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**Submitted to** International Journal of Sustainable Engineering

**Manuscript ID** TSUE-2020-0036

**Title** Biomass gasifier - internal combustion engine system: Review of literature

**Authors** Susastriawan, Anak Agung  
Purwanto, Yuli  
Purnomo, Purnomo

**Date Submitted** 20-Feb-2020



Anak Agung <agung589e@akprind.ac.id>

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## International Journal of Sustainable Engineering - Manuscript ID TSUE-2020-0036

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**International Journal of Sustainable Engineering** <onbehalfof@manuscriptcentral.com> Fri, Feb 21, 2020 at 11:40 PM  
Reply-To: TSUE-peerreview@journals.tandf.co.uk  
To: agung589E@akprind.ac.id, yuli690E@akprind.ac.id, purnomo@akprind.ac.id

21-Feb-2020

Dear Dr Susastriawan

Your manuscript entitled "Biomass gasifier - internal combustion engine system: Review of literature" by Susastriawan, Anak Agung; Purwanto, Yuli; Purnomo, Purnomo has been successfully submitted online and is presently being given full consideration for publication in the International Journal of Sustainable Engineering.

Your manuscript ID is TSUE-2020-0036 and the corresponding author is Dr Anak Agung Susastriawan

Please include the above manuscript ID in all future communications regarding this paper. If you require to make changes to your email address, correspondence address or research keywords please log in to Manuscript Central at <https://mc.manuscriptcentral.com/tsue> and click on "Edit my Account".

You can also view the status of your manuscript at any time by checking your Author Centre after logging in to <https://mc.manuscriptcentral.com/tsue>.

Thank you for submitting your manuscript to the International Journal of Sustainable Engineering.

Regards

Vishali Parameswaran - Editorial Administrator  
International Journal of Sustainable Engineering



Anak Agung <agung589e@akprind.ac.id>

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## International Journal of Sustainable Engineering - Decision on Manuscript ID TSUE-2020-0036

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International Journal of Sustainable Engineering <onbehalf@manuscriptcentral.com> Thu, May 28, 2020 at 5:12 AM  
Reply-To: TSUE-peerreview@journals.tandf.co.uk  
To: agung589E@akprind.ac.id

27-May-2020

Dear Dr Susastriawan:

Manuscript ID TSUE-2020-0036 entitled "Biomass gasifier - internal combustion engine system: Review of literature" by Susastriawan, Anak Agung; Purwanto, Yuli; Purnomo, Purnomo that you submitted to the International Journal of Sustainable Engineering, has been reviewed. The comments of the reviewer(s) are included at the bottom of this message.

You will see that, although the reviewer(s) found some merit in the paper, substantial revisions are required before we can consider it further. The reviewer(s) comments are included at the end of this email. Nevertheless, we do hope you will be able to undertake the additional work on the paper and look forward to receiving re-submission of a revised manuscript by 22-Jul-2020.

Please confirm by return your intention to revise and resubmit the paper.

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You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript, upload it and submit it through your Author Centre. Please highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or coloured text.

When re-submitting your revised manuscript please include an account of how you have responded to the review comments in the space provided. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s). Should you disagree with any detail of the review, your counter-argument will be helpful and welcome.

**IMPORTANT:** Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

If it is not possible for you to submit your revision in a reasonable amount of time, we may have to consider your paper as a new submission. Please advise us if the revision is delayed.

We thank you for submitting your manuscript to the International Journal of Sustainable Engineering and look forward to receiving your revision.

Sincerely,  
Professor S. Rahimifard  
Editor in Chief, International Journal of Sustainable Engineering

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author

Below you find my comments to the manuscript

Page 3. Table 1 - please change the values of HHV expressed in kcal/kg to MJ/kg.

Page 11. Authors state that "The effective equivalence ratio for biomass gasification lies from 0.2 to 0.4." The value of equivalence ratio less than 1 means that the air/fuel mixture is rich in air. In the gasification process the value of equivalence ratio should be more than one. Additionally, the equation 12 is definition of excess air ratio not

equivalence ratio. Please change it to the correct form. The equivalence ratio is equal to  $[A/F]_{\text{stoichiometric}}/[A/F]_{\text{actual}}$ .

Page 12. Equation 15, the description of "mf/t" is missing

Page 12. Similar mistake like on page 11. Authors state that "Temperature of gasification temperature is influenced by  $\phi$ . Temperature of gasification enhances as  $\phi$  increases (Guo et al. 2014). By expanding equivalence ratio, oxygen availability increases, results in enhancing oxidation process and releasing more heat." In fact the increase of equivalence ratio causes to less oxygen availability to the biomass. What finally the authors are going to discuss equivalence ratio or excess air ratio? Please use correct information in whole manuscript.

Reviewer: 2

#### Comments to the Author

The authors propose a literature review on biomass gasifier – internal combustion engine system by considering three aspects: thermo-chemical conversion of biomass into producer gas, removal methods for tar formed during conversion and finally the use of syngas as fuel in internal combustion engines.

