Sudan University of Science and Technology

Faculty of engineering

School of mechanical engineering

Power department

PREDICION OF EXHAUST GASES CONSTITUTENTS OF HYDROCARBON FUEL

A These Submitted to the Mechanical Engineering Department in a Partial Fulfillment for the Degree of B.Sc.,(Honors) in Mechanical Engineering (power)

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August 2014

آيـــة

قال تعالى:

"اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۚ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا

مِصْبَاحٌ ۖ الْمِصْبَاحُ فِي زُجَاجَةٍ ۖ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ

لَا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ

نَارٌ ۚ نُورٌ عَلَىٰ نُورٍ ۗ يَهْدِي اللَّهُ لِنُورِهِ مَنْ يَشَاءُ ۚ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ ۗ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ"

صدق الله العظيم

Acknowledgment

We must before all thank ALLAH the most merciful for blessing us with the power to do what right and to do our best in the current project and the following tasks in life, we are in great debt and we will always be.

We like to express our deeps thanks to our supervisor Dr/Ali Hamden for this dedication and great help in accomplishing the project.

We would also like to thank all those who helped us and stood by us, and dedicate this research to the parents who supported us financially and morally and now they see what their result.

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Abstract:

The process of combustion of the most important processes that occurs inside the engine and associated emissions of exhaust gases depending on the type of fuel and environment conditions of flammable.

This research talked about the difference types of fuel (liquid, solid, gas) and characteristics of each type and proportions of the expected emissions of each type, were studied combustion in general and the types of combustion from the combustion complete and incomplete combustion products with surrounding each type.

And provided this research with previous studies of methods for the analysis of exhaust gases accompanying diagrams illustrate the effect of environment on the proportion of ignition exhaust gases.

Been done by matlab program that calculates and analysis of chemical equilibrium equation to calculate the ratio of the combustion air and fuel and temperature of the flame front.

تجريدة

تعتبر عملية الأحتراق من اهم العمليات الكيميائية التى تحدث داخل المحرك ويصاحبها انبعاثات لغازات العادم حسب نوع الوقود وبيئة وظروف الإشتعال.

هذا البحث يتناول الوقود وانواعه المختلفة (سائل ، صلب ، غاز) وخصائص كل نوع والنسب المتوقعة لإنبعاثات كل نوع ، وتمت دراسة الإحتراق بصورة عامة وانواع الإحتراق من إحتراق تام وإحتراق غير تام مع توضيح نواتج كل نوع ، وزود هذا البحث بالدراسات السابقة لطرق تحليل غازات العادم مصاحبة بمخططات توضح تأثير بيئة الإشتعال على نسبة غازات العادم.

تم كتابة برنامج بواسطة الماتلاب يقوم بحساب وتحليل الإتزات الكيميائى لمعادلة الإحتراق وحساب نسبة الهواء للوقود ودرجة حرارة جبهة اللهب .

Abbreviations and Acronyms Used

Low Sulphur Heavy Stock	**LSHS**
Gross Calorific Value	**GCV**
Net Calorific Value	**NCV**
liquefied Petroleum Gases	**LPG**
Light Diesel Oil	**LDO**
Higher Heating Value	**HHV**
Air Fuel Ratio	**AFR**
Flame Ionization Detectors	**FID**
Hydrocarbons	**HC**
Chemo Luminescence Detectors	**CLD**
Internal Combustion	**IC**

Chapter One

Chapter One

1.1. Introduction:-

1.1.1. Introduction to Frontier Research on Combustion:

Combustion, initializing the civilization of human society, has developed for thousands of years. It refers to the exothermic process with light emission when fuel molecules strongly react with oxidizer, frequently oxygen. As a major way of utilizing chemical energy, it remains the most important way of providing energy in the current world, which is constrained and driven by the need to produce energy to manufacture, transport, provide heating and cooling, and generate electricity, etc. Chemical energy in the form of petroleum, coal, natural gas, and biomass taking up the largest part of the world energy, is contained in the chemical bond constructing the fuel molecules. Through combustion, chemical energy could be converted to thermal energy, and be further converted to mechanical energy through thermodynamic cycles.

Historically, combustion is an application-driven scientific discipline, meanwhile driving the development of technology. In its early period of development, fire safety issues were of primary importance, together with related knowledge on flammability limits and explosions. In the 1950s, combustion research was stimulated by aero-propulsion and then by rocket propulsion.

Since then the term “aero-thermo-chemistry” has become synonymous with combustion. Interests in combustion-generated pollutants such as ($CO/NO_x/SO_x$) and soot rose in the late 1960’s. The energy crisis of the 1970’s stimulated research on energy saving and combustion efficiency. In the 1980’s and 1990’s, more interests grew in supersonic combustion, combustion emissions and the related climate science. All these technology drivers are still present in combustion research. New drivers also emerge as can be seen in the following section. Three examples as the frontier research on combustion will be introduced below, which are representative directions of modern combustion science.

The major points of this article, the development of combustion energy is going toward the directions of new engine technique, new alternative fuels, and new interdisciplinary field study. Considering the interdisciplinary nature of combustion itself, there is a huge possibility of the coupling of other fields, e.g. material science, biology, etc, and combustion in the future.

