# Experimental Analysis of a Gas-Tank Water Heater with Porous Burner

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**ABSTRACT:** In this study, the effects of the porous burners and the conventional burner on the performance of gas-tank water heater have been investigated experimentally. In this experiment, a partially premixed burner with natural gas fuel is used. Four different types of the porous medium have been applied. In the Results, water temperature, flue temperature, flame temperature, emissions and combustion efficiency for different burners at various flow rates of fuel have been reported. Observation shows that the use of porous burner with 10 cm porous medium reduces the time that water temperature reaches 60 oC. Also observed that the conventional burner has the lowest flame temperature and the highest flue temperature in all of the tests. Moreover, it is showed that the burners with 10 and 5 cm porous medium have the highest flame temperature and the lowest flue temperature in all of the tests, respectively. The burner with 5 cm porous medium and conventional burner have the highest and lowest amount of carbon dioxide in all of the tests, respectively. Also, the combustion efficiency of gas-tank water heater increases about 15 percent by using the burner with 10 cm porous medium.

## 1- Introduction

Since the common fuel used in household equipment is natural gas, and considering the valuable sources of this fuel, the issue of increasing the efficiency and reducing the energy consumption of the equipment that works with this fuel seems necessary. One of the most common household equipment is the gas-tank water heater. So far, some research has been done on the gas-tank water heater, some of which are expressed.

Stilts [1] invented a thermal insulation jacket for water heaters. He used external insulation to prevent the heat loss of the water heater and reported that the thermal efficiency of the water heater increases with the use of insulation. Bartz and Carswell [2] constructed a water heater with perforated ceramic plate infrared burner. This method, using the radiation mechanism and preventing the heat loss of the exhaust gases, increases the efficiency of the heated water and reduces the production of NOx. Moeini Sedeh and Khodadadi [3] investigated numerically and experimentally the effect of a baffle on the thermal efficiency of a water heater. Their results indicated that the use of appropriate baffle at the suitable position reduces the consumption of natural gas by about 4.95%. Tavakoli and Moharramkhani [4] carried out a numerical study of the influence of a vent hood and baffles on temperature and flow field in a gas tank water heater. Their results showed that the proper position of the draft hood on the top of the flue prevents the backflow of air into the flue. Also, they reported an increase in the heat transfer to the water when using the baffles.

In the present study, the effect of using simple and cheap porous medium on the performance of gas-tank water heater performance has been investigated experimentally. The aim of this study is to improve the performance of existing gas-tank water heater with the least change in the combustion system process. An experimental study is carried out for a conventional burner, and burners with four different porous medium and discussed water temperature, flue gas temperature, flame temperature, combustion efficiency, and emissions.
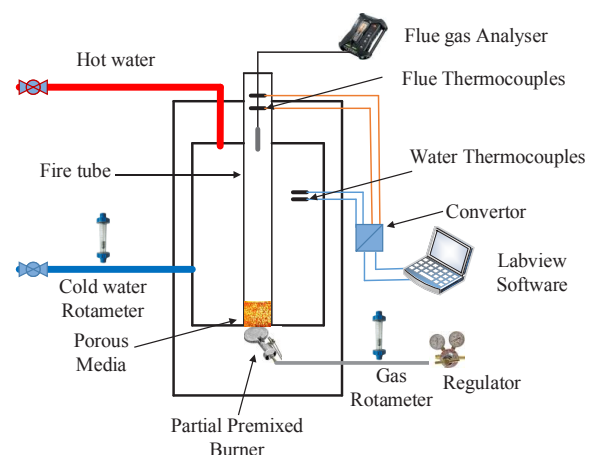


**Fig. 1. Experimental equipment**

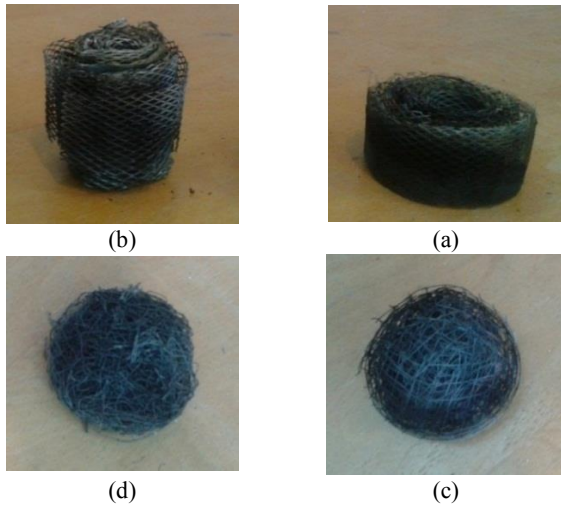*Corresponding author's email: hashemi@kashanu.ac.ir

