A revive: on Burners used for burning of Gas/kerosene and its performance characteristics

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Abstract : Burners are of different shape and sizes available in domestic use. The efficient burning of fuel is the key factor and complete combustion of fuel will produce smokeless flame. The shape of jet from which fuel is injected can be modified which improves combustion process. In this paper the research work done is studied and made available to further experimentation. Efficiency of burner and combustion process can be improved with certain changes which are also discussed. In this paper the various literature available on burners are compared and the issues with burning of fuel is discussed with survey.

IndexTerms **- Burner, Smokeless flame, combustion process.**

I. Introduction

It was reported by the World Heath Organisation in 2002 that more than two billion people worldwide continue to depend on solid fuels, including, wood, animal waste, agricultural residues and coal, for their energy needs. Utilising such sources to meet cooking and space heating requirements results in high levels of indoor air pollution being produced. Indoor air pollution as the name suggests is caused by the burning of fuel indoors, and can even be polluted from kerosene lamps. The majority of the problem however is the result of smoke back drafted from stoves or in the most extreme case produced from an open fire where no attempts have been made to extract the smoke produced. It can be seen that indoor air pollution is a global problem, however its most significant effects can be witnessed in developing world countries where open fires and cookstoves are still widely used and furthermore heavily depended upon for cooking and space heating needs.

The hazardous effects of indoor air pollution are a result of incomplete combustion, and the resulting wide range of pollutants, such as small particles and carbon monoxide, produced. The fact that it has been reported by the World Health Organisation that 2.7% of the burden of global disease is a result of indoor air pollution, is an illustration of the severity of the problem.[1]

Proper burning of fuel will gives smokeless flame. Hence design of burner must be improved in case of kerosene/gas stove.

II Literature Review

Vibhor Mehrotra, Philip Diwakar, Rimon Vallavanatt, "Troubleshooting Furnace Operations Using Computational Fluid Dynamics": In particular, combustion, flames, flares and chemical reaction are of interest because of the physics and the complex nature of the process. Two applications are presented in this paper to demonstrate the use of CFD modeling for improving furnace operations. The first concerns improvements in reboiler operation by changing burner arrangement. A three-burner arrangement has resulted in tube burnout in the past. CFD modeling suggested a four-burner arrangement is better. The recommendation was accepted and implemented by the refinery in 2002. Feedback from the refinery suggests a much cooler furnace operation is observed in the field. The second application concerns predicting Coker furnace operation of as yet uninstalled heater. The Coker radiant section is modeled with 4 burners. Predicting the impact of burner-burner interaction on the radiant heat flux helps in determining the time period for decoke. Several mitigation steps are suggested to increase the run length between decoking intervals. [1]

Catharine TIERNEY, Susie WOOD, Andrew T. HARRIS and David F. FLETCHER, "COMPUTATIONAL FLUID DYNAMICS MODELLING OF POROUS BURNERS": Porous burners offer potential for ultra-lean methane emission mitigation by combustion. In these systems heat recirculation between the porous medium and the fuel stream leads to enhanced combustion behaviour. In this research convective and radiative heat transfer models were added to the commercial computational fluid dynamics (CFD) code ANSYS CFX, to describe the interaction between the porous solid and the fluid. In addition a relatively detailed skeletal chemistry mechanism was incorporated and a stiff chemistry solver was used to provide an accurate assessment of the combustion behaviour. This paper describes the model basis, the skeletal kinetic mechanism and presents example results. The strategy used to obtain converged results from this highly coupled system is also discussed. [2]

Hassan Ali and Terence Tang Jia Wei, "CFD Study of an Improved Biomass Cookstove with Reduced Emission and Improved Heat Transfer Characteristics": In this paper, in an effort towards reducing indoor air pollution (IAP) exposure for cookstove users, an improved nbiomass cookstove has been proposed. A computational fluid dynamics (CFD) combustion study has been carried out for the proposed cookstove to analyze the combustion and heat transfer behavior using ANSYS Fluent Simulation. The wood combustion phenomenon inside the stove is modelled as gaseous combustion of volatiles generated by pyrolysis. Temperature gradients, velocity profiles and combustion product concentrations are presented. Based on comparison of CFD predicted results with a popular commercial improved cook stove (ICS), it was concluded that the proposed cook stove yields reduced combustion product concentrations as well as faster cooking resulting in better energy efficiency and a health friendly cook stove.[3]

