PROCEDURE OF DETERMINING THE MAIN CHARACTERISTICS OF INTERNAL COMBUSTION ENGINES WITH LAND & SEA DYNO-MAX DATA ACQUISITION SOFTWARE AND TEST BED

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Abstract: *The aim of the article is to present and evaluate the results of a internal combustion engine with the Dyno-Max Software and the test bed, which has a high applicability in the field of internal combustion engines and automobiles as well as the peripheral related equipment. For research it was used a Chevy 350 engine with a 350 cubic inch (5.7-liter) small block V8 with a 4.00 and 3.48 inch bore and stroke. The base version of this engine makes 195 horsepower and features an 8.5 compression ratio.*

Keywords: *combustion engines, Dyno-Max Software, test bed*

1. INTRODUCTION

Dynos Software and equipment it is used in field of automotive (auto engine, axel-hub engine, chassis, kart, motorcycle, tractor, truck- heavy duty, see FIG.1), marine, industrial but also for manufacturing prototypes of products custom made.

(a) heavy-duty (20”roll) AWD systems for multi-axle trucks

(b) single-axle, dual-axle, and even AWD tri-axle dynos

FIG. 1. Land & Sea’s DYNOmite Truck Chassis Dynamometer Systems combine super-duty frames and rollers with DYNO-MAX™ software for sophisticated industrial diagnostics and power testing.

“Pro” Docking Station Dynos (right) include: stationary heavy-duty steel absorption frame, quick-clamp engine cart with adjustable mounts, telescoping driveshaft with U-joints and hinged guard, 13" toroidal flow water-brake absorber, CW starter (accepts optional second CCW starter), electronic auto-load servo, DYNOmite data-acquisition computer, bidirectional full-bridge load cell, battery compartment.

"Pro" console, stainless-braided hoses, engine-temperature thermistor, thermostatic coolant tower, illuminated wiring/coolant and wiring subsystem with full-function data harness. (AC absorber optional.)

DYNO-MAX™ software option creates a full engine dynamometer lab on your Windows PC. Features include: real-time trace graph display, adjustable voice/color limit warnings, pushbutton controls, plus user configurable analog and digital gauge ranges. Publication-quality color graphs and detailed reports are available for printing or even importing into other programs. With appropriate automated electronic loading and throttle control hardware options, operators can easily execute complex race simulations and engine test cycles, see FIG 2. [1]

(a) Stationary Test Stand Dynos

(b) Mobile Test Stand Dynos

FIG. 2. The Test Stand Dynos

The Chevrolet small-block engine is a series of automobile V8 engines built by the Chevrolet Division of General Motors. The particularity of this engine generation is that the General Motors are using the same basic engine block. [2] The Chevy 350's V8 block is one of the most productive engines in history with many variants. On this type of engine it can be performed representative tests. [3]

2. THEORETICAL ASPECTS

The typical engine dynamometer test cell example it consists from CO Detector, windows, sound-bloc wall, load control valve, PC Cameras, air compressor, absorber return line, engine cooling tower, water-brake absorber, supply-water tank, sump pump, water-pressure regulator, bladder surge tank, centrifugal supply pump, fuel tank. (FIG. 3) [4]

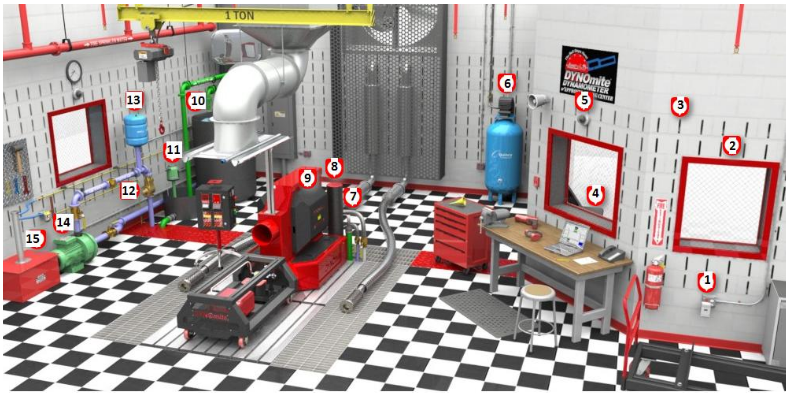

FIG. 3. The typical engine dynamometer test cell

In Table 1 are detailed the components of the typical engine dynamometer test. This configuration can be achieved in a high performance test with the test bed. Similar opportunities for optimally matching components and streams exist in considerably more complex systems for power and torque test. [5]

