CHAPTER 1 INTRODUCITON

1.1 Rationale

A self-aspirating conventional gas burner (CB), as shown in figure 1.1, is widely used for small and medium scale enterprises (SMEs) in Thailand [1], especially in food industry because of their simple construction, low cost, low maintenance, rapid heating and high heating rates produced by a directly impinging flame and leading to short processing time [2-5]. As the name implies of a self-aspirating burner, wherein the combustion air or primary air is naturally entrained by momentum transfer between the high velocity of fuel jet and the ambient air rather than using an additional energy for forced flow. Although, the CB has many advantages but a thermal efficiency of the CB is relatively low about of less than 30% [6] because of a design of the CB depends on the open combustion flame, in which a large amount of heat is mainly transferred to thermal load by thermal convection [3-9]. With energy crisis in the world today when the fossil-fuel expenditure and energy price are increasing whereas the energy reserve is decreasing. A popular gas fuel is a liquefied petroleum gas (LPG) because of a clean fuel and easy to use. Especially in Thailand, the LPG consumption is increasing every year [10] as shown in figure 1. A main LPG usage device in domestic and SMEs sections is the self-aspirating gas burner [11] but the CB has a big problem that is a low thermal efficiency [6]. It causes a low efficient of LPG utilization. Therefore, an improvement of thermal efficiency of the CB will have significant impacts on decreasing the world's LPG expenditure [9, 11].

In this study our aim is to improve the thermal efficiency of the self-aspirating gas burner by porous medium technology. Three main sections are presented in this thesis. Section 1 is a concept design for new model of a self-aspirating porous medium burner (SPMB) and preliminary test to understand a fundamental phenomenon of it. Section 2 is a thermal efficiency test and pollutant emission test of the SPMB as compared with the CB. In order to increase the thermal efficiency, a heat recirculation technique is cooperated with the SPMB and combustion performance results are shown in last section.

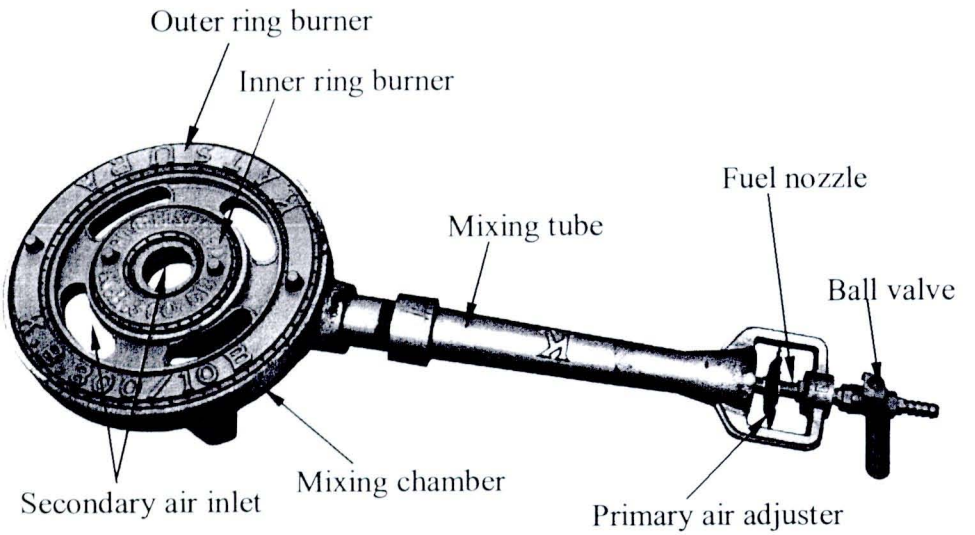

Figure 1.1 Self-aspirating conventional gas burner.

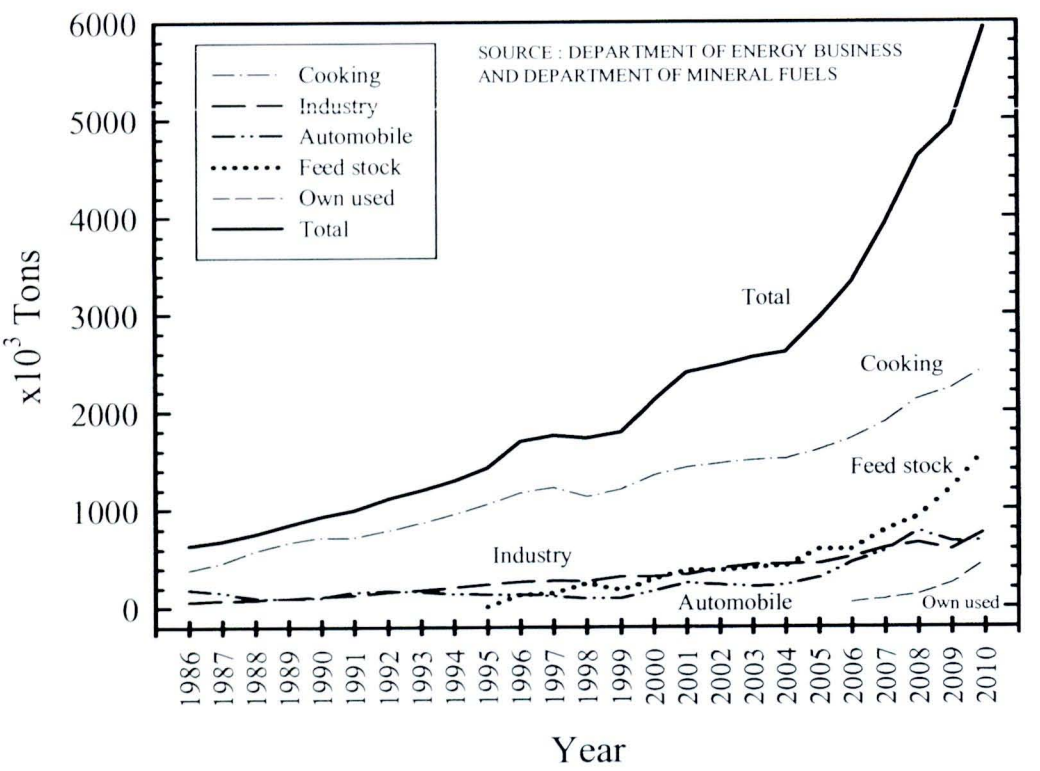

Figure 1.2 LPG consumption in Thailand [10].

