CHAPTER I
INTRODUCTION

As civilizations and innovations had drawn over the last part of 19^{th} century, several types of engine were established and also developed for supporting the increase of worldwide energy demand. Even though fuel combustion based engines are currently used around the world, they are still operating with problem resulted from a large magnitude of harmful emissions being generated during the combustion process.

The use of natural gas has been considered as an alternative way to eliminate the problem on the account of their clear burn, and also abundant supply. The combustion of natural gas generates significantly higher energy per mole of "greenhouse gas" CO_2 produced when compared to other fuels (Chin and Resasco, 1999), because it contains methane, which has a high H/C ratio, as a major constituent. For example, while the combustion of methane generates 819 kJ/mol of CO_2 produced, the corresponding value for n-decane and coal (graphite), for instance, are 678 and 393 kJ/mol of CO_2, respectively. At the same time, the level of nitrogen and sulfur impurities in natural gas is much lower than in other fuels. The source of sulfur impurities is mostly from the odorant tetrahydrothiophene (THT) added to the natural gas. Moreover, the use of natural gas would avoid the possible formation of soot, which can be rather significant when, for instance, diesel fuel is combusted.

Nowadays, the modern emission regulations become more and more tighten until the homogeneous combustion of natural gas cannot reach the present emission standards. Therefore, many methodologies were developed and also applied to the combustion system in order to achieve ultra-low emissions as the regulations required. An alternative approach that has increased considerably in recent years is catalytically stabilized combustion or complete catalytic oxidation of natural gas (mostly considered as a catalytic combustion of methane since it is a major component in natural gas). This approach is based on a heterogeneous combustion or oxidation reaction on catalytic surfaces requires lower activation energy for combustion than in a homogeneous combustion. Therefore, a mixture of fuel (methane) and air below lean flammability limit can be burned and stabilized below the threshold temperature for thermal NO_X formation.

Noble metal catalysts are the most active species for performing the complete oxidation of hydrocarbons. It is known that the most active substances for total oxidation of methane are platinum group metals including palladium (Pd), platinum (Pt), and rhodium (Rh) (Sadamori, 1999). Since the catalytic properties depend on many factors, large numbers of catalytic formulas need to be tested. The conventional approach is expensive, inefficient, and requires more time to discover the formula of desired catalysts. Consequently, the development of a system allowing the activity determination of a large number catalytic formulations at the same time is required. Combinatorial catalysis and high throughput methodologies also become more and more applicable nowadays.

Combinatorial heterogeneous catalysis is a methodology or a set of tool where large diversities of solid-state materials are prepared, processed and tested for catalytic activity and selectivity in a rapid fashion (Senken, 2001). Their essential components are: (I) rapid library synthesis, (II) high throughput testing, and (III) large-scale information management. However, high throughput syntheses and screening are not expected to provide high precision data. The main goal here is lead identification.

The main purpose of this work was to investigate the lead formulas of methane combustion catalysts, aiming to reduce emissions from gas turbine engine by using combinatorial preparation and high throughput catalytic testing. In addition, the multi-flow reactor was developed to simultaneously screen and time test.