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Exhaust Gas Fertilizer

Ibraheem Raza Khan[1]

***Abstract*: The paper deals mainly with conceptual design of exhaust gas used as fertilizer, a setup is been designed using CAD to understand the working of the system. The benifits of injecting Exhaust gas, with or without seeds, into the soil is discussed. The contents of an Exhaust gas and basic element requirement for crop growth are additional highlights of the paper.**
Keywords: Exhaust Gas Fertilizer ,Tractor Exhaust, Soil Requirement, Exhaust Gas Intercooler, Exhaust gas contents

I. INTRODUCTION

Exhaust gas from Tractor contain elements which are harmful for human health but are very propitious for plants as agricultural fertiliser replacement, the exhaust can supply surplus Nitrogen, Carbon Dioxide. Spreading the exhuast across the field is facile as the tractor moves into the field for cultivation of soil or for sowing seeds. It is found that the exhaust gas does help in reducing the uses of fertiliser and the extra time and labour required for the fertilizer to be spread. On the bigger picture it also reduces the carbon footprint, further expensive exhaust treatment systems can also be avoided as the environmental impact due to this exhaust is been reduced. In this research, the conceptual design of setup for soft top Tractor is highlighted. Nutrients in soil which are essential for better production are present in tractor exhaust, experiments have been performed earlier for effective injection of exhaust into soil, but because of unavailability of technology they were not successful. Farmers in Canada, Australia and from the United States of America have invented exhaust gas fertiliser system where the exhaust is treated and added with required nutrients, whereas sometime the diesel is mixed with certain additives which give Phosphorus, Potassium and other nutrients. These gases are then added with seeder, where the seeder air intake is replaced with exhaust gas.

II. SOIL

Sixteen elements are essential for plant nutrition, which are classified as major and micro nutrients. The major nutrients are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S). The micronutrients (present in much lower concentrations) are iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) boron (B), molybdenum (Mo) and chlorine (Cl). Plants can contain other elements in significant quantities that are not essential for plant growth; for example silicon (Si), aluminium (Al) and sodium (Na). Most of the plant dry matter is made up of C, H, O and N (>95% of the plant dry matter). Plants obtain these requirements of C, H and O (and to some extent N) from air and water. The other essential plant nutrients are supplied from the soil or from fertilizers [1].

Nitrogen is the main driver of plant growth and is the cornerstone of all plant protein production. Organic matter (OM) is the main store of N in soils (can be in excess of 5000 kg/ha), therefore soils with higher soil organic matter such as Peats and Gley soils, have the potential to release more N to the growing crop. The rate at which N is released is dependent upon the ratio of C:N (10-12:1 is optimum) and soil conditions such, temperature, moisture and oxygen. Generally, the highest N release from the soil occurs in late spring and early autumn when soil temperature and moisture levels are favourable. However, N is a volatile nutrient, and moves freely through soils, plant, water and air. It exists in many different compound forms, some of which are available for uptake by plants (e.g. ammonium and nitrate), some of which are a potent greenhouse gas (e.g. nitrous oxide) and some of which can be lost in drainage water (e.g. nitrate). Grassland and crops grown on lighter and well drained soils such as Brown Earths and Brown Podzolics are likely to be very responsive to N fertilizer inputs.

III.EXHAUST GAS

Pollutants from diesel engines can be roughly divided into three elements. The first one is NOx. The NOx mainly consists of nitrogen oxide (NO) and nitrogen dioxide (NO_2). The concentration of NO in diesel exhaust is higher than that of NO_2; however NO_2 has much higher toxicity than NO. In addition to these two species, N_2O has been recently gathering attention because of its 200 times higher impact factor than carbon dioxide on global warming. Although it can be said that NO, NO_2, and N_2O have different impacts on the environment [2].