1.2 Literature reviews

In view of the global effort to use our fuel resources more efficiently, the enhancement of thermal efficiency of a self-aspirating conventional gas burner (CB) can be achieved by several techniques such as changing a flow pattern of flame from radial flow to swirling central flow [12-14] and applying a heat recirculation technique within the CB [6]. The swirling central flow is enhanced the thermal efficiency of the CB by an improvement in a residence time of the hot combustion products in a vicinity of a loading vessel bottom and the central flame covers a greater heat transfer area of the loading vessel bottom in comparison with the radial flow of the CB's flame [12]. Also improvement in mixing and combustion process can be realized in the swirling central flame because of the rotating movement of the flow field. However, most of energy transferred from central swirling flame to the loading vessel bottom is mainly limited to a convection heat transfer [3-9].

Much effort has been made to enhance the heat transfer rate by employing radiative heat transfer except for the convection heat transfer as is occurred in the CB and in the swirling central flame burner. To obtain the purpose, a porous medium burner (PMB) is seemed to be the most suitable choices because of a relatively high emissivity of solid as compared with that of the gas [15].

In recent years, combustion of premixed gaseous fuels in a PMB made of a porous inert medium has received considerable attention because of exceptional advantages of the PMB compared with the CB. The PMB features a permeable core that is used to maintain stable gaseous combustion and to enhance radiation heat transfer. The PMB could be characterized into two modes [16]: (I) a burner in which the flame is anchored at the surface of the porous matrix and (II) a burner in which the flame is submerged and stabilized in the porous matrix. But the PMB with a submerged flame within a porous matrix has a higher radiant efficiency as compared with the surface-stabilized flame [17-18]. Once a premixed mixture of gaseous fuel and air flows through the PMB, a steady state submerged flame having flame temperature higher than the corresponding adiabatic value can be achieved within the PMB [19]. This is called an excess enthalpy flame [20] that allows for an internal heat recirculation from the hot products to the incoming reactant within the PMB through complex multimode heat transfer. This process of energy recovery in the PMB occurs naturally without the need

for an external heat exchanger. This internal heat recirculation results in an effective preheating of the reactants and consequently a greater increase in local super-adiabatic combustion temperature and higher rate [16, 19-21]. This allows the combustion zone temperature control, so that the emissions of the pollutants are reduced [16, 18]. The resulting burning velocity is significantly greater than the laminar flame speed [22] with the substantial increase in combustion efficiency [16, 23] and extension of the ranges of flammability and flame stability [16, 23-24]. In addition to these, flame stabilized in the PMB has shown low emissions of CO and NO_x (as low as 5 to 35 ppm and 10 to 120 ppm, respectively) [25] and high radiant efficiencies (as high as 26 to 40 percent depending on equivalence ratio) [26].

Unfortunately, very few studies had been reported on the thermal efficiency of the CB with heat-recirculating system. Jugjai and Rungsimuntuchart [6] investigated the combustion performances of self-aspirating central swirling flow gas burner with the porous heat exchanger that relies on heat recirculation principle. It was found that the thermal efficiency of the proposed burner is higher than that of a self-aspirating conventional radial flow gas burner by about of 30 percentage points (50% relative). This is a new innovation of a self-aspirating burner.

While the above-mentioned development of the PMB with a submerged flame and heat-recirculating burner using porous medium technology has been focused on the forced draft of large-scale industrial gas burners and there are not integrated in one unit, very little attention has been paid to a self-aspirating porous medium burner (SPMB) with the heat-recirculating system. Thus, the main objective of this thesis is the improvement of thermal efficiency of CB by using the porous medium technology. The results are reported in 3 parts.

Part 1 is a design and development of the SPMB with flame stabilized inside a porous matrix. Focus has been made in acquiring fundamental data in terms of temperature profiles within the burner and emissions of pollutants (CO and NO_x) for the SPMB when operating with free flame combustion. Part 2 shows the thermal efficiency and pollutant emissions of an impinging flame of the SPMB. And the last past, to enhance the thermal efficiency even more, a porous radiant recirculated burner (PRRB) from Ref. [6] is redesign to work with the SPMB. Moreover, the thermal efficiency and pollutant emissions of the CB and the SPMB are compared.

1.3 Objective

To improve the thermal efficiency of a self-aspirating gas burner with a porous medium technology.

1.4 Scope

1. The liquefied petroleum gas (LPG) in Thailand is used as a gas fuel.
2. The self-aspirating conventional gas burner (CB) in the Thailand market, which is KB-10 size, is used to compare burner performance with a new model of self-aspirating gas burner.
3. The alumina sphere and perforated stainless steel are used as a porous medium.
4. The burner performance is a thermal efficiency and pollutant.
5. The investigation of pollutant is a carbon monoxide (CO) emission and oxide of nitrogen (NO_x) emission.

1.5 Significance and Usefulness

The results obtained from a new model of self-aspirating gas burner in this study, the SPMB, have been expected to be replaceable in the Thailand SMEs with minimum modified.