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Improve and reduce the economic cost and pollutants of a swirl burner

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ABSTRACT. The Arab Gulf region is rich in oil products, as Iraq is the second largest country in the Gulf with oil reserves, as Iraq exports to the world 3,500,000 million barrels per day, thus oil is the main source of energy production. However, the main challenges facing energy developers are efficiency, pollution and the economy. Therefore, this paper focused on pollution problems associated with combustion operations as well as economic costs by changing the type of fuel from diesel to liquefied petroleum gas and modifying the system to raise its efficiency and reduce emissions and cost, by setting a vane guide to make swirl fluid with a strong and coherent structure and thus a near perfect ideal few Emission of greenhouse gases at an acceptable cost compared to diesel fuel, where the economic side of the system was highlighted in terms of excessive fuel consumption, as diesel fuel consumption for the system during the whole working hour reached 24,000 Iraqi dinars, while fuel consumption with LPG reached 15,600 Iraqi dinars, thus saving 8,400 Iraqi dinars Thus, fuel consumption was reduced by 0.35%. Consequently, the improved fuel economy and environmental considerations of the external combustion system make it a sustainable choice in the energy field such as industries, power stations and all other fields.

Keywords: Equivalence ratio, Reduce pollutants, Reduce cost , Swirl burner .

INTRODUCTION

The progress made in the field of energy and treatment of combustible emissions resulting from combustion is considered the international economic standard for meeting human

requirements through clean energy sources that do not form and are totally unreliable without the need for fossil fuels, as Iraq is an oil country and has large quantities of fossil fuels, but the associated pollution problems For combustion processes, as well as excessive consumption, we decided to choose low-pollution (environmentally friendly) fossil fuels at low cost, energy and high efficiency.

At the present time, many engineers, companies and factories have used different types of fuel to reduce the excessive consumption and economic cost of fossil fuels, as well as reduce pollution resulting from combustion processes. (1). Hydrogen, ammonia, and nitrogen are considered promising fuels to produce energy and great combustion efficiency, as carbon-free and hydrogen-rich ammonia promotes clean, emissions-free fuel and thus is the clean future energy of human life (2). Liquefied petroleum gas(LPG) is considered one of the most promising energy sources that consists of alkane in addition to propane in different proportions and concentrations depending on the type of fuel, as well as it contains biotylene with low concentrations to know the leakage areas through its strong odor, and therefore it is considered one of the clean sources with less pollution compared to the heavy liquid fuels used in engines, factories and power stations(3). Swirl-stabilized combustion is the most broadly unfold deployed technology used to stabilise and control combustion in gas turbines and severa different systems. but, the interplay of the swirling flows with the burner geometries could be very complex, and it's been proved that any change within the burner geometry can have an effect on the flow field within the combustion chamber, close to the burner mouth and downstream the combustion zone. for that reason, most burners are provided with a central fuel injector that centrally delivers well-known fuels allowing the stabilisation of the system previous to operation under entirely premixed conditions. furthermore, the injector anchors the vital recirculation zone formed downstream of the nozzle (4). There are two important techniques related to the flame instability represented by the flashback in the resulting boundary layer due to the flame speed overcoming the velocity of the flowing fluid, as well as the flashback technology in the center of the resultant flame due to the collapse of the vortex resulting from the combustion that attacks the center of the burner nozzle (5). Also one of the modern technology used at the University of Cardiff to counter the flashback border using a metal micro-grid with a diameter of 50 micro inside the walls of the burner(6). Geometric technology had a great role in the stability of the flame, using three types of edge of the burner nozzle with a fixed diameter of 5 cm and different lengths, and it had an important role in drawing the flame stability map represented by the flashback and explosion limits, as well as determining the distance of the flame From the burner nozzle, which helps to protect the system from high temperature and prevents the phenomenon of self-ignition by using liquefied petroleum gas(LPG) (7–9). Pollution operations associated with combustion processes are considered one of the important challenges for the designers and engineers of external combustion systems used in many areas of energy, in the country of Bangladesh, which is famous for making boiled rice that needs 15-20% of energy and thus generates large and harmful pollution and thus high consumption of fuel and costs Necessary to complete the operation(10). Some studies used to feed a swirl burner with a mixture of methane fuel and ammonia, which revealed that emissions of nitrogen oxides(NO_x) and carbon monoxide (CO) were very low (11) . Reducing the carbon ratio depends directly on the variables and nutrients specific to external combustion systems that improve the quality of combustion and reduce harmful pollutants and thus obtain an environment free from emissions, global warming and acid rain harmful(12). Burning fossil fuels is directly and jointly linked to carbon dioxide emissions that cause global warming and climate change as low energy causes high fuel consumption and therefore a large amount of energy is lost during operation and thus requires as much as possible to reduce harmful emissions(13). In this