The literature already presents similar reviews, and some books have been published that already contain some of the material presented in this work. The review is suppose to be related to systems that combine gasification with internal combustion engines, however, most of the paper is dedicated to gasification, where most of the reviews are already available, and only the last short section is dedicated to Gasifiers engine systems.

The conclusions drawn by the authors are very generic, and do not appear to contribute significantly to knowledge already in this field. Some of the available literature are also not mentioned in the paper.

## International Journal of Sustainable Engineering

**Decision Letter (TSUE-2020-0036)****From:** TSUE-peerreview@journals.tandf.co.uk**To:** agung589E@akprind.ac.id**CC:****Subject:** International Journal of Sustainable Engineering - Decision on Manuscript ID TSUE-2020-0036**Body:** 27-May-2020

Dear Dr Susastriawan:

Manuscript ID TSUE-2020-0036 entitled "Biomass gasifier - internal combustion engine system: Review of literature" by Susastriawan, Anak Agung; Purwanto, Yuli; Purnomo, Purnomo that you submitted to the International Journal of Sustainable Engineering, has been reviewed. The comments of the reviewer(s) are included at the bottom of this message.

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Sincerely,  
Professor S. Rahimifard  
Editor in Chief, International Journal of Sustainable Engineering

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The conclusions drawn by the authors are very generic, and do not appear to contribute significantly to knowledge already in this field. Some of the available literature are also not mentioned in the paper.

**Date Sent:** 27-May-2020

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## Detail Response to Editor's and Reviewers's Comments

### Dear Editor and Reviewers

Thank you very much for handling and reviewing my manuscript.

I have revised the manuscript (TSUE-2020-0036) as the Editor's and the Reviewers's comments and suggestions. The revisions are colored in **Red** in the **Revised Manuscript**. Meanwhile, detail response to the editor's and reviewers's comments and suggestions are as follows:

### Reviewer: 1

#### Reviewer's comment:

Page 3. Table 1 - please change the values of HHV expressed in kcal/kg to MJ/kg.

#### Response to Reviewer's comment

I have expressed the HHV of rice husk in MJ/kg. The HHVs of the rice husk become 16.57 MJ/kg (Yoon et al. 2012) and 14.39 MJ/kg (Lin et al. 1998)

#### Reviewer's comment:

Page 11. Authors state that "The effective equivalence ratio for biomass gasification lies from 0.2 to 0.4." The value of equivalence ratio less than 1 means that the air/fuel mixture is rich in air. In the gasification process the value of equivalence ratio should be more than one. Additionally, the equation 12 is definition of excess air ratio not equivalence ratio. Please change it to the correct form.

The equivalence ratio is equal to  $[A/F]_{stoichiometric}/[A/F]_{actual}$ .

#### Response to Reviewer's comment

I have revised the definition and the equation of the equivalence ratio. The revision is as follows Equivalence ratio is a ratio between air to fuel ratio stoichiometric and air to fuel ratio actual. Since the gasification is a thermochemical process with very less amount of oxidizer, the equivalence ratio should be more than unity (rich mixture). The equivalence ratio is calculated using Eq. (11)

$$\phi = \frac{[A/F]_{st}}{[A/F]_{act}} \quad (11)$$

where  $\phi$  is the equivalence ratio,  $[A/F]_{st}$  and  $[A/F]_{act}$  are the air to fuel ratio stoichiometric and the air to fuel ratio actual.

**Reviewer's comment:**

Page 12. Equation 15, the description of "mf/t" is missing

**Response to Reviewer's comment**

I added in the description of Eq (15) and Eq (16) as Meanwhile, the term of  $\frac{m_f}{t}$  is defined as the feedstock consumption rate (kg/s)

**Reviewer's comment:**

Page 12. Similar mistake like on page 11. Authors state that "Temperature of gasification temperature is influenced by  $\emptyset$ . Temperature of gasification enhances as  $\emptyset$  increases (Guo et al. 2014). By expanding equivalence ratio, oxygen availability increases, results in enhancing oxidation process and releasing more heat." In fact the increase of equivalence ratio causes to less oxygen availability to the biomass. What finally the authors are going to discuss equivalence ratio or excess air ratio? Please use correct information in whole manuscript.

**Response to Reviewer's comment**

The revision has been made as:

Temperature of gasification temperature is influenced by equivalence ratio. Temperature of gasification enhances as equivalence ratio decrease. From Eq. (11) it can be shown that more air is used in the gasification with reducing equivalence ratio. More air used means that oxygen availability increases, results in enhancing oxidation process and releasing more heat.

**Reviewer: 2****Reviewer's comment:**

The authors propose a literature review on biomass gasifier – internal combustion engine system by considering three aspects: thermo-chemical conversion of biomass into producer gas, removal methods for tar formed during conversion and finally the use of syngas as fuel in internal combustion engines.

The literature already presents similar reviews, and some books have been published that already contain some of the material presented in this work. The review is suppose to be related to systems that combine gasification with internal combustion engines, however, most of the paper is dedicated to gasification, where most of the reviews are already available, and only the last short section is dedicated to Gasifiers engine systems.

