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A New Engine Simulation Structure Model Applied to SI Engine Controlling

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ABSTRACT

High ratio emissions that outcome from incomplete combustion cause air contamination, poorer the performance of the spark ignition (SI) engine and raise fuel consumption. Because of engine configurations, engine wrong adjustment and engine subsystems, unfortunately completed combustion is not possible with SI engines .As a result of uncompleted combustion a high ratio of CO, HC, NO_X and PM harmful emissions such as come into atmosphere. Study has exposed that exact AFR control can successfully decrease emission of dangerous exhaust, such as CO, NO_X and unburned HC. To achieved this goal we need to make a correct engine simulation structure which it can be used to controlling AFR. Firstly, the existing engine simulation models and structures will be studied in this paper, where benefits and disadvantages of several simulation models and structures kinds are discussed. After that we will present our new engine simulation structure model.

KEY WORDS: *SI Engine; Structure Model; Emission*

NOMENCLATURE

mvem	mean value engine model
P_i	Pressure of intake manifold
n	Speed of engine
m_f	Flow rate of fuel to the intake valve
T_i	Temperature of intake air
m_{at}	air mass flow past throttle plate
m_{ap}	air mass flow into the intake port

1.0 BACKGROUND OF ENGINE SIMULATION MODELS

Late at 1970's, a model which is produced by [3] has been generally settled as a standout amongst the most widely recognized routines for the depiction of engine systems (SYS). Four fundamental segments of the SYS are incorporated in this model. They are exhaust gas recirculation (EGR), fuel, intake and ignition SYSs. Cassidy model give well execution in simulating procedure, be that as it may, because of its inconvenience, it is not proper for development and assessment of the engine control SYSs. Aftereffects of reenactment and tests are the premise of the model and it has a restricted notoriety. Linearization is utilized for acquiring a percentage of the mathematical statements and parameters of the model so that the dynamic attributes of engine can't be accurately reflected. From 1980s to now, the electronic controlled engine utilized both of static engine model and the semi static engine model [7, 9, 5].

It is conceivable to mirror a few engine presentation parameters in the stable conditions because of steady state examinations of engine are the source of model information. Two fundamental purposes behind putting these models separated and not utilizing them prevalently are:

They can't mirror the dynamic attributes while the engine is working under transient conditions.

They are absolutely needy to the experimental information so that require high measure of labour and material resources. For conquering the disadvantages of the aforementioned engine models and simulation of the qualities of dynamic, a model named the mean value engine model (MVEM) was arranged and got extra advancement by distinctive researchers [4, 8, 3]. Finally, Hendricks methodically compressed the mean model [5]. For the most part, for explaining the dynamic procedure of the engine, the mean value of variables included in cycle SYS of the engine is utilized as a part of this model. Accordingly, the engine dynamic qualities can be effectively reflected in the transient conditions. In this manner, researchers and analysts created and upgraded the MVEM overwhelmingly in the oil film are and in addition the torque models. Together with the science and innovation change, numerous researchers improved the MVEM; they have connected hybrid models and astute control also. The extent of the MVEM application has been spread by [6] since he connected this model to a turbocharged gas engine. The air/fuel effect and spark angle have been considered by [10, 11, 12] on the yield torque. Subsequently, by a low precision model mistake of beneath 5%, it is conceivable to apply the mean model to the lean burn engine. For displaying of gasoline engine, a hybrid model was set up by [2].

2.0 ENGINE SIMULATION STRUCTURE

Figure 1 outlines the structure of engine simulation structure proposed by [1] which has some crucial and fundamental constituting blocks. There are six engine model inputs as underneath:

- Speed of engine (N),
- Angle of the throttle (alpha),
- External temperature (T_e),
- Eternal pressure (P_e),
- Temperature of engine manifold (T_m),
- Time of fuel injection ($T_{i\ -com}$).
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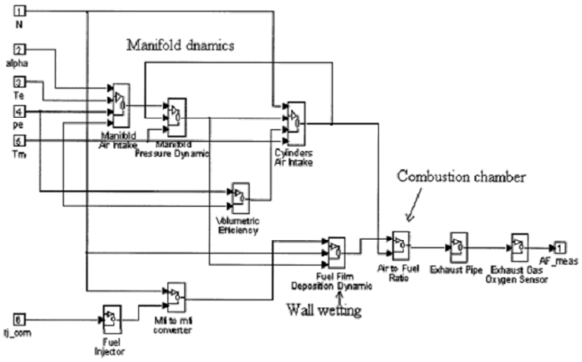