M. D'Amico*, U. Desideri** and F. Fantozzi, "CFD SIMULATION OF A BURNER FOR SYNGAS CHARACTERIZATION: PRELIMINARY RESULTS ANDEXPERIMENTAL VALIDATION": Furner for syngas combustion and LHV measurement through mass and energy balance was realized and connected to a rotary-kiln laboratory scale pyrolyzer at the Department of Industrial Engineering of the University of Perugia. A computational fluid dynamics (CFD) simulation of the burner was carried out to consider thermal inertias and heat ransfer constraints and to investigate temperature and pressure distribution, and distribution of the combustion products and by products. The simulation was carried out using the CFD program Star-CCM+. Before the simulation a geometrical model of the burner was built and the volume of model was subdivided in cells. A sensibility analysis on the number of cells was carried out to estimate the approximation degree of the model. The model was validated with experimental data on propane combustion and the comparison between numerical results and experimental data provided useful information for research. [4]

Moh, Kenechukwu David, "The Design and Construction of a Portable Kerosene Pressure-Cooker": This paper dealt with the design and construction of a portable kerosene pressure-cooker. The existing cookers and the problems associated with them were analyzed. The need and importance of this work were also high highlighted. The design consists of three parts: the cylinder, the piping, and the frame. The R-12 refrigerant cylinder was redesigned to suit the kerosene cylinder, since it has the desirable features for that purpose. Using the principles of fluid dynamics, this work was able to establish that the power of the cooker is 179.922KW, and that under a constant pressure of IMPa the cooker will discharge and burn 1 litre of kerosene in 3.5 minutes giving out an enormous heat energy of 38.2MJ [5]

Md Ehsan a, *, Manabendra Sarker a , Rifath Mahmud a , Paul H Riley b, "Performance of an Electricity-Generating Cooking Stove with Pressurized Kerosene Burner": The cooking stove design was adapted to meet performance needs such as: heating rate, cooking efficiency, energy distribution, electric power generation, exhaust emissions and time taken to boil water using standardised water boiling tests. Performance was also compared with conventional (non-electrically generating) stoves that use a pressurised kerosene burner. A stove suitable to be demonstrated was developed to obtain feedback from some end-users for evaluation. Effects of the technical changes to the stove required for field trials and laboratory experimental results are presented. Technical deficiencies are documented and recommendations for improvements and future research in order to obtain wider end-user acceptance are made. [6]

Gaurav Jambhulkar, Vibhor Nitnaware, Manisha Pal, Neha Fuke, Purva Khandelwal, Pallavi Sonule, Sneha Narnawre, V. P. Katekar, "Performance Evaluation of Cooking Stove Working on Spent Cooking Oil": This paper deals with the use of spent cooking as a fuel in kerosene stove In order to avoid the reuse of spent cooking oil for cooking which has adverse effects on the health of human being, corrective steps are needed to be taken. With an approach of alternative fuel for kerosene pressurized cooking stove, blends of kerosene and spent soya bean cooking oil of various propor- tions have been prepared. These samples were tested one by one in an existing kerosene pressurized cooking stove at various pres- sures. From the study, it has been found that at 1.5 bar pressure, efficiency of 50% proportion of spent soya bean oil with 50% proportion of kerosene is better than pure kerosene.[7]

Aruna Devadiga 1 , Prof. Dr. T. Nageswara Rao 2, "Optimizing Bunsen burner Performance Using CFD Analysis": The present work has attempted to establish the validity of the Computational results by conducting appropriate experiments. The first series of simulations were done for proper mixing of fuel-air in the mixing chamber of burner. These were done for different mass flow rates of the fuel. Variation in the mass flow rates resulted in variation of the flame lengths, flame velocity, and temperature profiles across the flame. The second stage included the modelling and meshing of the combustion zone(assumed to be cylindrical in shape) with different number of grid points to check the accuracy of the mesh and also to see the variation in the results obtained from solver. The results obtained from the mixing chamber are the values which are input to the combustion chamber.[8]