The second element of diesel exhaust is hydrocarbons and CO. Hydrocarbons consist of thousands of species, such as alkanes, alkenes, and aromatic. Although their toxicity, carcinogenicity, and impact of oxidant formation vary from species to species, they are usually treated together as total hydrocarbons (THC). These uniform treatments of NOx and THC have arisen for two reasons. The first one is that the exhaust gas of automobiles is regulated only by levels of NOx and THC. Another one is the difficulty in measurement. Usually, an analysis of engine exhaust is performed by gas chromatography–mass spectrometry. However, achieving quantitative analysis takes a long time. Real time measurement is desirable for engine exhaust analysis because the exhaust gas composition changes in real time along with changes in the engine operating conditions.

IV. EXHAUST IN SOIL

A. History

Recycling exhaust gas, which is in essence burnt composted vegetable matter, may seem like a new idea, however the benefits of CO_2 to plant growth have been well known since the early 1900's. In 1923 a German gentlemen named Friedrich Riedel designed a process that would utilise exhaust gas containing carbon dioxide for agriculture. Again in 1929 TW Hicks designed a machine that would "prepare the soil for stimulated plant growth" by incorporating exhaust gas from a combustion engine into the soil. The main drawback to these ideas was the complexity of taking 250 degree Celsius combustion gases and injecting them into the ground in a cost effective way. These challenges were further exacerbated by the wide spread use of artificial fertilisers in the post war period, consequently the idea of using CO_2 faded away.
In the 1960's the process of incorporating exhaust gas from combustion powered water pumps into irrigation water breathed new life into the idea of CO_2 as a plant stimulant. Further ideas for CO_2 incorporation into irrigation, green houses and soil were published in the 1980's and the 1990's however with the development of the airseeders, an implement that is widely used amongst broad acre farmers, it instantly overcame many of the challenges of the 1920's opening the doors for CO_2 enrichment of soils in broad acre farming [3].
Exhaust gas fertilizer technology, which injects vehicle exhaust emissions into the soil via the seeder during seeding, is at the cutting edge of agricultural technology. Exhaust injection is claimed to stimulate microbial activity in the soil, resulting in mineralisation of nutrients from the soil and production of nitrogen (N) by free-living N- fixing bacteria. This is said to improve root and plant growth, leading to better crop performance and changes in the harvest ratio of crops, making them more drought tolerant. Other claims for the exhaust injection technology, include improvements in: • soil condition and structure, which increases water-holding capacity • crops' ability to avoid or withstand insect attack performance of crops sown in saline soil conditions due to increased availability of calcium and phosphorus, which makes the plants better able to withstand the saline soil conditions.

B. Untreated Exhaust Emissions

Diesel fuel going into an engine is mostly carbon and hydrogen, with sulfur, calcium, iron, silicon, and chromium among the other constituents. Engine oil also contains mostly carbon and hydrogen, along with some zinc, phosphorous, and calcium. In addition to gases containing the breakdown products of these constituents, exhaust emissions contain significant particulate matter. The actual chemical composition of tractor exhaust emissions is determined by the thermal efficiency of the engine, which is in turn dependent upon the type of fuel, engine speed, engine load, injection settings and the operating temperature of the engine. In addition, we can add fuel additives to adjust the composition of the exhaust. Heavy metals - toxic to us - become nothing more than another trace element available to the plant, absorbed only if needed [4]. We can even blend the fuel we use to match the micronutrient needs of the plants we want to grow and the soil we're growing them in.
Emission System increases the availability of nitrogen compounds (NOx) in several ways. First, carbon dioxide at 7% raises the soil CO_2 level which, in turn, stimulates free-living nitrogen-fixing bacteria which produce amino acids. Also, when the plant uses only nitrates (NO_3), it is twice as efficient at sequestering CO_2 as when ammonium (NH4) is used. The surplus CO_2 continues to stimulate the nitrogen-fixing bacteria, setting up a positive feedback loop which keeps the cycle going longer. As NO_3 is transported to the shoots, potassium (K) is used to metabolize it, and HCO_3 is free to pass into the soil. Thus the chloride content in plants, particularly in the roots, can be strongly depressed by increasing nitrate concentrations. When a plant feeds on ammonium (NH_4, traditional fertilizer) instead of NO_3, the root is called upon to exchange twice as much hydrogen (one H from NH_4 and one H from HCO_3) to form urea before it is transported to the shoot [5]. This is a much less efficient process, with a significant portion of the sugar compounds never entering the roots to become the exudates which feed microbial life. Ammonium fertilizers placed on the soil must be in such high amounts to last the season, often contributing via run-off to water pollution and the creation of nitrous oxide – a potent greenhouse gas. Thus the Emissions Method has distinct advantages over urea or ammonium soil-placed fertilizer. Each kilogram of commercial nitrogen fertilizer placed on a field creates about 8.301 kilogram of CO_2 equivalent to manufacture, transport and apply it – a considerable detriment to the environment. Also, in almost all cases, external ammonium strongly suppresses net uptake of nitrate. It turns out that free-living nitrogen-fixing soil bacteria are often restricted in their nitrogen fixing capacity by substrate limitations due to inadequate availability of organic residues. The advantages of nitrate-fed plants are: - a higher exchange rate through the roots - less hydrogen is lost from the roots - more CO_2 is exchanged into the soil - plant tissues