study, the pollution rates resulting from combustion processes were verified by using two types of fuel (LPG & DIESEL) and also compared them economically.

Experimental Work

The system used in the experimental part before making the modifications is a low energy burner with a capacity of 13 Kw/h that works on diesel fuel. The fuel pump feeds the diesel burner through a throttle at a rate of 3.5 kg per hour, and the system also contains an air blower with a flow rate of (9.5 - 11) m^3/min e that provide air to obtain a high mixing ratio to ensure combustion, where the rate of air driving is controlled automatically through Equipped voltages for the pneumatic actuator by using a (variac). In addition to that, the system contains a cylindrical burner body that consists of four parts with different diameters, as the first part has a height of 20 cm and a diameter of 13 cm that is opposite to the blower hole equipped with air, as for the second part, it is a divergent cylindrical section that starts with a diameter of 13 cm and ends with a diameter of 16 cm this part slows the flow of the mixture and thus helps to give sufficient time to complete the mixing process of the fluid and increases the pressure, for the third part of the burner body it is in the form of a converged cylindrical shape beginning with a diameter 16 cm and ends with a diameter of 10 cm. The benefit of this part is to increase the speed of the fluid mixture and thus ensure the flame ignition and maintain the formation of a strong and coherent vortex. As for the last part represented by the nozzle of the burner with a diameter of 5 cm and a variable height (5, 10, 15) cm respectively. The system contains an electrical control panel used to operate the blower and control its speed, as well as control the closing and opening of the electric valve to stop the fuel automatically in the event of any problem represented by the phenomenon of flashback to protect it from damage . In addition, the quantities of fuel supplied to the system (pre-mixing area) in the first part of the cylinder burner body are controlled by a rotometer.

In order to develop the system and make it economical, a simple modification of the system was made to make it work with gas fuel instead of diesel and without any change to the original system, as the amendment included disposal of the diesel fuel pump and replacing it with a gas outlet coming from the source and the supplied quantities are controlled through the rotometer. Work to develop a directional vane guide containing diagonal slots that give the mixture (fluid) passing through a vortex movement that leads to the acquisition of air and fuel a coherent structure that allows giving sufficient time to complete the homogeneous mixing process and be located at the end of the first part of the cylinder burner body (above the fuel and air source) as shown in figure 1.

Fig.1 Swirler vane guide

Modifications, development and testing of the system were conducted in the laboratories of the University of the College of Technical Engineering in Najaf, AL- Furat AL-Awsat Technical University under the supervision of a specialized scientific team to complete the system as required as shown in Figures 2 and 3 .