M.R. Ravi, Sangeeta Kohli and Anjan Ray, "Use of CFD simulation as a design tool for biomass stoves": This paper presents an approach in which detailed CFD simulations of the flow, heat transfer, pyrolysis and combustion in the configuration of a simple sawdust stove are used to evolve simple algebraic equations that describe individual phenomena. Such equations are needed in the field for performance analysis and prediction, and could also be used for the optimization of stove geometry for performance. The paper describes the development of the building-blocks of the detailed simulation model and its use in the derivation of simple model equations relating design and performance parameters.[9]

Mukund Y Pande 1 , Suraj Patil 2 , Kunal Desale 3 ,Ganesh Rajput 4 , Kunal warke 5 , Ashish Patil 6, "Experimental Investigation on Pressure Stove with Different Blends of Fuel": From this report the effect of bio-fuel on stove efficiency, flame intensity, durability and the corresponding effect factors are surveyed in details. While for some "improved" stove fuel combinations, the increase in flame intensity is studied. In normal horizontal pressure stove the copper coil is incorporated to absorb the heat radiated through burner to heat up the blend to control its viscosity. [10]

Bezuayehu Mulugeta 1* , Derese T. Nega 2, Shewangizaw W. Demissie 3, "Design, Optimization and CFD Simulation of Improved Biogas Burner for 'Injera' Baking in Ethiopia":To get optimum cooking heat distribution of injera baking burner optimum design size, number of holes on burner, proper mixing of air and fuel flow rate was analyzed in this study. From the result obtained it is concluded and proposed that the optimum burner manifold diameter is 26cm. Therefore, it is believed that, the study will pave the actual fabrication of the improved biogas injera baking stove and attempts to improve the life style of energy poor peoples in urban and rural areas of Ethiopia through reduction of traditional inefficient biomass burning. [11]

P.L.Navaneetha krishnan 1 M.K.Sathish Kumar 2 B.Charles 3 N.Udhaya kumar 4, "Bio-Diesel Burner Design for Rural Thermal Application": In this paper contains the work for designing biodiesel burning pressure stove. This pressure stove can reduce the dependency on fossil fuels. This paper contains experiments and results that deal with comparison of kerosene stove and biodiesel. The design of the biodiesel burner was proposed in this paper. [12]

Md Ehsan 1 , Manabendra Sarker 1 , Rifath Mahmud 1 , Paul H. Riley 2, "Performance of a Score-Stove with a Kerosene Burner and the Effect of Pressurization of the Working Fluid": This paper deals with the modification in design of kerosene stove. With the modification 18% thermal efficiency is increased. The modification is done in Bangladesh University of Engineering and Technology ((BUET). Results are compared and calibrated with actual performance. The validation of thermal performance is done with practical performance and tests which are conducted on modified stove. [13]

S Kakati 1 *, P Mahanta 1 and S K Kakoty 2, "Performance analysis of pressurized kerosene stove with porous medium inserts": Performance evaluation has been carried out of BIS high-pressure kerosene stove incorporating porous medium technology (PMT) in conventional burners. Burners with and without porous material were used for the study in terms of thermal efficiency, kerosene consumption rate and emission. Overall fuel saving was found to be 103 g/h (34%) with increase (10-11%) in thermal efficiency. Similarly, emission factors for pollutants CO (% vol), HC (ppm) and NOx (ppm) were controlled in the range of 32%, 15% and 83% respectively with PMT. Flames stabilized within the port of porous structure due to internal heat feedback of burned gases to unburned gases by radiation and conduction. [14]

Tafadzwa Makonese a, b, c , Crispin Pemberton-Pigott b , James Robinson a, b , David Kimemia a, b , Harold Annegarn a, "Performance evaluation and emission characterisation of three kerosene stoves using a Heterogeneous Stove Testing Protocol (HTP)": In this study, three kerosene stoves including two wick stoves and one pressurised stove were tested for thermal performance and CO gas emissions using the Heterogeneous stove Testing Protocol (HTP) developed at the SeTAR Centre, University of Johannesburg. Results from the testing showed that the diameter of the pot had little effect on the performance of the tested kerosene stoves in terms of CO emissions, but it did have an effect on the thermal efficiency at the high power setting. Power setting was found to influence the thermal efficiency and combustion performance of all stoves tested, indicating the need for assessment of the appliances across the full range of power settings (where feasible)[15]

