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Tractor Air Intake Pressure Use in Pneumatic Planter

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Abstract

Farm productivity enhancement has become inevitable to feed the increasing population. Intensive agriculture is one way to achieve this. But, this requires adoption of newer technologies in combination with the available farm power. The increasing cost of machineries is making condition of interested poor farmers' worst, those who want to adopt the advanced technologies for higher productivity as well as returns. Thus, the emphasis should be to either decrease the cost of machine or develop a universal machine capable of performing many operations. The pneumatic pressure is being used in many agricultural specialized implements like planters, seed cleaners, etc. Thus, an innovation has been carried out to use the suction created in tractor intake pipe for pneumatic purposes in pneumatic planter to reduce the cost of owning such machines. To accomplish this, a bypass system was attached to air intake pipe and pressure created in the bypass was used for pneumatic purposes. The effect of bypass in air intake system on engine performance was assessed at different air intake opening percentage and engine rpm in terms of vacuum pressure in bypass, fuel consumption, sound pressure level created by engine and exhaust gas configuration. It was found that as the engine rpm increased, the vacuum pressure in bypass, fuel consumption, sound pressure level generated by the engine and CO_2 concentration increased, while NO_x concentration decreased. Since, no distinct pattern for fuel consumption, sound pressure, CO_2 and NO_x levels level were obtained for different air intake pipe openings, thus, intake system bypass may be used for pneumatic purposes.

Keywords: *air intake pressure, pneumatic, vacuum pressure, noise level, exhaust gas emission.*

1. Introduction

Due to limitation of cultivable land, feeding of increasing population is becoming a challenge day by day. Crop intensification can help in meeting the increased demand of growing population. But, this will require increased amount of farm power availability and a huge amount of agricultural machineries as most of the machines are crop specific. Thus, shift is towards the tractors to enhance the productivity. Increase in farm power also helps to complete farm operations in short time and avoid reduction in crop production due to delay in sowing, weeding or other farm operations. But, tractor without farm implement is worthless. Farm operations can be completed attaching specialized farm implements like harrow, plough, cultivator, seed drill, sprayer, weeder, reaper, thresher, etc. to farm tractors.

No modern farm is complete without an array of advanced machines compatible with the available tractor to share the workload of farmer. The every purchased machinery increases the capital cost as well as running cost, resulting in increased cost of production. The initial cost of machineries are also increasing day by day making the condition of poor farmers worst, those who wanted to adopt the advanced technologies. Thus, the emphasis should be

on either decrease the cost of the machine or develop a universal machine capable of performing many operations.

Intake system of tractor is an important system of an engine, which allows fresh air to enter the engine at very high negative pressure, so that maximum amount of air can enter into the cylinder. Then, the compressed air burns with the fuel sprayed in form of small droplets. A CI engine uses large quantities of air for combustion, generally, the ratio between air and fuel varies from 14-18. The air-fuel ratio greatly influences the performance of engine. BMEP and brake thermal efficiency may decrease with increase of the air-fuel ratio. However, the BSFC increases with increase of the air-fuel ratio [1]. The exhaust emissions HC and CO also increases as the ambient pressure decreases and as the altitude of the engine increases. The concentrations of the HC and that of the CO increases with reduction in air intake pipe diameter, while CO_2 and the O_2 remains relatively constant [2]. Both NO_x and smoke may be reduce significantly at the same brake specific fuel consumption at high engine speeds above 1400 rpm. While at low engine speeds below 1000 rpm, NO_x may be reduce slightly with minor penalty in the brake specific fuel consumption [3].