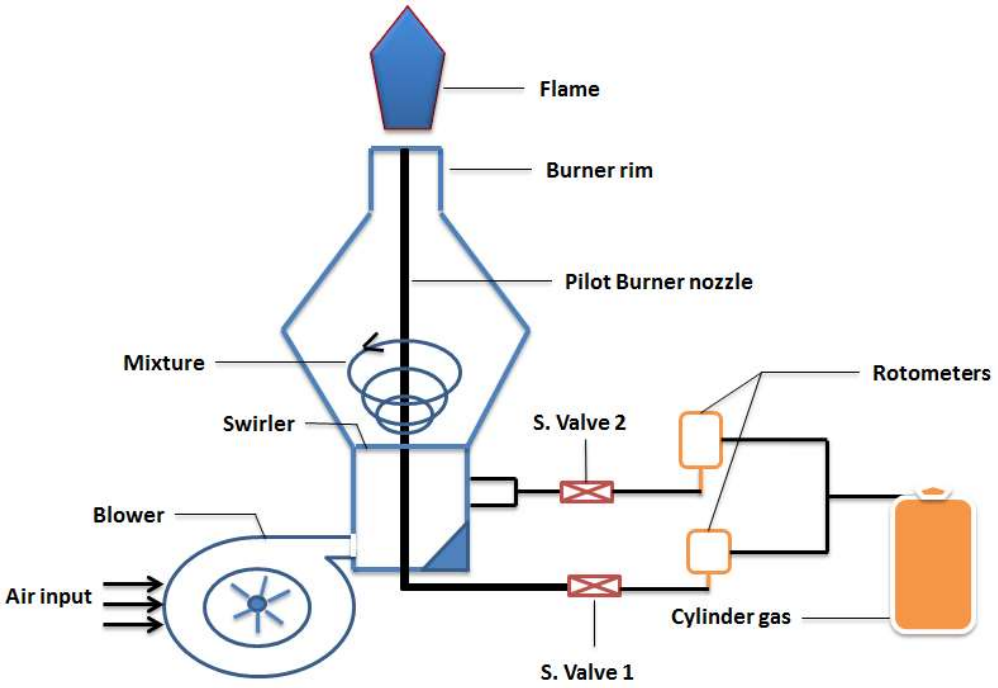

Fig.2 Experimental rig sketch

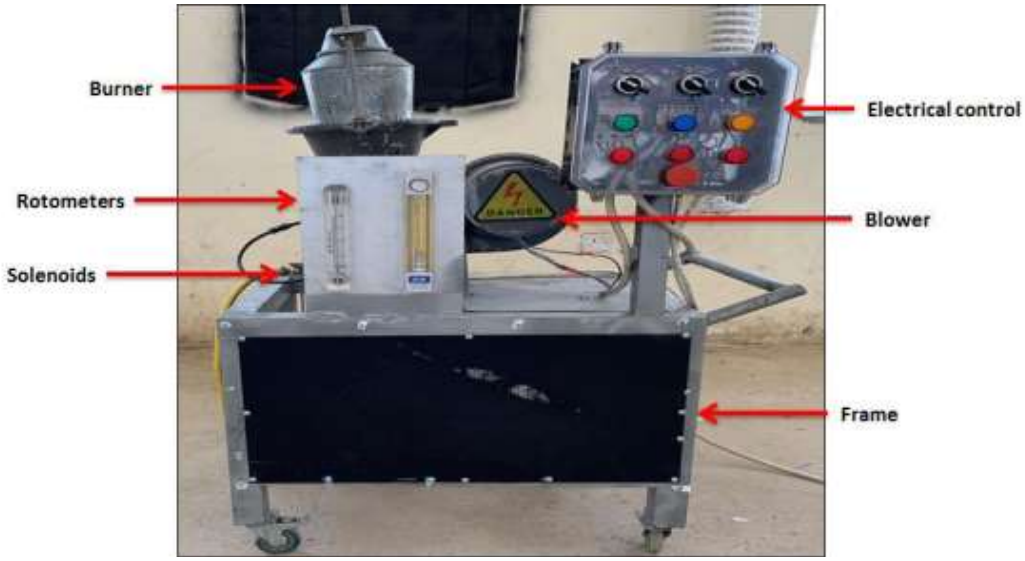

Fig.3 Photograph experimental system

RESULTS AND DISCUSSION

Laboratory results that focused on two important aspects showed the determination of the amount of harmful emissions to the environment through combustion processes using two types of fuel (diesel + LPG), and the amount of economic cost and its comparison in terms of consumption. For the first aspect that deals with the analysis of harmful gases (carbon monoxide, carbon dioxide, hydrocarbons and