maintain a higher pH which defends against insects and fungi - higher pH soil encourages plants to utilize nitrates preferentially - higher copper levels in plant tissue - chloride uptake is controlled in natrophobic plants - nitrate with sodium is a growth stimulant for natrophilic plants - salty soil lacks organic matter and plant growth as a result of low CO_2.

V. TACTOR

With different tractor design, the available for the setup installing in constrained. These designs can be broadly classified as Tractors with closed cabin (hard top) and Tractors with open cabin (soft top). The setup constrain for Tractor with open cabin (soft top) is, the intercooler (exhaust gas intercooler) cannot be placed on top of the cabin, generally the intercooler is placed on top of the tractor's cabin (with hard top) keeping all hot points out of human reach. Whereas in soft top cabin tractor, the setup requires long hoses to transfer he exhaust to other aggregates, this can be further advantageous as the exhaust gas gets much more time to dissipate heat to the atmosphere. This reduces the bulk design of the intercooler.

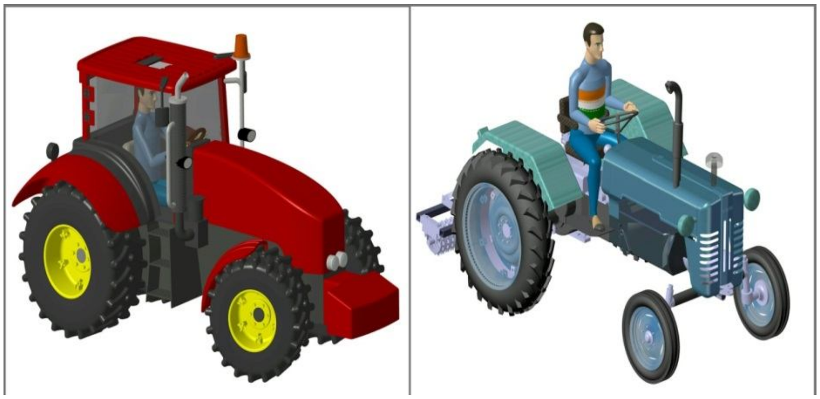

Figure 1 Hard Top Close Cabin Tractor & Soft Top Open Cabin Tractor

VI. SETUP

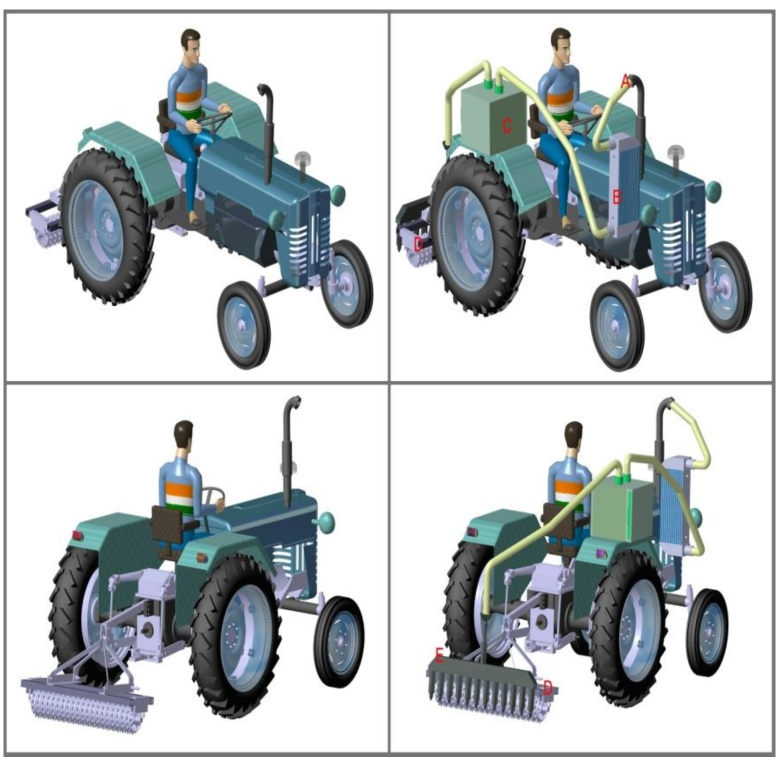

Figure-2 Left to Right Tractor without Exhaust Fertiliser System and With Exhaust Fertiliser System

Starting with left column, the images show a conventional tractor with open cabin and an agricultural attachment connecter to the tractor in the rear. The images shown the right column represent a tractor with installed setup. The setup as its bulky does hinder the visibility for which further design modification are undergoing.

VII. WORKING

The exhaust comes out of the exhaust manifold, the high pressure and high temperature exhaust because of a pressure difference moves through the exhaust system. The exhaust has certain shock waves which are absorbed in muffler of the exhaust system. Exhaust system for a tractor includes exhaust manifold which is connected to the engine body to which generally turbocharger cavity is attached, after the turbocharger the exhaust gas moves into the exhaust pipe which has a muffler, the muffler reducers the shocks and so reduces the temperature as the exhaust gas gets an opportunity to expand in muffler.