Figure 1: Engine Simulation Block (Alippi, Russis & Piuri, 2003)

The AFR can be spoken to by the simulation block output. Really, by method for gathering the block of manifold air intake, dynamic of manifold pressure and block of cylinder air intake, it is conceivable to perform the estimations of the air mass into the cylinder. Measure of fuel mass into the cylinder can be dictated by utilizing fuel injector and the dynamic of fuel film deposition, utilizing a proper physical driven model, two blocks. Identification with the AFR and exhaust pipe are characterized as engine AFR.

Figure 2 demonstrates the model of engine simulation which is introduced by [13]. There are two input variables (throttle open angle (u) and fuel flow rate (mfi)), and one output (AFR (air fuel ratio)) in this model of engine simulation. Symbols utilized as a part of this model are as per the following:

- P_i, Pressure of intake manifold
- n, Speed of engine
- m_f, Flow rate of fuel to the intake valve
- T_i , Temperature of intake air
- m_{at}, air mass flow past throttle plate
- m_{ap}, air mass flow into the intake port

By executing air mass flow and fuel into the intake port which is taken structure manifold pressure block and fuel injection block, the AFR is calculated in the AFR block.

In like manner, in the block of speed of engine, the engine speed is computed. Block of time delay is utilized for simulating the AFR time delay which is join in the counts amid the simulation of engine. Model of manifold temperature alludes to the air mass flow into the intake port, intake manifold pressure and air mass flow past throttle plate for processing the intake manifold temperature. Dynamics of Fuel film of the intake ports can be simulated by the fuel injection model.

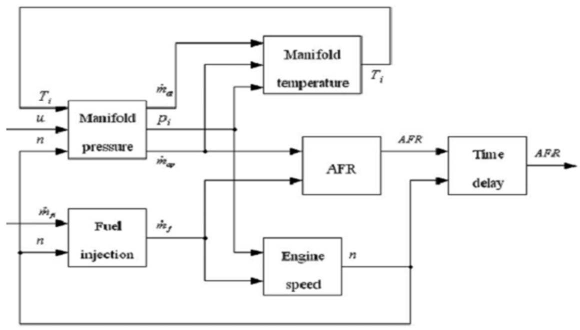

Figure 2: Engine Simulation Model (Wang & Yu, 2008)

Countless of SI engines can be simulated by an engine model (a nonlinear dynamic model) which is presented by [12]. Diverse variables which are incorporated in the engine simulation model are represented in figure 1.3. They are:

Input variables:

- angle of throttle (α),
- flow rate of fuel (m_{fi}),
- spark timing (SA),

Disturbance:

- load of torque (T_L),

State variables:

- mass of air in throttle (m_{at}),
- mass of air into cylinder (m_{ap}),

- air to fuel ratio (λ_c),
- engine brake torque (T_{br})
- mass of fuel in the fuel film (m_{fc})

Output variables:

- pressure of intake manifold (P_{man}),
- speed of engine (N)
- AFR time delay (λ_e).

Calculation technique is same as two past models. Mass of Air and fuel into the cylinder are initially calculated by the model. Besides, the engine AFR is processed. At long last, for Calculating torque of the engine brake, torque generation model is used. Rotational dynamics of the engine, intake manifold and fuel film are incorporated in the model of [12] and transport delays which are common in the four stroke engine cycles.