nitrogen oxide) using LPG as fuel and know the effect of the length of the burner nozzle on emissions, where the gas analysis was done for three nozzles with a fixed diameter of 5 cm and a different height (5 , 10,15) cm respectively, where the results showed that most of the cases examined for the nozzle were 5 cm higher than the other two models in carbon dioxide emissions and the same case in carbon dioxide emissions as shown in figures 3 and 4.

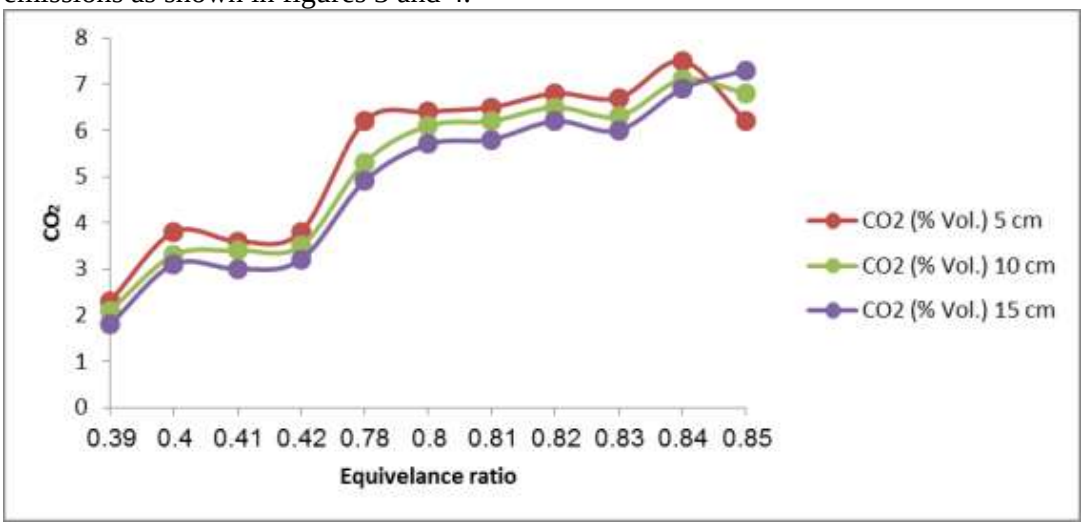

Fig.4 The relationship between equivalence ratio and carbon dioxide emissions(CO_2)