Figure-3 (A-exhaust tailpipe, B- Exhaust intercooler, C- intermediate unit)

Further the exhaust gas moves to the tailpipe of the exhaust system. The tail pipe in conventional tractors is open to atmosphere, whereas in this case, the tailpipe mouth is connected to a hose which connects tailpipe and exhaust intercooler inlet(ref **A** in figure). The exhaust intercooler(ref **B** in figure) is used to cool the exhaust gas so as to make it compliant with the required temperature for productive growth and which does not burns the seed injected with exhaust gas pressure [6]. The intercooler used works on natural cross flow heat exchange between atmospheric air and exhaust gas. Intercooler or in this case exhaust gas intercooler, the design of cavity for an intercooler is based on the heat exchanger ratio, inlet and outlet temperatures, intercooler efficiency. The exhaust here is cooled and become dense, further it is sucked by an unit which reduces the possibility of any back pressure buildup.

Figure-4 (D- Farming attachment for Tractor, E- Exhaust Injector/ Seeder)

The intermediate unit(ref C in figure) can have just a suction pump or can also have elements in powder form which further increase the soil productivity when blended together with exhaust. These all are mixed together and are pumped to the seeder unit. The seeder unit comes with separate pneumatic injectors which pump in the seed with the exhaust gas. The exhaust gas can be injected either while cultivating or during sowing seeds. Or it can be done in two stages or one after the other. Different attachment can be made as per requirement of the field (ref D in figure).

The exhaust injector(ref E in figure) is supplied with exhaust gas, with or without seeds depends on the application and time of use. The injector, injects the exhaust gas with the movement of cultivator/seeder.

VIII. CONCLUSION

With use of exhaust gas as fertiliser, carbon footprint will be reduced, from reduced impact of Tractor exhaust to reduce CO_2 emissions in production of urea. In addition the use of system cuts the cost of farming by reducing the need of urea. As Nitrogen and Carbon injection into soil helps nitrogen fixing bacteria and also provide a large organic matter, it helps in effective plant growth. Further optimization of design of exhaust gas setup is in progress.