Mr. Prashant Jadhav 1 and Prof. D. S. S. Sudhakar 2, "Analysis of Burner for Biogas by Computational Fluid Dynamics and Optimization of Design by Genetic Algorithm": This paper aims to design burner suitable for domestic cooking which will use biogas as a fuel. To get maximum output from burner optimum design of burner is require. The optimum design aims to optimum dimensions, optimum number of holes on burner, proper mixture of air and fuel and most important the optimum fuel flow rate. For that Computational Fluid Dynamics is used to simulate combustion of biogas on burner and Genetic Algorithm is used to optimize design of burner. The numerical simulation results verified with other researches done by expert persons and data available in various sources. Development of such burners leads to more efficient use of biogas without its waste. This technology is very less costly which will be helpful for poor people of urban and rural part. [16]

Gyan Sagar Sinha, "Development and Performance Analysis of Self-Aspirated Porous Radiant Burners for Kerosene Pressure Stove": The present work, addresses this issue through the development of self-aspirated porous radiant burners (PRB) for kerosene pressure domestic stoves. The present work utilizes the principles of PMC for the development of kerosene pressure cooking stoves. For domestic cooking, burner power in the range of 1.5 – 3 kW is developed. The developed cooking stoves with PRB are stand-alone systems. [17]

III OBJECTIVE OF STUDY

- To learn various types of burners available.
- To understand design improvements to be done to provide smokeless flame.
- Comparison of burners on the basis of efficiency, burning process and design.
- To understand modification possible in case of burner.
- To study of advances burners available.
- To learn design characteristics of burner.

IV SCOPE OF STUDY

- Smokeless flame can be achieved in case of kerosene burner.
- Complete combustion of kerosene with improved thermal efficiency can be achieved.
- Information generated from this review will can be utilized for kerosene/gas burner study and modification.
- Different types of Solar kerosene/gas burner are explained by this review, which gives another dimension for further study.

V OUTCOMES FROM LITERATURE REVIEW

- Jet modification is to be focused to achieve better results.
- Study on kerosene stove burner and its CFD analysis may produce better results of fuel combustion and smokeless flame.
- Authors have focused on smokeless flame and effective combustion of fuel.
- Various types of burners are available which gives better performance and it may improve efficiency.
- Porous burners are also a better option to improve thermal efficiency of burning process.

VI CONCLUSION

- The detailed study on burners is done which needs to improve efficiency of burner and produce smokeless flame.
- Porous burners, jet type burners are the effective burners.
- CFD analysis of burning process shows the turbulence in burning , hence the efficiency can be improved.
- Burners are having less maintenance and need less calibration.

VII REFERENCES

[1] Vibhor Mehrotra, Philip Diwakar, Rimon Vallavanatt, "Troubleshooting Furnace Operations Using Computational Fluid Dynamics", ASME PVP 2004, July 25-29, 2004

[2] Catharine TIERNEY, Susie WOOD, Andrew T. HARRIS and David F. FLETCHER, "COMPUTATIONAL FLUID DYNAMICS MODELLING OF POROUS BURNERS", Seventh International Conference on CFD in the Minerals and Process Industries CSIRO, Melbourne, Australia, 9-11 December 2009

[3] Hassan Ali and Terence Tang Jia Wei, "CFD Study of an Improved Biomass Cookstove with Reduced Emission and Improved Heat Transfer Characteristics", Journal of Clean Energy Technologies, Vol. 5, No. 6, November 2017

[4] M. D'Amico*, U. Desideri** and F. Fantozzi, "CFD SIMULATION OF A BURNER FOR SYNGAS CHARACTERIZATION: PRELIMINARY RESULTS ANDEXPERIMENTAL VALIDATION", 18th European Biomass Conference and Exhibition, 3-7 May 2010, Lyon, France

[5] Moh, Kenechukwu David, "The Design and Construction of a Portable Kerosene Pressure-Cooker", An International Multi-Disciplinary Journal , Ethiopia, Vol. 4 (2) April, 2010

[6] Md Ehsan a, *, Manabendra Sarker a , Rifath Mahmud a , Paul H Riley b, "Performance of an Electricity-Generating Cooking Stove with Pressurized Kerosene Burner", 6th BSME International Conference on Thermal Engineering (ICTE 2014), Procedia Engineering 105 (2015) 619 – 627, www.elsevier.com/locate/procedia