The air before entering into the cylinder becomes dust free by the pre-cleaner and cleaner to avoid wear and tear of the engine parts. After operation of several hours, these cleaners start getting choked by the dust particle and resist the flow of the air. Thus, air filter plays as important role in the engine performance. As air filter causes restrictions in the path of incoming air, which results in incomplete combustion due to less availability of air. By eliminating the air filter, the air flow restriction through the air intake system may be reduced [4]. Hence, better combustion and less unburned components are achieved because of higher air availability. If the fuel filter is not clean than fuel economy may decreases [5]. The excessive pressure across a dirty air filter can cause a 1–15% increase in fuel consumption. The fuel economy with a new air filter may improve as much as 14% over that with a severely clogged filter. The restriction in the path of air intake causes pressure drop, which results into increase the fuel consumption and reduces the engine efficiency [6]. A higher air intake pressure is required to increase air density, which allows better combustion within a limited time to improve fuel economy, power output and exhaust emissions. Complete combustion also lead to reduction of unburned components such as C, H_2, CO_2 and OH causing less hazardous emissions.

The pneumatic pressure is being used in many agricultural implements like planters, seed cleaners, etc. Thus, an innovation has been carried out to use the suction created in the intake pipe of an engine for pneumatic purposes in pneumatic planter, considering that during seed sowing operation very less power of tractor is being. This use will reduce the cost production of machine. To accomplish this, a bypass system was attached to air intake pipe and pressure created in the bypass was used for pneumatic purpose in planter. And, effect of bypass in air intake system on engine performance as well as exhaust gas emission was assessed.

2. Materials and Methods

The effect of bypass in air intake on engine performance was measured in terms of vacuum pressure in bypass, fuel consumption rate, noise level created by the engine and exhaust gas configuration at varying area of air intake pipe and engine speed. The study was carried out on a 3 stroke, 4 cylinder mini tractor of make -Mitsubishi Shakti having 70 mm bore and 78 mm stroke length with swept volume of 900 $cm^{3.}$ The engine was having 3 stage oil bath type air cleaner.

Plate 1: Modification in air intake system

Modifications were carried out in the intake system of the tractor (Plate-1) by making a bypass in the air intake pipe of the engine. To accomplish this, pre-cleaner mounted on the intake pipe was removed and a pipe of ID 50 mm dia was connected to the intake. Above this pipe a UPVC ball valve was attached to vary the area of pipe through which air was sucked by the engine. A bypass was made in the pipe by attaching suction hose pipe of ID 25 mm and 3 m length was attached to it. Further, a pipe of ID 6 mm and 1m long was attached for application of vacuum pressure created in it to the pneumatic planter.

To carry out the study, engine rpm and intake air opening were taken as independent parameters. Three levels of engine rpm (1800, 2200 and 2500) and five levels of intake air opening (23.36%,

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44.49%, 56.74%, 64.49% and 100%) were varied and vacuum pressure, fuel consumption, engine sound pressure level and exhaust air gases configuration in terms of NO_X and CO_2 were measured. To measure the vacuum pressure in the bypass of air inlet pipe, dial type pressure gauge was used. While, the fuel consumed during experiment was measured by making up the fuel to pre determined level in the fuel tank after the completion of each experiment. The sound created by the engine was measured with the help of a sound level meter SL 4001 at 1 m away from tractor engine and at the arms' height on left side of the tractor engine. The Gas analyzer PA 960 was used to measure the engine exhaust gas configuration in terms of CO_2 and NOx levels at different parameters under study. After field experiments, collected data was analyzed to know the effect of engine bypass on various parameters under study.

3. Results and Discussions

Experiments were carried out to study the effect of intake pipe area opened along with engine rpm on engine performance in terms of bypass pipe, fuel consumption, noise created and change in exhaust gas configuration. The results obtained from the study are discussed below:

3.1 Vacuum pressure

Engine speed affected the vacuum pressure in bypass of air inlet pipe significantly. Vacuum pressure increased with increase in engine speed and decreased with increase in opening area of the inlet pipe (Fig. 1). Maximum vacuum of 125 mm of Hg was obtained at 23.36% inlet pipe opening and 2500 rpm, while minimum vacuum of 2 mm of Hg was obtained at 100% inlet pipe opening and 1800 rpm. Since, vacuum pressure requirement for seeds of sugar beet, watermelon, onion, cucumber, melon and maize varies from 15-30 mm of Hg [7], that means inlet pipe opening of 44.49% and below may be used for the pneumatic purposes.

