INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Development and Performance Analysis of Self-Aspirated Porous Radiant Burners for Kerosene Pressure Stove**

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SHORT ABSTRACT

In the rural part of India or any other developing and under developed nation, people use biomass and kerosene for cooking application because of the low cost as compared to LPG. The thermal efficiency of biomass is about 5 – 10 %. Severe usage of biomass not only lead to deforestation, but also create an imbalance of natural resources in the ecological system. Though, LPG is a clean fuel when compared to other fuels for cooking purpose, due to its high cost and less accessibility in remote areas, people in the rural areas cannot afford LPG. Hence, due to the low cost and easy availability of kerosene, low-income group people in rural, suburban and urban areas can certainly utilize kerosene for the cooking applications. Average thermal efficiency of pressure kerosene stove is 45 %. Kerosene stoves release huge amount of CO and NO_x emissions in the form of exhaust because of its incomplete combustion. Therefore, it is of vital importance to incorporate modifications in the design of kerosene pressure stove. The main purpose of the design modifications is to utilise the input energy to the maximum possible extent and to minimize the pollutant emissions. A conventional combustion device is associated with free-flame wherein the combustion takes place in the open-air environment, in which convection heat transfer is dominant. Free flame combustion comes with very low thermal conductivities and emissivities, so in conventional combustion devices, contributions of conduction and radiation is insignificant. Thus, due to poor heat transport, these devices are less efficient, and they have undesirable features such as low power density, high level of pollutant emissions, etc.

Conventional kerosene pressure stoves fall under this category. Performance of biomass stove when compared to LPG and kerosene stove is very low. Since the last decade, depending upon the economic conditions of the people, there has been a gradual shift from the usage of biomass to kerosene or LPG fuels. In kerosene stove, a premixed air-fuel mixture combust in the gaseous (air) environment and the flame stabilizes over the metallic burner head. The measured thermal efficiencies (laboratory conditions) of the conventional domestic kerosene pressure cooking stoves (1.5 – 3 kW) available in the Indian market are in the range of 48.5 – 58 %. CO and NO_x emissions from conventional domestic kerosene pressure stoves (1.5 – 3 kW) are in the range of 610 ppm to 915 ppm and 19 ppm to 35 ppm, respectively. These emissions levels are above the current standards of World Health Organization. Thus, curtailment of CO and NO_x emissions further necessitates development of efficient burners for cooking applications. PMC has emerged as an important technology for reduction of emissions of CO and NO_x. In PMC, the combustion takes place within a highly conductive and radiative solid porous medium (matrix) having very large surface area. Apart from preheating of the incoming premixed fuel-air mixture, several factors such as volumetric radiation, increased conduction and convection owing to higher surface area per unit volume of the porous matrix and homogenization of temperature lead to the elongation in the volume of the reaction zone. These aspects result in a higher thermal efficiency and reduced emissions. Some researchers have extended usage of porous matrix to kerosene pressure stoves. They have reported enhanced thermal efficiency and reduced emissions. A critical review of previous studies reveals that their developments were mainly focused on the development of burners based PMC technology with the supply of compressed air and hence they could not be used for domestic cooking. The supply of compressed air is not feasible, and it is also unnecessary for the cooking applications. 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. These burners does not require any supply of external air for their operation. Design of the cooking stoves has been substantially changed to work without the supply of external air. The changes are discussed in detail in the thesis. The work contained in the thesis has been carried out in two parts. The first part of the study is dedicated to the development of self-aspirated domestic kerosene pressure cooking stove with a PRB. The development of self-aspirated PRB for kerosene pressure cooking stoves with nanoparticle-blended kerosene is the second study. To compare the improvements in terms of thermal efficiency and emissions in the developed kerosene pressure stoves, experiments were performed with both the newly developed self-aspirated (with PRB) and conventional (same power input) kerosene pressure stoves. In the first part of the study, the burner input power range considered was 1.5 – 3 kW. The combustion behaviour within the burner has been also studied with the temperature details, measured at certain radial and axial locations. Use of compressed air has been one of the major limitations in using the kerosene pressure stoves with PRB for cooking applications. To eradicate this limitation, the design modifications in terms of kerosene supply pressure, orifice, burner port, and burner casing were done. With the improved design of the burner assembly, thermal efficiency, emission characteristics and temperature distribution were studied. A significant improvement in thermal efficiency (55.5 – 64.3 %), and large reduction in emissions (CO: 180 – 290 ppm and NO_x: 1.5 – 4.1 ppm) were observed. For different power inputs, the thermal efficiency of the conventional burners was found in the range 48.5 – 58 %. This increase in thermal efficiency is attributed to the improved combustion in the PRB. Nanoparticle blended kerosene was also tested in the kerosene pressure stoves of the same power range (1.5 – 3 kW) with self-aspirated PRB and conventional burners. The thermal efficiency was found to improve significantly (58.5 – 67.1 %), and the emissions (CO: 120 – 220 ppm and NO_x: 1.2 – 3.5 ppm) also reduced considerably in the kerosene pressure stove with the self-aspirated PRB.