Engine Development: *Engine Performance Testing*

by Ir. Hamzah bin Adlan

THE automotive industry in Malaysia started in the 1960s when the government granted license to assemble vehicles to several companies. Prior to that, most vehicles were imported into Malaysia in CBU form (Completely Built Up). As time pass, the local automotive industry gradually grew from being a car assembler to product development ranging from vehicle design up to engine development.

Engine development is considered a new area in Malaysia as the automotive industry is relatively young compared to other more established global automotive players. The word 'powertrain' refers to an engine and a transmission link-up or configuration according to the automotive dictionary. The powertrain department of an automotive company is responsible for designing and developing the engine and transmission.

Engine expenditure incurs almost 40% of the total cost when a new vehicle is developed. This essentially means that if a manufacturer could control the cost of producing engines by developing its own, it could more than likely control the entire selling price of its cars. Based on this simple mathematic rationale, more automakers have started establishing their own in-house engine development program despite realising that the design, development, testing and manufacturing process entail a significant initial investment.

Engine development is divided into several stages, including prototype, production-intent parts and pre-production, before it goes into mass production. At every development stage, a certain number of engines have to be built to comply with each test which has been agreed upon in advance. This is called a 'Stage Gate' where a formal meeting is set up to discuss and agree on the way forward or vice-versa.

Engine rig-up in a dynamometer (source: http://www.modified.com/)

A special test, which is called the Engine Performance Test, must be conducted to verify the development specification. The performance curve criterion is one of the most vital components derived from performance and functional specifications when deciding whether to proceed to the next development stage or not. Normally, a dynamometer is used to measure the engine performance in order to produce the curve. A dynamometer is an equipment that measures engine power, torque, engine speed, temperature and pressure related values. The collected data will then be analysed by the engineers and presented to project team members.

THE IMPORTANCE OF THE PERFORMANCE CURVE

a) The performance curve is one of the elements which have the biggest deciding factor in meeting agreed engine specification. Engine Specification is a technical document where all the targets and objectives of the engine development project are spelt out. It is a control document where access is closely guarded. Everyone who is involved in the project must strictly follow the document and any request for changes must go through a dedicated technical and commercial committee for approval.

b) The element in the performance curve is important to satisfy the project stakeholder who is usually the project leader. Normally, the project leader will keep track of every engine performance result, especially during the early development stage to make sure it meets or exceeds the target. Any lost of engine power, even as little as 2% or 3%, has a big impact on the total project duration as well as cost implication.

c) Engine designers are also keen on the engine performance curve aspect because it will show whether the system or sub-system, even at the component level, is working on a satisfactory level or not. It is normal, at each engine development stage, for engine performance curve results to be sent to every designer to make sure they are aware of what is going on during testing.

d) Meeting the engine performance curve requirement will satisfy the expectation of Production Quality Control (PQC) before the engine goes into mass production. People from PQC will check the performance of the engine even at the development stage to ensure its consistency even after the manufacturing date has passed.

HOW IS THE PERFORMANCE CURVE TEST DONE?

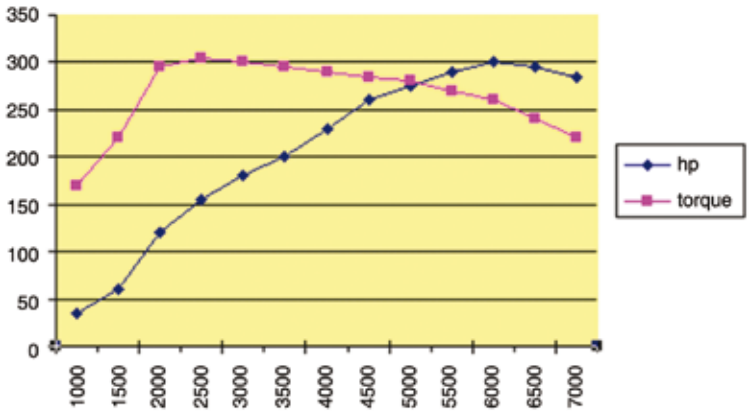
a) Normally, the test is planned in advanced before the actual testing, which is included in the master project schedule. The Test Request (TRF) is raised by the Engine Development Leader, then it cascades down to the test engineer where she/he will be appointed to a pre-designated engine test cell where a specific number of manpower will be allocated, and test duration scheduling and budget provisioning especially when these involve consumable items. In some cases, the Engine Built Request (EBR) is also needed when a special engine with unique features or newly revised components have to be added.

b) When the engine is completed, it is then passed to the integration team which will connect the engine to the dynamometer test rig. This is normally done outside the test room. By doing this, time and money could be saved especially when dealing with a large number of engines. The complete engine on the test rig will be coupled to the engine dynamometer using a universal joint linked to a propeller shaft. To make sure the engine, test rig, propeller shaft and dynamometer are in-line, an accurate alignment work is conducted by using a laser-guided alignment machine.

c) Before the actual test is run, a pre-test and sensor calibration must be done to ensure data integrity. Calibration of sensors can be executed using a master calibrator and an experienced engineer's help is always required to ensure that the pre-tested equipment is well and thoroughly checked.

d) The performance curve test is usually done by an automatic cycle which an engineer shall likely set beforehand. The raw data will be analysed and presented to the respective members in graph form. Sometime, there would be a need for re-tests due to technically unsatisfactory results as conducting the test on either a rainy/sunny day could spoil the results due to the sensitivity of the equipment.

e) Once confirmation from the project leader or chief engineer is obtained regarding the results, an official test report will be prepared and presented to the respective parties. Every test report is kept in the development library for each development stage for future reference.