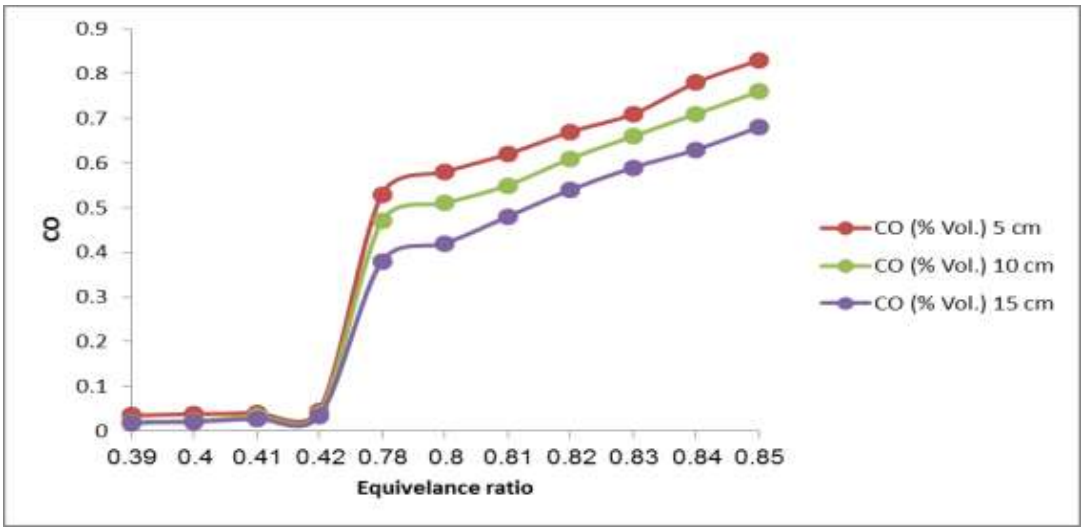

Fig.5 The relationship between equivalence ratio and carbon dioxide emissions(CO)

While the results of the hydrocarbon gas analysis showed that the burner nozzle with a length of 15 cm is more polluted in relation to the other two models as shown in Figure 5.

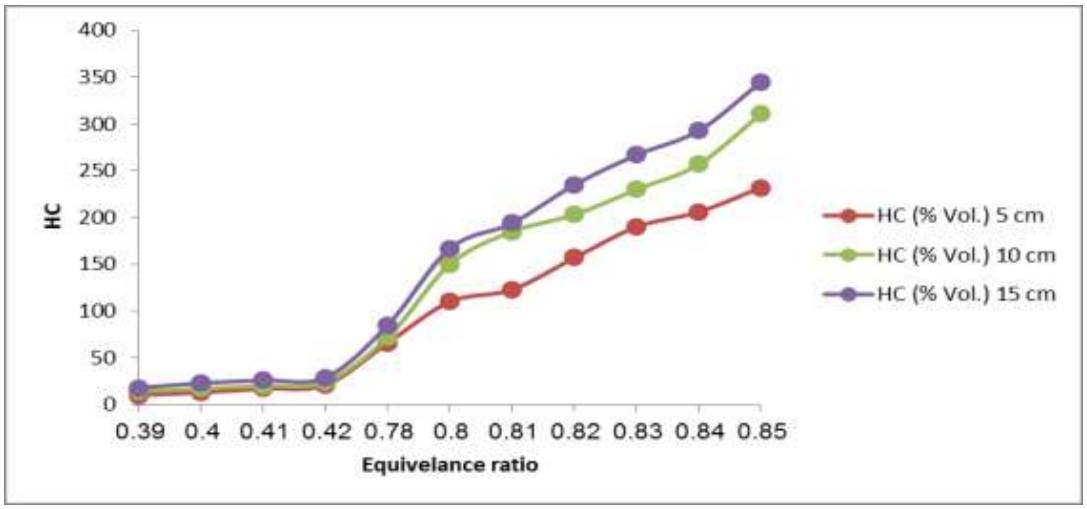

Fig.6 The relationship between equivalence ratio and hydrocarbons emissions(HC)

As for exhaust analyzes of diesel fuel for the burner itself, three quantities of air (9.5,10,10.5,11) m3 / min equipped with an air drive (blower), as it was found that Carbon dioxide (CO_2) and hydrocarbon emissions (HC) are reduced by increasing airflow rates, as shown in Figs 7 and 8.