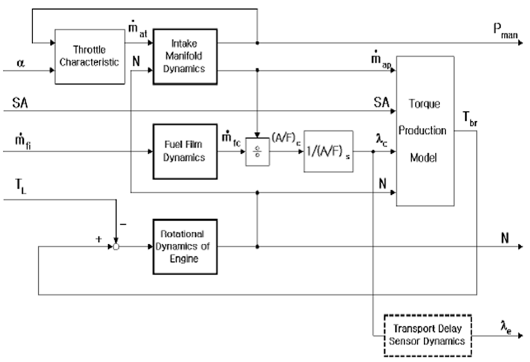

Figure 3: Nonlinear Dynamic Engine Model (Yoon et al., 2000)

Figure 4 demonstrates a nonlinear model of engine which is presented by [4]. There is no thermodynamic model included in their study for car IC engines. Be that as it may, the throttle dynamics, pumping wonders of engine, prompting procedure dynamics, SYS of fuel injection, torque of engine, inertia of rotating and EGR SYS dynamics are being spoken to in this simulation model.

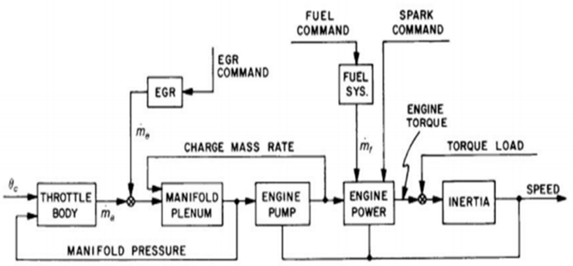

Figure 4: Nonlinear Engine Model (Cook & Powell, 1988)

A few diverse simulation model structures are exist that are excluded in this writing survey. This is on account of they may be like the examined models or lack adequate points of interest.

3.0 DISCUSSION

Some broad elements can be begun in four recreation models specified previously. As an illustration, the entire model can be isolated into three sections: computation of mass of air into cylinder is the first; the other one computes mass of fuel into cylinder, third part, at last, dissects speed of engine or torque output or the model of A/F based on the outcomes of first two parts. Be that as it may, Different qualities are incorporate in every model. Exhaust pipe dynamics is considered in Alippi's simulation model. The intake air temperature is recreated in Wang's model. Both of the sparking time impact and throttle progress are incorporated in Yoon's model. Powell's simulation model is the main model in which a block for the exhaust gas distribution SYS dynamic is exists. Developing AFR controllers is one of the primary goals of this paper. To accomplish this objective, it is obliged to utilize a bundle of engine simulation in which the intake air and fuel dynamics can be viably reproduced.

In view of the engine simulation models explored over, another model of engine simulation structure can be design.

4.0 PROPOSED ENGINE SIMULATION STRUCTURE

The greater part of the dynamic parts can be simulated well in the Wang's engine simulation model. Be that as it may, throttle body is not considered in this model. Due to this, we will consolidate this model with throttle body dynamic model. We utilized entire box of intake manifold dynamics rather than manifold pressure and temperature dynamics.so ,this new model of simulation incorporates three input variables: throttle angle (α), engine speed (N), injection fuel rate ((mfi)˙) and two outputs A/F ratio and torque of engine Figure 1.5 represents our new engine simulation structure.

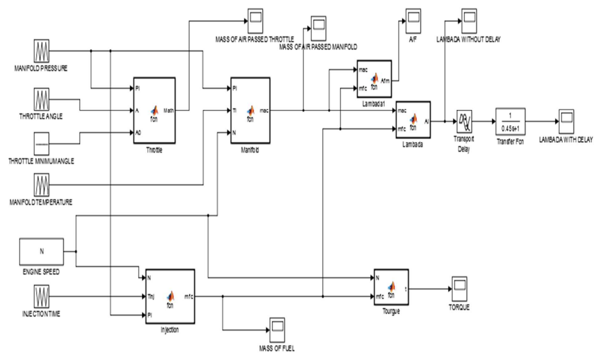

Figure 5: New Engine Simulation Structure

5.0 CONCLUSION

Study has uncovered that correct AFR control can effectively diminish emission of unsafe exhaust, for example, CO, NO_X and unburned HC. To accomplished this objective we have to make a right engine simulation structure which it can be used to controlling AFR. Firstly, the current engine simulation models and structures will be mulled over in this paper, where advantages and disservices of a few simulation models and structures types are discussed. After that we design our new engine simulation structure model which this model is exceptionally competent structure to utilizing in engine parameters controlling, for example, AFR and torque.

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