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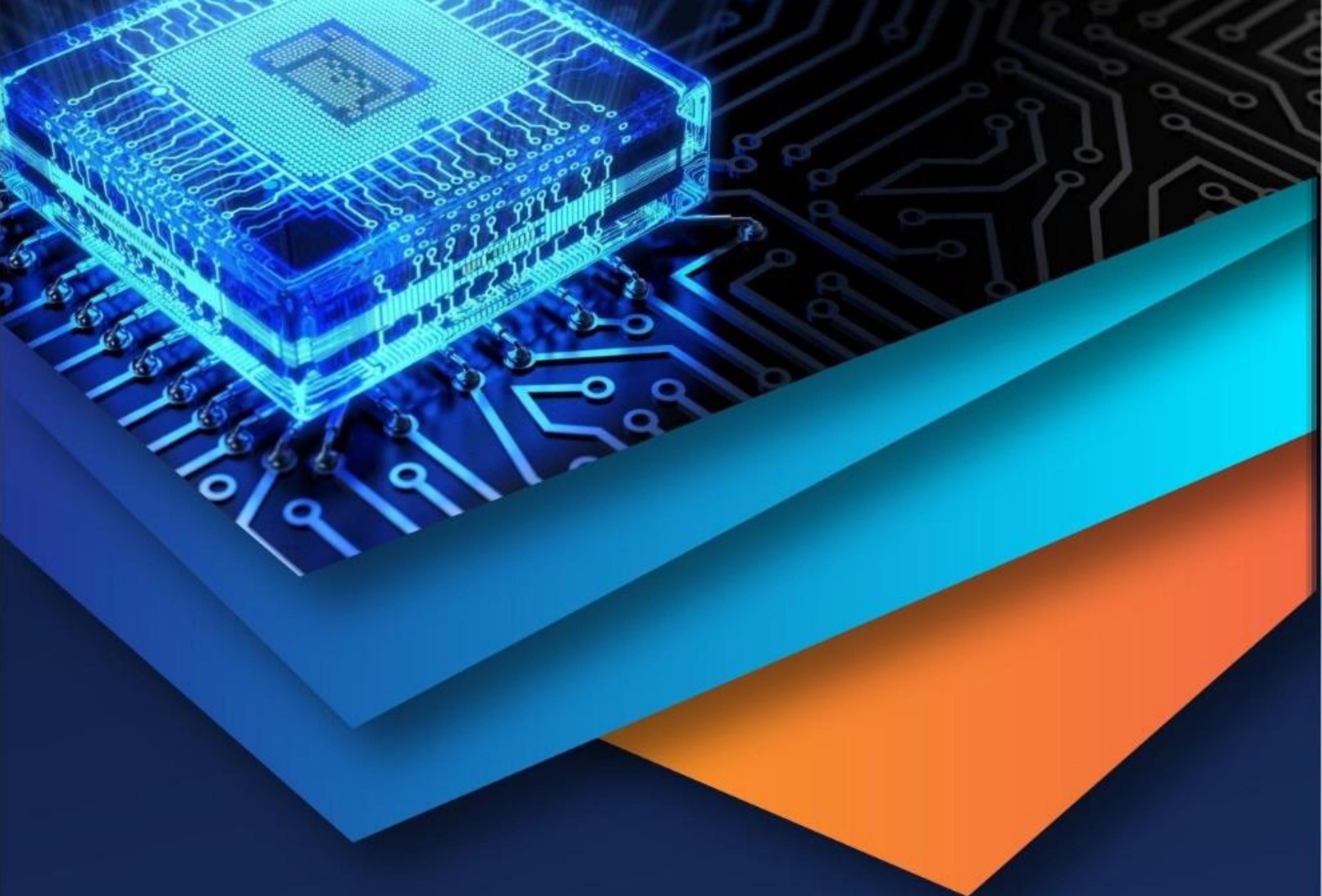

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