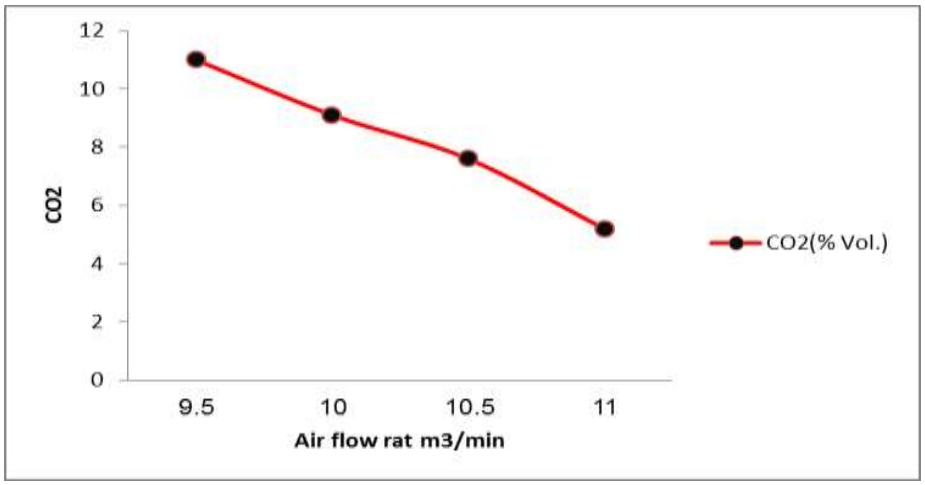

Fig . 7 The relationship between the rate of air flow to carbon dioxide emissions(CO_2)

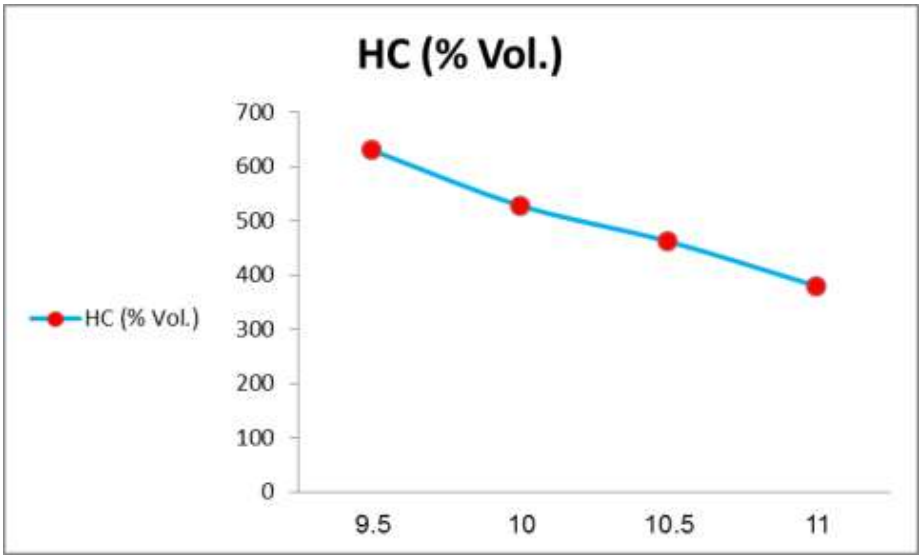

Fig . 8 The relationship between the rate of air flow to hydrocarbons emissions(HC)

While carbon dioxide emissions (CO) increase with an increase in the rate of air flow, as shown in Figure 9

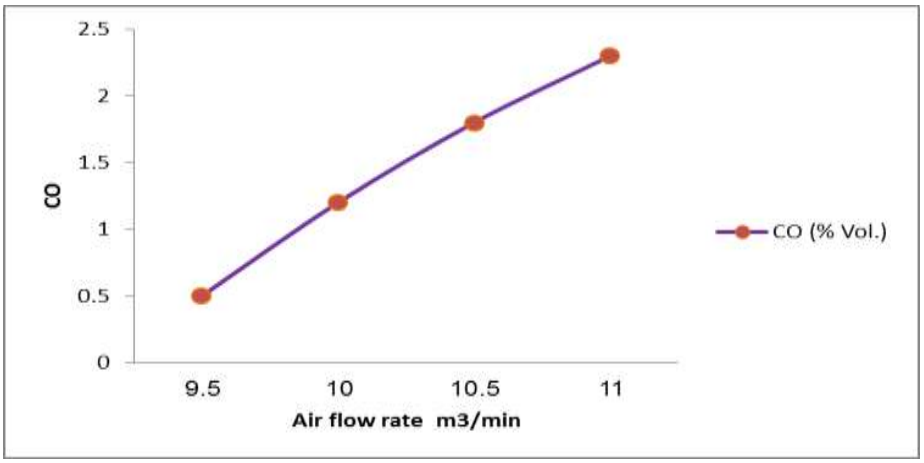

Fig . 9 The relationship between the rate of air flow to carbon dioxide emissions(CO)