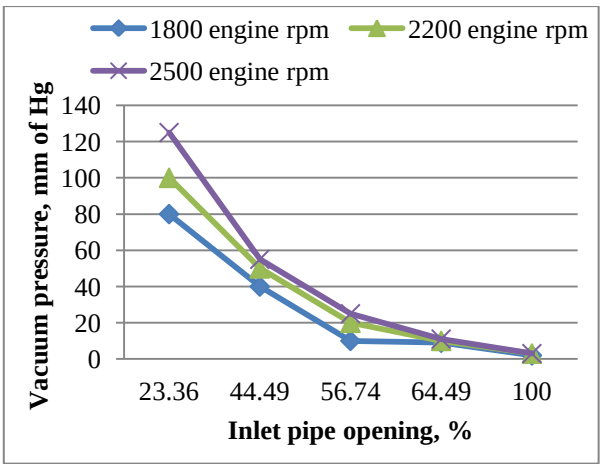

Fig. 1 Vacuum pressure at different air intake opening and engine rpm

3.2 Fuel consumption

The observations taken regarding fuel consumption of the tractor during the engine performance evaluation showed maximum fuel consumption of 1.5 l/h during inlet pipe openings of 23.36% & 64.49% at 2500 engine rpm, while minimum fuel consumption of 0.9 l/h was observed during 64.49% inlet pipe opening position at 1800 engine rpm. The fuel consumption normally increased with increase in engine rpm. The effect of different inlet pipe opening on fuel consumption did not follow any set pattern, while fuel consumption generally increased with increase in engine rpm (Fig. 2).

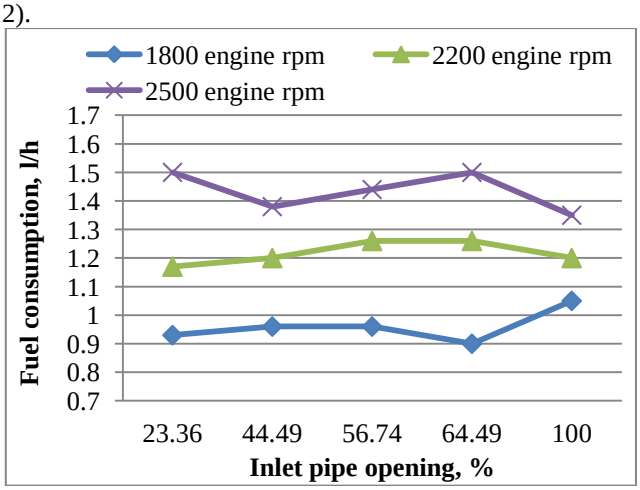

Fig. 2 Fuel consumption at different air intake opening and engine rpm

3.3 Noise level

The effect of engine rpm and inlet pipe opening on noise level was recorded in dB unit (Fig. 4.3). The maximum noise level of 93.77dB was observed during inlet pipe opening position of 23.36 % and 2500 engine rpm, while minimum noise level of 87.3 dB was observed during inlet pipe opening of

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56.74% and 1800 engine rpm. The noise level normally increased with increase in engine rpm.

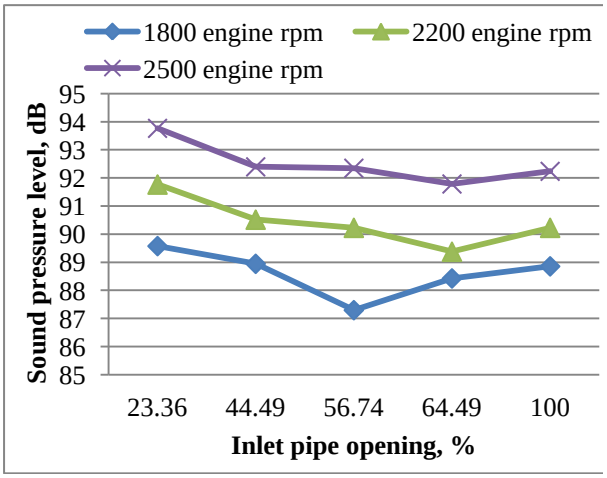

Fig. 3 Sound pressure level at different air intake opening and engine rpm

3.4 Exhaust gas configuration

The effect of engine rpm and inlet pipe opening on exhaust gas configuration was observed in terms of CO_2 and NOx level concentration in exhaust gas.

