Experimental Study on Effect of Transient in Engine Speed on Emissions of Multi-Cylinder Diesel Engine

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Abstract— Growing interest in quantifying and reducing the amount of engine emissions of CO, HC, and NOx loading the environment has led to increasingly tighter environmental regulations. Non-road emission standards are performed according to a steady-state test cycle, which does not include transient effects of emissions and thus underestimates the amount of emissions produced in real use of the engine. This study shows the effects of transients in engine speed on the fuel consumption and emissions in Multi- Cylinder diesel engines. Fuel consumption and emissions from the engines were measured in an engine dynamometer during various transient load conditions. The results showed that during fast transients, the measured fuel consumption was large. The effects of transients on emissions of nitrogen oxides were even greater, as effects of transient load increase with increasing transient conditions. In this study increasing in load there was increasing in fuel consumption NOx, HC and CO emissions.

Keywords: Transients in engine speed and torque, CO, NOx, HC.

I. Introduction

Multi-cylinder engine can have a better fuel economy compared to a single cylinder engine; it depends on the capacity of the cylinder, the size of the valves and how much they allow the fuel or air for diesel engines. One reason that I know of for a multi-cylinder engine to be preferred to a single cylinder engine is because it gives less stress to the engine when running it also causes the engine to be more stable. In addition a multi-cylinder engine has less time between power strokes so the engine is more efficient.

Turbocharger technology was improved greatly by developments during World War II and subsequent development of the gas turbine. It was now possible to use smaller turbochargers on smaller, higher-speed engines. Diesel locomotives with turbo diesels began appearing in the late 1940s and 1950s.

A turbocharged diesel engine has good characteristics that can improve fuel consumption rate, exhaust emissions, and the increase of specific power output of the engine. Such as a rapid acceleration or a sudden large load application, and then result in a worse response performance than those of naturally aspirated engine.

An experimental study was performed to investigate the improvement of transient characteristics of a turbocharged diesel engine under the conditions of low speed and fast acceleration with the load.

By the adopting the turbocharged diesel engine, the maximum thermal efficiency is increased, while turbo charged vehicle has a weak point of poor drivability under transient running conditions when the turbocharger does not work effectively, especially at low speed operation and rapid acceleration.

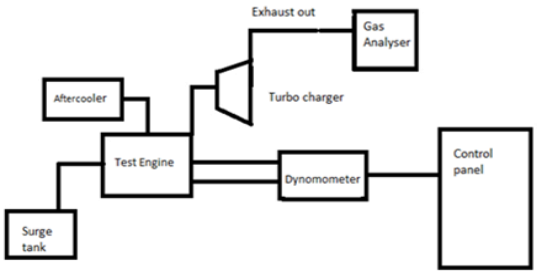

Fig. 1: Schematic layout of Experimental set up

II. Experimental Procedure

A Multi- cylinder 4-stroke water cooled diesel engine developing 242 kW at 1500 rpm was used. Engine details are given in Table 1. The schematic of the experimental setup is shown in Figure 1. An eddy current dynamometer was used for loading the engine. The fuel flow rate was measured on the volumetric basis. Experiments were initially carried out on the engine at 55 kW, 70 kW and 80 kW loads using diesel to provide base line data. Taking all measurements during the start of the engine to steady state condition.

Table 1. Experimental Setup Specifications.

Engine	**Caterpillar 3406 dita GP - 2, Four-stroke, six cylinder, water cooled diesel engine**
Maximum Power	242 kW @ 1500 RPM
Bore x Stroke	137*165 mm
Compression Ratio	14.5:1
Dynamometer	Eddy current dynamometer with loading unit

III. Results And Discussions

A. 3.1 Transient in Engine Speed According To Time, Sec(S)

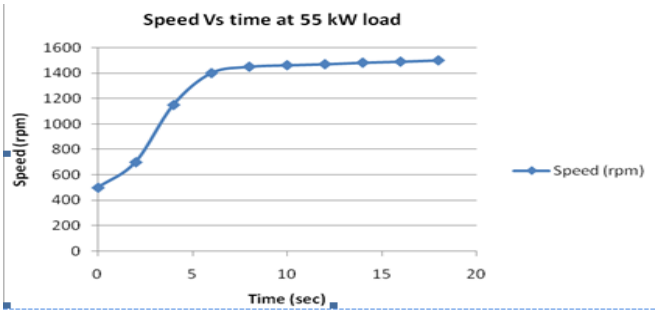

Fig 3.1: Transient in engine speed according to time (sec)
Transient zone is 0 to 10 sec(s) and then after engine get steady condition. 500 to 1400 rpm is a transient zone.