Performance curve sample of a 300 BHP Mitsubishi 3000cc twin-turbo engine. (Source: Wikipedia)

WHAT ARE THE SAFETY PRECAUTIONS WHEN CONDUCTING THE PERFORMANCE CURVE TEST?

a) Isolation of the engine test room from the operation room – the room must be built with thick, double layered bricks to reduce noise and vibration issues. Furthermore, the gap between the operation room and the engine test bed is separated by a double layered, tempered and laminated glass for safety reasons. Further measures could be made by the installation of a laser detector to avoid any human operator from entering the room while the engine is running. The engine test bed design must be placed as a 'special island' surrounded by absorption materials such as epoxy to reduce transmitted vibrations.

b) Personal Protective Equipment (PPE) – proper PPE such as goggles, gloves, ear plugs, respirators, *etc.*, ought to be used while conducting the tests in a workshop environment handling special materials such as chemical compounds or dealing with composite fibre. Adequate training and implementation, followed by enforcement must be in place once it is officially gazetted.

c) Fire Prevention System – Fire extinguishers must be in place at all times. They must be checked periodically and proper training must be provided whenever newcomers join the organisation. Periodical fire drills must be conducted to ensure that everybody is aware what action has to be taken when any emergency occurs.

d) Proper storage of chemicals or hazardous materials must be enforced. They must be properly labelled and kept inside ventilated areas. Only people with the right authorisation are allowed to handle such materials.

e) Tools must be put in place with proper tags and in the correct arrangement. Measurement tools must be calibrated with the right control of standard calibration practices and corresponding certificates. Special tools must be locked safely where authorised usage must be made exclusive for better tracking and to create an organised inventory system.

f) Proper training is essential as part of the on-the-job training especially when dealing with engine test cells. This is regarded as a hazardous environment due to the source of fires and various chemicals that operators have to deal with cautiously. By conducting this activity correctly and periodically, it would more than likely ensure that everybody is reasonably competent when conducting their varied tasks.

CONCLUSION

Engine development is a new area for engineers in Malaysia. Such a project consumes a lot of capital and has a long lead time to fruition. It also requires a whole new set of skills. There are evidences that currently implemented safety measures have improved the industry significantly, but continuous improvement must be followed through to ensure that the industry can expand without compromising on Environment, Health and Safety elements. ■

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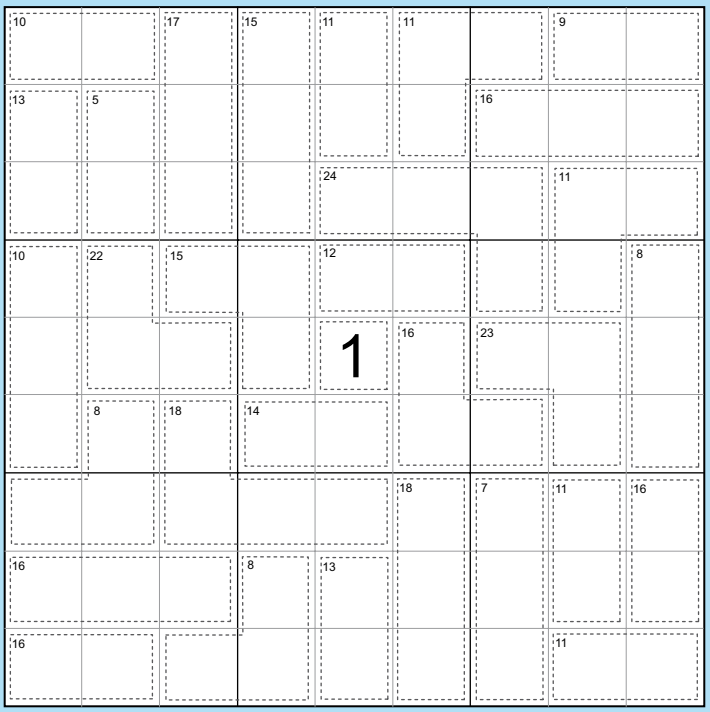
[1] Siti Iswalah Arshad. Automotive Report. MITI, www.unescap.org/tid/publication/part_two2223_mal



1SUDOKU

Centerpiece "3"

by Mr. Lim Teck Guan

About the puzzle:

In this Sudoku variant, only 1 number is given as clue, thus the name 1Sudoku. The rest of the clues are given in the numbered cages (the dotted frame encompassing 2 or more squares). You are to search for the right combinations to fit the total for the cages and end up with a Sudoku Grid, the 9 by 9 composite of squares where there is no repeat of the number 1 to 9 in every Row, Column or Block.

Fill in the remaining 80 squares with single digits 1-9 such that there is no repeat of the digit in every Row, Column and Block. The number at the top left hand corner of the dotted cage indicates the total for the digits that the cage encompasses.

For tips on solving, visit www.1sudoku.com.my

Answer is in the following pages of this edition.