3.4.1 CO_2 level

The maximum CO_2 level of 3.94 % was observed during 23.36% inlet pipe opening and 2500 engine rpm, while minimum CO_2 level of 1.8 % was observed during 100% inlet pipe opening and engine rpm of 2200. The CO_2 level normally increased with increase in engine rpm, which may be due to more burning of fuel. While, no distinct patterns were obtained for different inlet pipe opening (Fig. 4).

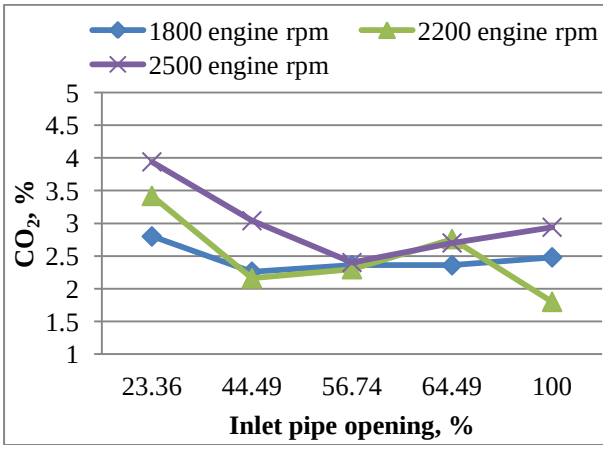

Fig. 4 CO_2level at different air intake opening and engine rpm

3.4.2 NO_x level

The maximum NO_x level of 284 ppm was observed during 56.74% inlet pipe opening and 1800 engine rpm, while minimum NO_x level of 151.4 ppm was observed during inlet pipe opening position of 100% and engine rpm of 2500. The NO_x level decreased with increase in engine rpm. The effect of inlet pipe opening on NO_x did not follow any pattern as shown in Fig. 5.

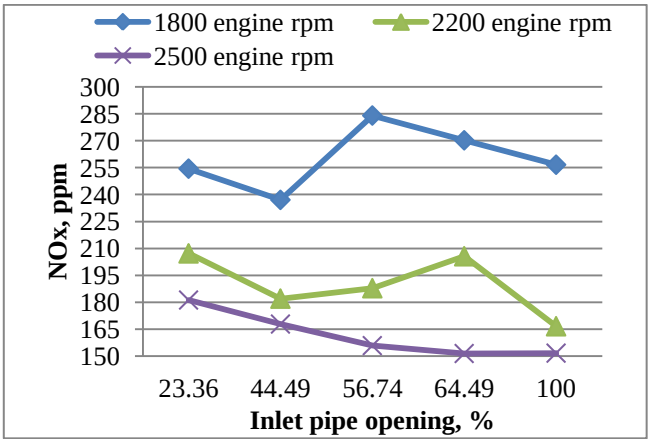

Fig. 5 NO_x level at different air intake opening and engine rpm

Based on the above study, it is obvious that engine rpm affected the various parameters undertaken on engine performance. Effect of air intake pipe opening was more on the vacuum pressure generated in the bypass than other parameters. Therefore, bypass may be used for pneumatic purposes without too much compromising with the engine performance.

4. Conclusions

Based on the results of the study, following conclusions could be drawn:

1) Increase in engine rpm, increased the fuel consumption, vacuum pressure in bypass, sound pressure level, CO_2 level and decreased the NO_x level.
2) With increased intake pipe opening lower values of vacuum pressure in by pass were obtained.
3) The inlet pipe opening of 44.49% and below was able to generate sufficient vacuum in air intake bypass, which may be used for the pneumatic purposes.
4) Since, no distinct pattern for fuel consumption, sound pressure, CO_2 and NO_x levels level were obtained for different air intake pipe openings, thus bypass may be added to intake pipe.

Based on the above, it may be said that tractor air intake bypass may be used for pneumatic purposes without much compromising with the engine performance.

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