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B. 3.2 Transient in Engine Speed Vs Hydrocarbons

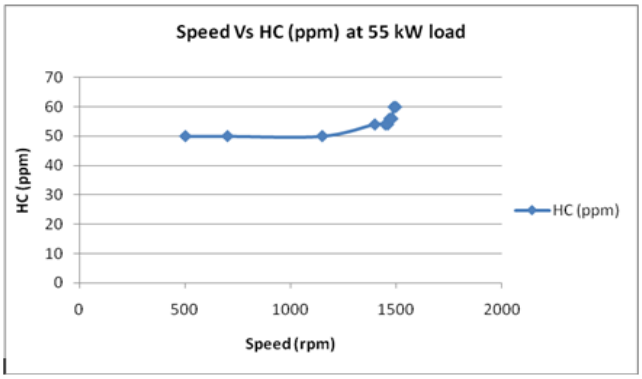

Fig. 3.2: Effect of transient in speed on HC

Whenever transients in engine speed there was increasing in hydrocarbons due to lean mixture of air- fuel. During transient in speed modest increasing in hydrocarbons.

C. 3.3 Transient in engine speed Vs NOx emissions

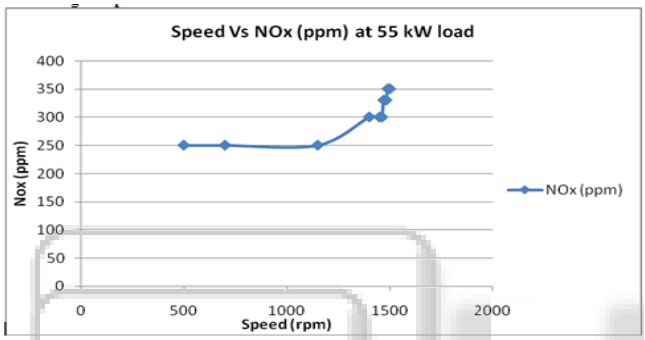

Fig. 3.3: Effect of transient in speed on NOx

Larger increasing in NOx with transient in speed as shown in the fig 3.3 due to increasing peak combution temperature and fuel consumption. Here transient in speed is 500-1400 rpm as shown in fig 3.3.

D. 3.4 Transient in Engine Speed Vs Carbon Monoxide (Co) Emissions

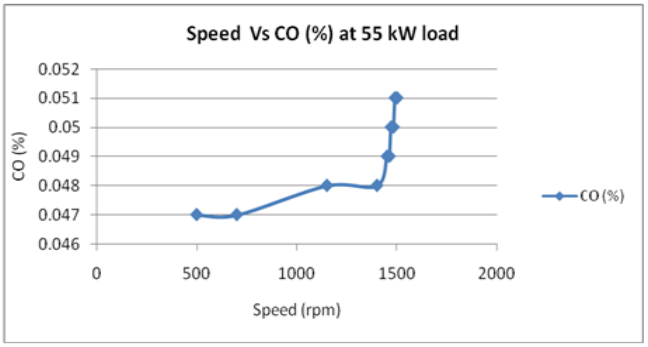

Fig. 3.4: Effect of transient in speed on CO emission

Whenever transients in engine speed there was increasing in Carbon monoxide (CO) due to incomplete combustion of fuel. In this graph maximum point of CO (0.051 %) emission is 1500 rpm as shown in fig 3.4. CO emissions suddenly large increased during transient condition because of more fuel consumption compared to steady state condition as shown in fig 3.4.

E. 3.5 Transient in Engine Speed According To Time, Sec(S)

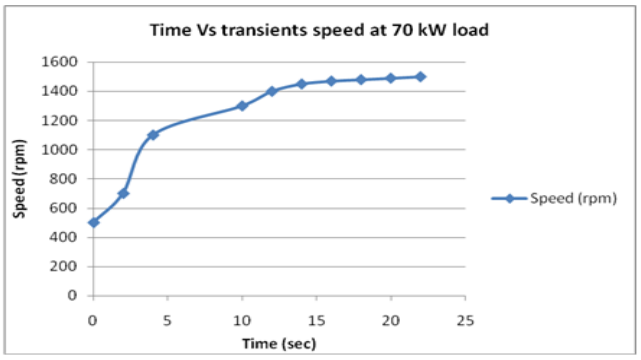

Fig 3.5: Transient in engine speed according to time (sec)

Transient zone is 0 to 14 sec(s) and then after engine get steady condition.

