INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Performance and Feasibility Assessment of Porous Radiant Burner Aided Cook-stoves for LPG, Biogas and Waste Cooking Oil Fuels**

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SHORT ABSTRACT

Currently, 3 billion people lack access to clean-cooking and are exposed to dangerous levels of air pollution. India's cooking scenario indicates that only 43.8% of households use clean cooking fuel. Commercially available gaseous and liquid fuel cook-stoves in India are characterized by Free Flame Combustion (FFC) in which the combustion takes place in open air environment, and convection is the main mode of heat transfer. Research works reported on the development of energy efficient cook-stoves includes the use of Porous Media Combustion (PMC) technology, in which instead of combustion in the gaseous environment, like in the FFC, fuel is made to combust in a highly conducting and radiating porous matrix. Owing to enhanced heat transfer, thermal efficiency goes up, and emissions of CO and NO_x comes down. Recently naturally aspirated cook-stoves with Porous Radiant Burners (PRBs) were developed using LPG and kerosene for domestic as well as medium scale cooking applications. It was observed that the commercial applicability and detailed cooking performance assessment of these developed cook-stoves were lacking. It was also observed from the literature that no research works were carried

out on the development of naturally aspirated cook-stove with PRBs for alternate cooking fuels viz., biogas and waste cooking oil. This necessitated the need to search for design modifications in the developed LPG cook-stoves with PRB for its commercialization, and also to develop cook-stoves for biogas and waste cooking oil as alternative options.

Control Cooking Test (CCT) on domestic scale PRB cook-stove shows a fuel savings of approximately 93.27 g per day per household. Cooking time saving of approximately 51 min explains the extent to which time budgets can be affected by cook-stove with PRB. Investigation on medium scale LPG operated PRB based cook-stoves shows that it has a surplus of 7% Life Cycle Energy Efficiency for input power of 5 kW which further rises to 11.6% for 10 kW. With reference to the functional unit tested at IIT Guwahati, the life cycle cost can be reduced to a great extent with an annual saving of ₹43,192 /- and ₹73,831 /- when compared to CB at 5 and 10 kW, respectively.

Further, investigation was focused on overcoming the shortcomings of existing PRB designed for medium scale LPG cook stove. Newly designed burner works with unreduced pressure regulator (commercially feasible) and results in maximum thermal efficiency of 64.49%. With the improved design, significant amount of LPG was saved (30-45%) and the measured emissions were found lower than the conventional burner. As the developed stove works on the natural draft, it is ideally suited for replacement of conventional medium scale LPG cook-stove.

The work contained in the development of biogas cook-stove has been carried out in two parts. First, from forced air supply the range of biogas flame stability limit (equivalence ratio) in two-layer PRB is found as 0.75-0.95 for domestic power range. Second, with self-aspirated PRB design about 22% improvement in thermal efficiency was observed. CO emissions are found as 36-48 ppm with self-aspirated PRB, whereas same is 235-276 ppm in case of CB. Similarly, NO_x emissions are always found lower than 2 ppm in PRB whereas the same is 15 ppm in case of CB.

Present investigation also demonstrates a comparative study of combustion characteristics of WCO in a conventional kerosene pressure stove (CKPS) and a newly developed pressure stove with PRB (PKPS), with the following specific objectives. Maximum of 50% WCO and kerosene blend combustion can be sustained in both the test stoves. At condition of maximum blending (50% WCO), maximum ~9% improvement of thermal efficiency is found in case of PKPS. The

newly developed PKPS reduces CO and NO_x emission by 50-60% and 74-83%, respectively. From CCT it has been found that, on per day basis, PKPS results in 49 minutes and ~59% saving in cooking time and fuel consumption, respectively, as compared to CKPS. Techno-economic Assessment (TEA) indicates that, in a span of 10 years, PKPS can offer a sum of ₹16,817 as net present worth of savings.