**Fig. 2. Different porous medium tested. a) 5 cm porous medium length. b) 10 cm porous medium length. c) Low-density wired network. d) High-density wired network.**
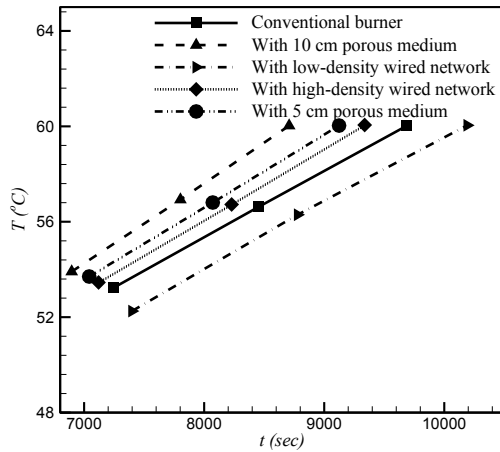


**Fig. 4. Combustion efficiency of the different burners versus flow rate of natural gas.**



**Fig. 3. Variation of water temperature with time at Q= 300 lit/hr for conventional burner and different porous burners.**



**Fig. 5. Analysis NOx for different burners.**

## 2- Methodology

The water heater studied in this study is a typical gas-tank water heater with a capacity of 155 lit. In this model, the water is collected in a cylindrical enclosure and heated through a partially premixed burner with a power of 7500 kcal/hr. Fig. 1 shows the experimental setup used in this study.

Four types of porous medium are used in this study, as shown in Fig. 2.

## 3- Results and Discussion

The effect of using porous medium on the performance of gas-tank water heater was investigated. Fig. 3 shows the water temperature versus time for different burners at Q=300 lit/hr. According to this figure, using a 10 cm porous medium, the less time is spent to bring the water temperature from 30 oC to 60 oC. This behavior shows that if this porous medium is used, the efficiency of the gas-tank water heater will be higher than other burners.
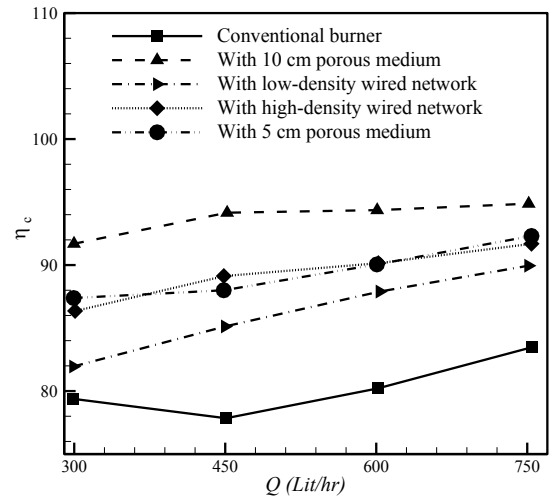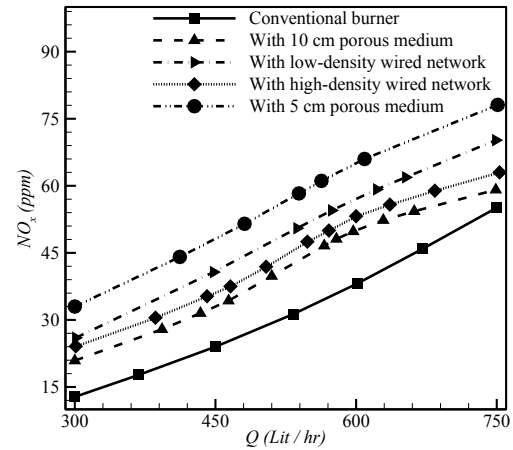
The combustion efficiency is defined as the ratio of the total energy used in the water heater system to the total fuel input energy, which is shown in Eq. (1) [5].

$$\eta_c = 1 - \left( (FT - AmbT) \times \left( \frac{0.66}{21 - \%O_2} + 0.009 \right) \right) \quad (1)$$

Fig. 4 shows the combustion efficiency of the five different burners against fuel flow rate. As can be seen in this figure, the combustion efficiency of all burners except conventional burner continuously increases with increasing fuel flow rate. Also, it is clear that the combustion efficiency of the burner with 10 cm porous medium has the highest and the conventional burner has the lowest efficiency in the fuel flow range.

The emissions of NOx for all burners is shown in Fig. 5. By increasing the fuel flow rate and consequently increasing

the equivalence ratio, the amount of NOx increases, which is due to increased temperature [6]. Also, it is observed that the conventional burner and burner with a 10 cm porous medium have the least NOx emission. In these two burners, the flue temperature is lower than that of other burners, and therefore the amount of thermal NOx is reduced.

## 4- Conclusions

In this study, using four porous burners and conventional burner, the effect of using porous medium on water temperature, combustion efficiency, and NOx was observed. The most important results are as follows:

1- The use of porous burners in a gas-tank water heater increases the combustion efficiency of a conventional burner, which is sometimes up to 15%.

2- Conventional burner and burner with 10 cm porous medium have the least NOx emission.

3- Due to the water temperature and NOx contamination, the burner with 10 cm porous medium was selected as the optimal mode.

## References

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