F. 3.6 Transient in Engine Speed Vs Carbon Monoxide (CO) Emissions

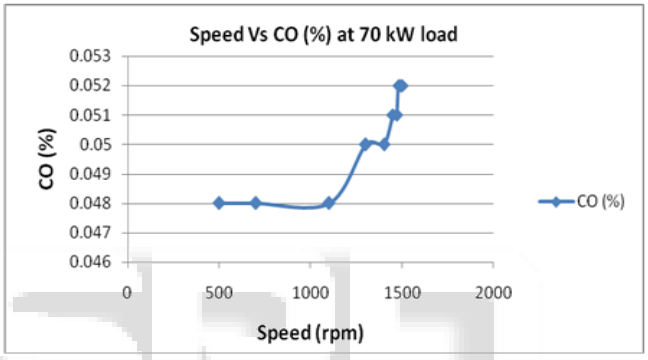

Fig 3.6: Effect of transient in speed on CO emission

Whenever transients in engine speed there was increasing in Carbon monoxide (CO) due to incomplete combustion of fuel. In this graph maximum point of CO emission is 1500 rpm as shown in fig 3.6. CO emissions suddenly large increased during transient condition because of more fuel consumption compared to steady state condition as shown in fig 3.6.

G. 3.7 Transient in Engine Speed Vs Hydrocarbons (HC) Emissions

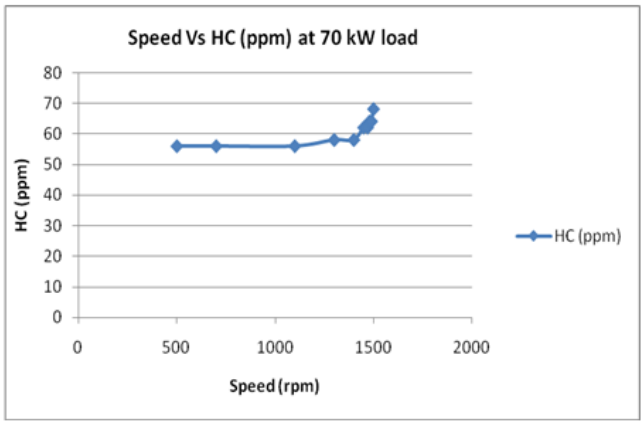

Fig 3.7: Effect of transient in speed on HC emissions

Whenever transients in engine speed there was increasing in hydrocarbons due to lean mixture of air- fuel. Fig 3.7

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clearly showed that modest increased in hydrocarbons during transient in engine speed.

H. 3.8 Transient Speed Vs Hydrocarbons (HC) Emissions

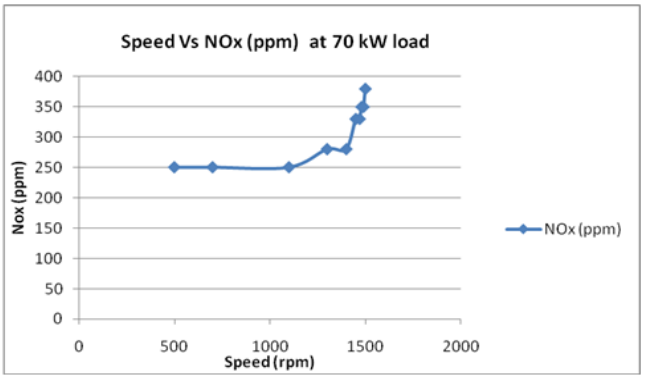

Fig 3.8: Effect of transient in speed on NOx emissions

NOx increased with transient speed as shown in the fig 3.8 due to increasing in peak combustion temperature and more fuel consumption at increasing in load. Fig 3.8 clearly shows that large value of increased in NOx emissions during transient speed (500-1300) rpm is a transient condition and there after engine get steady state.

I. 3.9 Transients in Engine Speed According To Time, Sec(S)

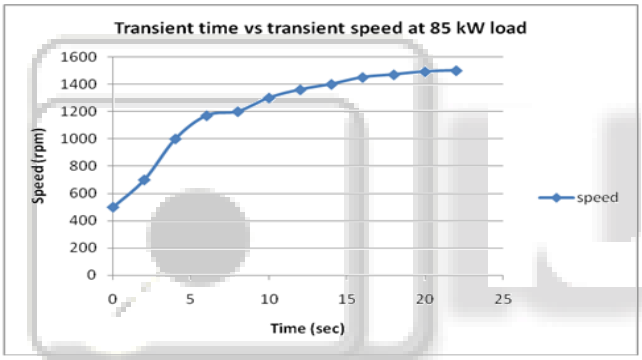

Fig 3.9: Transient in Engine Speed According To Time (Sec)

Transient zone is 0 to 16 sec(s) and then after engine get steady condition.