With combustion still being the major energy source, other energy utilization methods should be strongly encouraged and explored so that more future energy options could be developed.

1.1.2. Combustion Thermodynamics:

Combustion is a self-propagating exothermic oxidative chemical reaction, mostly in gas phase, producing light, heat and smoke in a nearly-adiabatic flame front. The overall process in combustion is analogous to those taking place in fuel cells and living-matter respiration, so that the same overall results apply in all three cases, in spite of their details being so different; combustion is characterized by the very high temperatures reached.

The practical goal in combustion study is the prediction of its performance, for a safe, efficient and clean design and operation of fire-making devices, in terms of the multiple physic-chemical phenomena involved; it is thence a prerequisite to analysis the latter. Those phenomena may be split in two groups: equilibrium behavior (what we need and what we get), and kinetics (how we get it; at what rate).

Combustion Thermodynamics focuses on the former physic-chemical phenomena: (fuel/air) ratios, heating values, maximum work obtainable, exhaust composition etc, whereas Combustion kinetics focuses on mixing process, flame geometry, ignition, extinction, propagation, stability, etc.

The study of combustion is based on the more general subject of Thermodynamics of Chemical Reactions, usually called Thermo chemistry.

We shall deal here only with the peculiarities of the combustion reaction, i.e. with focus on the thermodynamics of a fuel-and-air gas-phase reaction.

It may be helpful to have in mind a concrete instance of a combustion process, and we proposed the idealized burner sketched in (figure 1.1), a steady-state combustor burning natural gas (here idealized as pure methane) in air, with some heat output (as in a domestic water heater). This model already emphasizes the black-box approach typical of thermodynamic analysis (it does not look into the internal details of how the fuel and air mix, the geometry of the flame, or any other gradient or discontinuity within), and assumes the combustor is large enough for the exhaust to be in equilibrium (no longer reacting, no gradients).

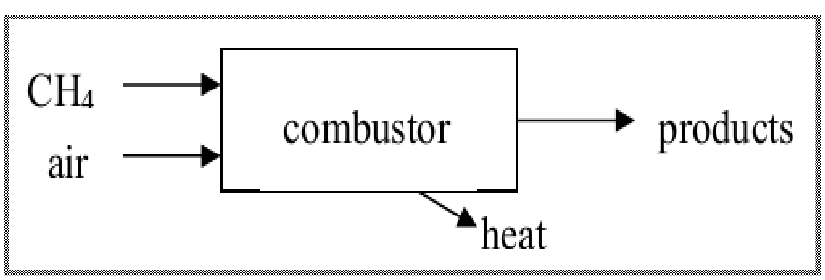

Figure.1.1. A simplified model of a natural-gas combustor.

A detailed description of fuels, oxidizers, their mixing, the ignition process and the kinetics of its propagation, can be found elsewhere. A succinct description of the process in (figure 1.1) may be as follows. As it will be shown below, at least 9.5 m^3 of air are required for the complete combustion of $1m^3$ of methane at same (p-T) conditions the molar stoichiometric (air/fuel) ratio is (A_0=9.5), with a maximum heat output of 55 MJ/kg CH_4 or 37 MJ/m^3 CH_4 , the higher heating value of methane) that would decrease as the exhaust temperature increase until a maximum when no heat is exchanged, some 2200 K (the adiabatic combustion temperature for the stoichiometric mixture). The exhaust composition for stoichiometric mixture consists of (71% by volume of N_2, 19% H_2O, 9% CO_2), and much less than (1%) of undesirable gases called ‘emissions’, that are noxious to the health: (CO, NO, NO_2), aromatic-hydrocarbon vapors and maybe soot.

1.1.3. Combustion Chemistry:

The gasoline-powered internal combustion engine takes air from the atmosphere and gasoline, a hydrocarbon fuel, and through the process of combustion releases the chemical energy stored in the fuel of the total energy released by the combustion process, about20% is used to propel the vehicle, the remaining 80% is lost to friction, aerodynamic drag, accessory operation, or simply wasted as heat transferred to the cooling system.

Modern gasoline engines are very efficient compared to predecessors of the late 60’s and early when emissions control and fuel economy were first becoming a major concern of auto motive engineers. Generally speaking, the more efficient an engine becomes, the lower the exhaust emissions from the tailpipe. However, as clean as engines operate today, standards continually tighten. The technology to achieve these ever-tight eninge missions targets has led to the advanced closed loop engine control systems used on today's Toyota vehicles. With these advances in technology comes the increased emphasis on maintenance, and when the engine and emission control systems fail to operate as designed ,diagnosis and repair.

1.2. Problem of the research:-

- The diagnostic of all heat devises or burners depended main on the analyses of the exhaust gases.
- The determination of the exhaust component needs time and money.
- The availability of a computer program will be simple and comfortable way to solve this problem.

1.3. The objectives of the project:-

- To identify the components of the combustion products.
- To study the influence of different factors on the composition of the exhaust gases.
- To write a computer program that can predict the components of combustion products without using a gas analyzer.