Table 1. Main parts of the typical engine dynamometer test

Nr.	Label	Specification
1	CO Detector	Carbon monoxide alarm digitally monitors the cell's CO levels and sounds an alarm above safe limits. Place low to floor for earliest warnings against dangerous exhaust leaks.
2	Windows	Sound-rated windows feature multiple panels of thick (1") laminated fire-rated safety glass with solid-concrete filled steel frames.
3	Sound-Bloc Wall	Sound-absorbing acoustical-lined chambers in thick (8"-12") concrete block and sand-filled cores, provide great sound attenuation, reduced echoing and excellent fire rating.
4	Load Control Valve	Manual or electronic servos valves control the absorber's fill level (loading) during testing.
5	PC Cameras	Networked cameras provide extra control-room eyes, with optional recording, into test cell activities.
6	Air Compressor	Air-compressor and storage tank provide regulated air for pneumatic service tools and other equipment - in both test cell and general shop.
7	Absorber Return Line	Unsubmerged drain line(s) from absorber to sump tank or city sewer.
8	Engine Cooling Tower	Cooling-tower assemblies provide thermostatic controll to maintain precise engine temperature with minimal water usage
9	Water-Brake Absorber	Water-brake dynamometer absorbers are the most cost effective loading devices available for engine testing.
10	Supply-Water Tank	Unpressurized water storage tank
11	Sump Pump	High-volume high-temperature sump pump - used to transfer absorber discharge water from a small gravity-drain tank to a verticaly-higher main supply tank.
12	Water-Pressure Regulator	Very-high-volume pressure reducing valve limits pressure to load-control valve to 60-PSI maximum
13	Bladder Surge Tank	Air-charged bladder tank, prevents "water hammering" as load control valve rapidly opens and closes.
14	Centrifugal Supply Pump	High-volume low-pressure pump delivers 40 to 60-PSI to load control valve.
15	Fuel Tank	Small-volume fuel cell provides safe storage of test fuel.

The standard document has been produced by the Society of Automotive Engineers to provide a standard method of obtaining repeatable measurements that accurately reflect real world engine performance. The software has a equation background and some of the basics mathematical. Calculation model and validation is made after many formulas like:

$$Power = EngineSpeed \times Torque$$

$$P[kW] = \frac{2\pi[rad]xN[rpm]x\tau[Nm]}{60[rev/\min]} \quad (1)$$

$$SweptVolum = \frac{\pi \times BoreDiameter^2 \times Stroke}{4} \quad (2)$$

$$V_{Swept}[mm^3] = \frac{\pi \times (b[mm]^2) \times s[mm]}{4} \quad (3)$$

$$BreakMeanEffectivePressure = \frac{P}{V_{swept} \times N} = \frac{\tau}{V_{swept}} \quad (4)$$

$$FuelMassFlowRate = \dot{v}_{fuel} \times Density\_of\_Fuel = \dot{v}_{fuel} \times Fuel\_Specific\_Gravity \quad (5)$$

$$\dot{m}_{fuel}[kg/hr] = \dot{v}_{fuel} \times \rho_{fuel} \quad (6)$$

$$SpecificFuelComsumption = \frac{\dot{m}_{fuel}}{P} \quad (7)$$

$$AirFuelRatio = \frac{\dot{m}_{air}}{\dot{m}_{fuel}}$$

$$AFR = \frac{\dot{m}_{air}[kg/hr]}{\dot{m}_{fuel}[kg/hr]} \quad (8)$$

$$Lambda = \frac{AirFuelRatio}{StoichiometricAirFuelRatio} \quad (9)$$

$$MeanPistonSpeed = \frac{2 \times N \times s}{t} \quad (10)$$

For calculation of engine friction, the Chen-Flynn Friction model is used. The equation used to calculate friction is given below:

$$FMEP = A_{cf} + \sum_{i=1}^{ncyyl} [B_{cf}(P_{\max}) + C_{cf} \cdot (S_{fact})_i + Q_{cf} \cdot (S_{fact})_i^2]$$

$$S_{fact} = RPM \cdot \frac{stoke}{2} \tag{11}$$

where: A_{cf}, B_{cf}, C_{cf}, Q_{cf} need user input according to parameters of the calculation engine (the value of FMEP is modified using the test data for this study); P_{max} is maximum cylinder pressure; RPM is cycle-average engine speed; stroke is cylinder stroke. [6]

For calculation of the power correction factor it will be used the formula:

$$P_{corrected}[kW] = P_{observed}[kW][1.18\left(\frac{99}{p_{air}[kPa]}\right)(\{\frac{T_{air}[^{o}C] + 273.15}{298.15}\}[K] - 0.18)] \tag{12}$$

3. EXPERIMENTAL RESULTS

A mainly used in applications that require a high power output and a reliable, small size and lightweight power producing system. One of these applications it can be made with the Dyno-Max Software and the test bed. After a demonstrative feature of the tested engine it can be seen hat the all the need parameters are monitored and analyzed. On Table 2 are more detail on the engine model. [7]

Table 2. Engine Model used for the test

Engine Model	350 Chevrolet	
Engine Description	Crate Engine	
Bore	4,000	inches
Stroke	3,480	inches
Air temp	55	degree F
Barometric pressure	38,25	in Hg
Weight	3450	lbs
Descrintion	1988 Chevrolet Coivette Coupe	

