade solid fuel / A.V. Keiko, I.A. Shirkalin, D.A. Svishchev // News of the Russian Academy of Sciences. Energy. – 2006. – No. 3. – P. 55-63.
[24] Keiko A.V., Svishchev D.A., Kozlov A.N. Gasification of low-grade solid fuel: level and directions of technology development. – Irkutsk: ISEM SB RAS, 2007. – 68 p.