[7] Gaurav Jambhulkar, Vibhor Nitnaware, Manisha Pal, Neha Fuke, Purva Khandelwal, Pallavi Sonule, Sneha Narnawre, V. P. Katekar, "Performance Evaluation of Cooking Stove Working on Spent Cooking Oil", International Journal of Emerging Science and Engineering (IJESE), ISSN: 2319–6378, Volume-3 Issue-4, February 2015

[8] Aruna Devadiga 1 , Prof. Dr. T. Nageswara Rao 2, "Optimizing Bunsen burner Performance Using CFD Analysis" ternational Journal of Modern Engineering Research (IJMER), Vol. 3, Issue. 5, Sep - Oct. 2013 pp-2773-2785

[9] M.R. Ravi, Sangeeta Kohli and Anjan Ray, "Use of CFD simulation as a design tool for biomass stoves", Department of Mechanical Engineering, Indian Institute of Technology, Hauz Khas,New Delhi 110 016, India, Energy for Sustainable Development, Volume VI No. 2, June 2002

[10] Mukund Y Pande 1 , Suraj Patil 2 , Kunal Desale 3 ,Ganesh Rajput 4 , Kunal warke 5 , Ashish Patil 6, "Experimental Investigation on Pressure Stove with Different Blends of Fuel",
IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 4 Ver. I (Jul. – Aug. 2017), PP 61-68, www.iosrjournals.org

[11] Bezuayehu Mulugeta 1* , Derese T. Nega 2, Shewangizaw W. Demissie 3, "Design, Optimization and CFD Simulation of Improved Biogas Burner for 'Injera' Baking in Ethiopia", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 6 Issue 01, January-2017

[12] P.L.Navaneetha krishnan 1 M.K.Sathish Kumar 2 B.Charles 3 N.Udhaya kumar 4, "Bio-Diesel Burner Design for Rural Thermal Application", IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 09, 2016 | ISSN (online): 2321-0613

[13] Md Ehsan 1 , Manabendra Sarker 1 , Rifath Mahmud 1 , Paul H. Riley 2, "Performance of a Score-Stove with a Kerosene Burner and the Effect of Pressurization of the Working Fluid", Journal of Power and Energy Engineering, 2015, 3, 458-466, Published Online April 2015 in SciRes. http://www.scirp.org/journal/jpee, http://dx.doi.org/10.4236/jpee.2015.34063

[14] S Kakati 1 *, P Mahanta 1 and S K Kakoty 2, "Performance analysis of pressurized kerosene stove with porous medium inserts", Journal of Scientific & et Industrial Research, Vol. 66, July 2007, pp. 565-569

[15] Tafadzwa Makonese a, b, ⁎ , Crispin Pemberton-Pigott b , James Robinson a, b , David Kimemia a, b , Harold Annegarn a, "Performance evaluation and emission characterisation of three kerosene stoves using a Heterogeneous Stove Testing Protocol (HTP)", Energy for Sustainable Development 16 (2012) 344–351, Contents lists available at SciVerse ScienceDirect

[16] Mr. Prashant Jadhav 1 and Prof. D. S. S. Sudhakar 2, "Analysis of Burner for Biogas by Computational Fluid Dynamics and Optimization of Design by Genetic Algorithm", INTERNATIONAL JOURNAL FOR RESEARCH IN EMERGING SCIENCE AND TECHNOLOGY, VOLUME-2, ISSUE-7, JULY-2015

[17] Gyan Sagar Sinha, "Development and Performance Analysis of Self-Aspirated Porous Radiant Burners for Kerosene Pressure Stove", Department of Mechanical Engineering Indian Institute of Technology Guwahati, Guwahati – 781039, India, November 2017

[18] Cristiano V. da Silva, Maria Luiza S. Indrusiak, Arthur B. Beskow, "CFD Analysis of the Pulverized Coal Combustion Processes in a 160 Mwe Tangentially-Fired-Boiler of a Thermal
Power Plant", CFD Analysis of the Pulverized Coal Combustion Processes in a 160 MWe Tangentially-Fired-Boiler of a Thermal Power Plant

[19] Valerio Battaglia 1 , Francesco Crippa 1 , Enrico Malfa 1 , Massimiliano Fantuzzi 2, "CFD for Flameless Burners Development", 31st Meeting on Combustion, 1. Centro Sviluppo Materiali – Italy, 2. Tenova LOI Italimpianti - Italy