The other side of this study is knowledge of the economic operating cost of the burner and its consumption comparison, as the price of one liter of diesel in Iraq is 400 Iraqi dinars, while the price of one liter of LPG is 200 Iraqi dinars. A cost comparison was made using the same burner for one working hour using two types of fuel (diesel and LPG) in the same operating conditions where the economic results showed that using LPG is much better than using diesel fuel as shown in Figure 9

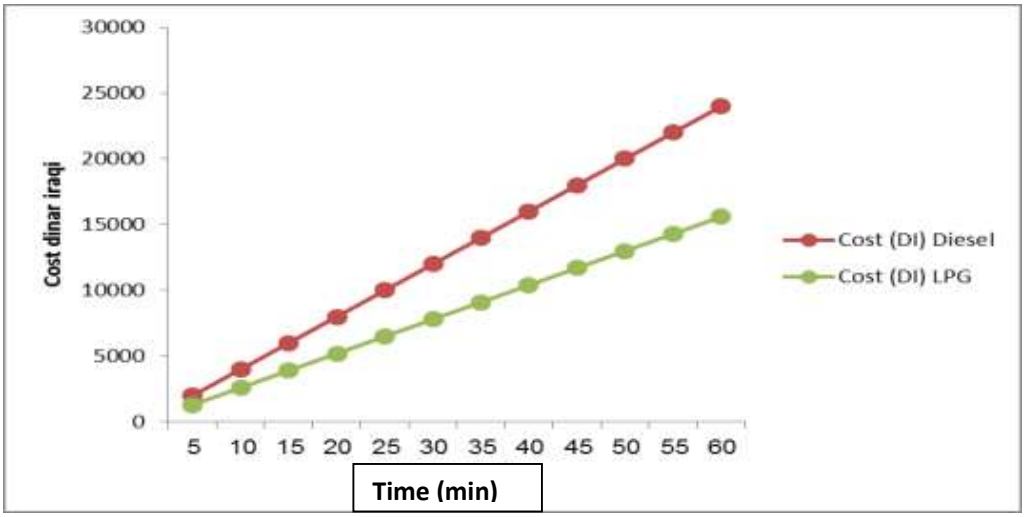

Fig . 10 The costs consumed for the system within one hour of work in Iraqi dinars

CONCLUSIONS

The important points that were drawn in this paper are as follows:
1 - The possibility of converting any diesel fuel burner into a liquefied petroleum gas burner without any deformation of the original system and at very little cost.
2 - Adding a Swirler vane guide that makes the fluid more strong and coherent (the fluid structure) and it is swirl and thus increases the efficiency of the burner and reduces pollution and reduces the cost.
3 - The flame was pushed from the edge of the burner using LPG, which makes the system cool and stable, contrary to what we observe from using diesel fuel that makes the flame in contact with the edge of the burner and thus causes future problems in the burner edge and the system (cracks and erosion in the edge of the burner) thus reducing costs For factory owners and industrial systems.
4 - Through the previous forms, we notice the big difference in reducing polluted gases using LPG fuel systems instead of diesel.
5 - The geometric effect of the system on the incinerator nozzles had a great role in reducing pollution by using a 15 cm nozzle instead of the other two models.
6 - Using LPG instead of diesel, save high financial costs of (1,512,000) Iraqi dinars for a month, at 6 hours per day.

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