**Response to Reviewer's comment**

I have added more discussion in gasifier-engine system. The additional discussion are:

Modification of the intake system of either SI or CI engine is required when the engine is fueled with a producer gas. Reed and Das (1988) used the gas mixer to replace the liquid-fuel carburetor. The gas mixer behaves like liquid-fuel carburetor in which the producer gas and atmospheric air mix in correct ratio. Venturi type gas mixer with throat diameter of 25 mm was used to supply proper mixture of producer gas and air required for the engine (Homdoug et al. 2015). The producer gas mixer must mix a proper ratio of air with the producer gas,

approximately a 1:1 ratio of fuel to air by volume (Reed and Das, 1988). Since the composition of a producer gas fluctuates during the process, the combustion properties of the producer gas also alter that affect performance of the engine. In order to an effective operation of the engine. Babu, Clement, and Rajan (2019) proposed the air-gas regulator (AGR) for a 2.2 kW engine. This regulator aimed to regulate the amount of fuel flow according to engine load. The regulator was attached before the carburetor. To support required engine load, an adequate port diameter has to be appropriate selected for ensuring sufficient fuel flow. The required air-fuel ratio is set in carburetor. Many gasifier- IC engine systems have been successfully developed worldwide. Roy, Datta, and Chakraborty (2013) and Zainal *et al.* (2002) reported their work in developing gasifier-engine system fed by furniture waste and wood chip, respectively. Meanwhile, a small-scale rice husk gasifier-IC engine system has been reported by Yoon *et al.* (2012).

**Reviewer’s comment:**

The conclusions drawn by the authors are very generic, and do not appear to contribute significantly to knowledge already in this field. Some of the available literature are also not mentioned in the paper.

**Response to Reviewer’s comment**

The conclusion is redrawn in more specific manner. The conclusion becomes:

1. Biomass gasification is a promising renewable energy conversion technology to utilize biomass energy into useful producer gas for internal combustion engine.
2. Besides gasifier design, performance of a gasifier is affected by various operating parameters, i.e. feedstock size and properties, gasification medium, equivalence ratio, and gasification temperature. Performance of a gasifier can be evaluated in terms of combustible and heating value of a producer gas, tar content in a producer gas, and cold gas efficiency of a gasifier.
3. Typically, a downdraft gasifier produces a low tar content producer gas. However, tar removal is still required when a producer gas is used as a fuel of internal combustion engine. Tar content in a producer gas must less than 100 mg/Nm<sup>3</sup> when a producer gas is used for fueling an internal combustion engine
4. Tar removal of a producer gas can be done by primary method or secondary method. Primary method removes a tar inside the gasifier’s reactor (in-situ) and secondary method removes a tar downstream the reactor.
5. Modification of an intake system of either a Spark Ignition or a Compression Ignition engine is required when the engine is fueled with a producer gas. In order to get proper

mixing between a producer gas and an atmospheric air, a liquid-fuel carburetor is replaced by a gas mixer or by attaching air-gas regulator before the carburetor.

- Several additional of the previous works have also been added, especially in gasifier-IC engine system. The additional references are:

Babu M.S., S. Clement, N.K.S. Rajan. 2019.” Adaptation of Air-Gas Regulator for Small Capacity Producer gas Engine.” *Energy Procedia* 156 (2019): 435–441.

Homdoug N., N. Tippayawong, N. Dussadee. 2015.” Performance and emissions of a modified small engine operated on producer gas.” *Energy Conversion and Management* 94: 286–292.

Roy PC, Datta A, Chakraborty N. 2013.”An assessment of different biomass feedstocks in a downdraft gasifier for engine application.” *Fuel* 106:864–868.

Zainal Z.A., A. Rifau, G.A. Quadir, K.N. Seetharamu. 2002. “Experimental investigation of a downdraft biomass gasfier.” *Biomass and Bioenergy* 23: 283 – 289.



Anak Agung <agung589e@akprind.ac.id>

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## International Journal of Sustainable Engineering - Decision on Manuscript ID TSUE-2020-0036.R1

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**International Journal of Sustainable Engineering** <onbehalf@manuscriptcentral.com> Thu, Sep 3, 2020 at 4:39 AM  
Reply-To: TSUE-peerreview@journals.tandf.co.uk  
To: agung589E@akprind.ac.id

02-Sep-2020

Dear Dr Susastriawan:

Ref: Biomass gasifier - internal combustion engine system: Review of literature

Our referees have now considered your paper and have recommended publication in International Journal of Sustainable Engineering. We are pleased to accept your paper in its current form which will now be forwarded to the publisher for copy editing and typesetting.

You will receive proofs for checking, and instructions for transfer of copyright in due course.

The publisher also requests that proofs are checked and returned within 48 hours of receipt.

Thank you for your contribution to International Journal of Sustainable Engineering and we look forward to receiving further submissions from you.

Sincerely,  
Professor S. Rahimifard  
Editor in Chief, International Journal of Sustainable Engineering