J. 3.10 Transient in Engine Speed Vs Carbon Monoxide (CO) Emissions

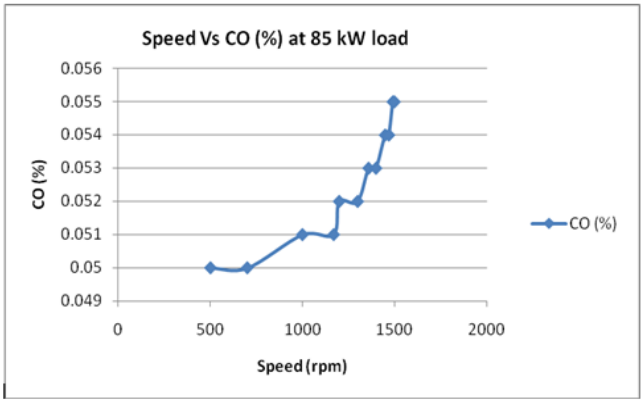

Fig 3.10: Effect Of Transient In Speed On CO Emission

Whenever transient in engine speed there was increasing in Carbon monoxide (CO) due to incomplete combustion of fuel. In this graph maximum point of CO emission is 1500 rpm as shown in fig 3.10. Fig 3.10 also shows that, CO increased with transient in speed(500-1300 rpm is a transient speed).

K. 3.11 Transient in Engine Speed Vs Hydrocarbons (HC) Emissions

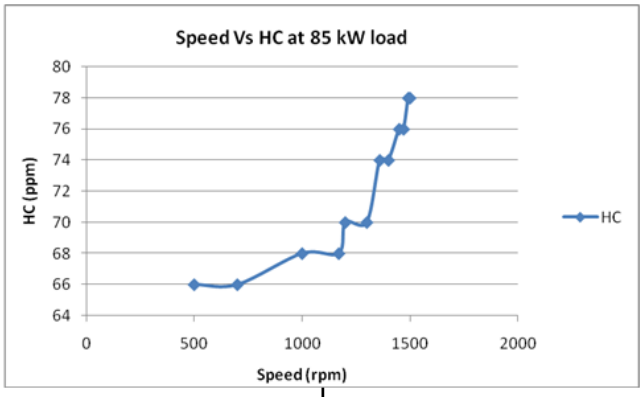

Fig 3.11: Effect Of Transient In Speed On HC Emissions

Whenever transients in engine speed there was increasing in hydrocarbons due to lean mixture of air- fuel. Fig 3.11 clearly showed that modest increased in hydrocarbons during transient in engine speed. In this graph HC continuously increased at transient zone 500-1400 rpm.

L. 3.12 Transient in Engine Speed Vs Nox Emissions

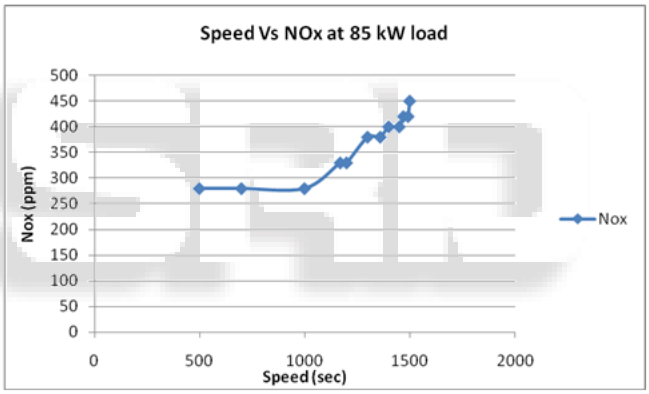

Fig 3.12: Effect of transient in speed on HC emissions

NOx increased with transient in speed as shown in the fig 3.12 due to increasing in peak combustion temperature and more fuel consumption. Fig 3.12 clearly shows that small value of increased in NOx emissions due to increasing in load.500-1000 rpm NOx suddenly increased and there after modest increasing in NOx emissions.

IV. CONCLUSIONS

This paper presents analysis of various parameters and drawn following conclusions:

From the experimental study:

- Whenever Transient in engine speed, larger increasing in carbon monoxide (CO) , Nitrogen oxide (NOx) and modest increasing in Hydrocarbons(HC) emissions because of incomplete combustion, more fuel consumption, high peak combustion temperature and lean air-fuel mixture.
- Also increasing in load there was also increasing in carbon monoxide (CO), Nitrogen oxide (NOx), Hydrocarbons during transient in engine speed.

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