The results demonstrated the accuracy and precision that it proves especially when raising the power needs to enrich high performance. Results from the engine model 350 Chevrolet used for the test show exactly the same quantitative performance guaranteed by the manufacturer. Table 3, FIG. 4 [8]

Table 3. Results from the engine model 350 Chevrolet used for the test

RPM (RPM)	Hp(Hp)	Torque(ft-lb)
1700	119.9	360.9
1000	125.9	368.0
1900	137.2	379.5
2000	145.2	381.0
2100	149.9	374.8
2200	156.7	374.3
2300	166.8	380.8
2400	175.1	382.8
2500	187.2	393.5
2600	195.5	394.5
2700	197.9	384.9
2800	204.6	384.2
2900	214.3	383.7
3000	221.3	386.9
3100	230.2	390.7
3200	235.8	386.0
3300	242.1	385.8
3400	246.8	380.9
3500	253.0	379.8
3600	255.2	371.7
3700	258.9	367.6
3800	262.3	363.0
3900	271.0	365.0
4000	276.8	363.4
4100	273.5	350.2
4200	275.3	344.4
4300	270.2	329.3
4400	268.1	320.0

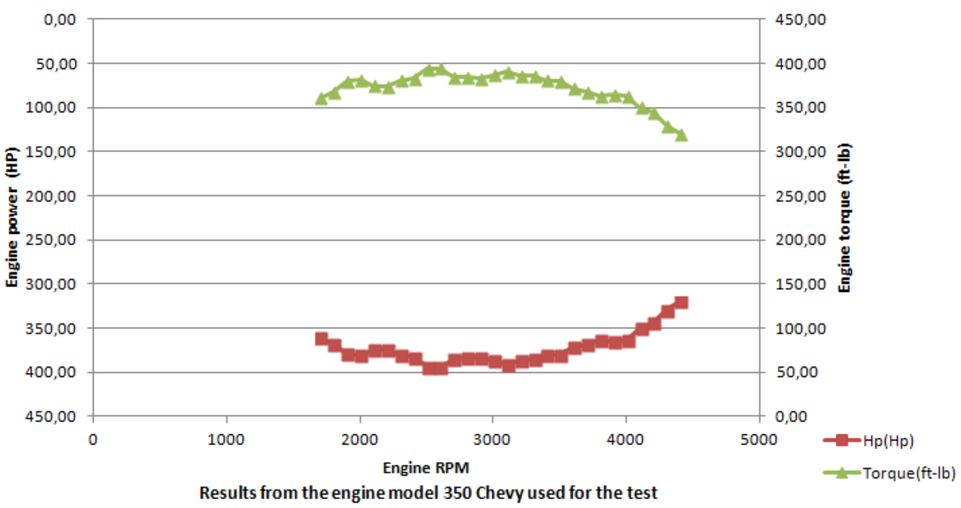

FIG. 4. Diagram of the results from the engine model 350 Chevrolet

Even if due to the fact that the test parameter can may vary slightly on a tolerance of 2-3% but no more, that fact is assumed by the variables like medium temperature, air pressure. During the study on a test bench in the form of a chainsaw the acoustic characteristics and the hydraulic resistances of the created silencers were determined. According to the obtained results of the research the most effective method is to use the same fuel, to repeat the test in the same period of time. [9]

The proposed solutions are experimental. It can be seen that the higher peak of the test it is at the 4000 PRM were we have 276 HP and 363,4 ft-lb. The analysis of scientific literature indicates the absence of a common approach regarding the internal efficiencies. [10] But modeling results for the internal efficiencies are up to 90%. The designed process and with an assumed maximum cylinder pressure of 150 bar simulation, the process can achieve an effective efficiency of more than 90%. [11] This results can be produce which at lower costs than other systems. [12]

In some case the calculation are made also to simulated steam mixtures is between 2 m/s and 8 m/s at a pressure of 1 bar. [13]

In FIG. 5 it can be seen the software interface of the Dyno Software while testing the engine parameters running though the test.

(a) DYNO-MAX "Pro" features numerous built-in consoles

(b) DYNO-MAX powerful graphing and data presentation tools

FIG. 5. The typical software interface of the Dyno Software while testing the engine parameters

4. CONCLUSIONS

With the DYNO-mite Dynamometer Software and data acquisition it is possible to test applications for the following domains like automotive, industry and also manufacturing more types of dynamite dynamometer systems than any other company - in the world. Products include: outboard, marine, or PWC prop-shaft hydraulic dynamometer, kart, RC, and snowmobile dyne kits, tractor-PTO trailer and towing (drag) dynamometers, data-acquisition, do-it-yourself dynamometer plans, and used dynes.

Another advantage would be the ease of use of software and logistics equipment. The results obtained are processed in the most efficient way possible and in the shortest time and the accuracy of data acquisition has minimal deviations.

5. ACKNOWLEDGMENT

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