CHAPTER I

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INTRODUCTION

General Background

During recent years motor vehicle design has undergone a process of continuous development and improvement. Each new model is more refined in terms of safety, pollution and smoothness of operation as claimed by industry, these features now ranking equally with reliability, economy and performance. This is due to increased awareness of customer requirements and increasingly in meeting the demand of legal regulations.

Of all the internal combustion engines run on the road, 4-cylinder in-line petrol engine is the most popular due to its many advantages but there is a technical problem inherent in its function, namely the secondary harmonic vibrations. Such vibrations are strong limiting factors governing the size of 4-cylinder engines that can be built and few manufacturers are prepared to go far beyond 2000 cc. capacity because of this. This is a drawback, since in theory, the fuel consumption of an engine having fewer cylinders and using parts of equal power output is better due to the lower internal friction; the cost to produce the engine will be less as fewer parts are used and it is also likely that the weight will be lower too. This latter factor has its own contribution to make to improve fuel consumption. The classical way to overcome the effects of secondary harmonic vibrations is by increasing the number of cylinders, an in-line 6-cylinder engine is smoother than a four and a V12 is smoother than either. Hence there are some manufacturers who are able to justify the high cost making larger than 4-cylinder engine just to have smoothness and the absence of inherent unbalance as the main factor justifying the expense, complication and weight that such engines inevitably possess. Table 1-1 and Table 1-2 summarized the unbalances for the in-line and V-type engines respectively.[1]

If, however, the secondary unbalances in 4-cylinder can be tackled at sources, it becomes feasible to build large 4-cylinder engines to gain the above advantages.

In a conventional 4-cylinder engine, the inertia of the reciprocating masses give rise to vertical shaking forces tending to lift and press the engine upward and downward and also rolling moments, the combined effects of gas pressure torque reaction and inertia couple of reciprocating parts, tending to roll the engine from side to side around the crankshaft axis. These two effects cause noise, uncomfortable riding and unduly stresses to engine ancillary parts.

In a counter balancing shaft engine, a pair of counter balancing shafts introduce additional secondary harmonic vibrations which are at all times in opposition to those produced by the piston and connecting rod, effectively reduces secondary shaking forces and rolling moments as claimed by the manufacturer.

Previous Studies

In the following section, the previous works related to suppression of internal combustion engine vibrations will be described briefly:

The study of multicylinder engine vibrations can be divided into three parts:[2]

(a) Inertia balance deals with the balance of the engine against vertical and lateral forces and against moments about vertical and lateral axes.

(b) Torque reaction deals with the effect of the torque due to inertia and cylinder pressures acting on the stationary parts about the longitudinal axis.

(c) Torsional vibrations of the crankshafts deal with the consequences of the longitudinal torque on the moving parts of the engine.

Of all three vibration constituents, most of the previous works were dealt with the last one since many crankshafts have been broken on account of it.

The subject of balancing secondary unbalance forces due to inertia could be summarized for different vehicles as followings:

The mechanism, for rail vehicle as shown in Fig. 1-1[3], consists essentially of two equal rotating weights G_e with eccentricity e coupled by the gears A, B and C to the crankshaft so that they rotate in opposite directions at twice the speed of the engine. The eccentricities must both be in the position 180 when the crank is at upper dead centre.

Lanchester has devised, and applied to 4-cylinder automotive engines, a piece of mechanism termed an "Anti-Vibrator" as shown in Fig. 1-2.[4] In the diagram, the balance weights A are attached to shafts B_1 and B_2 which are driven by means of helical gearing C_1 and C_2 from the crankshaft at twice the crankshaft speed rotating in opposite direction. The mechanism has been fitted successfully to certain British car engines.

The subjects of torque reactions and torsional vibrations derive from the same exciting sources namely inertia torque and cylinder pressure torque. The subjects mainly focus on the arrangement of cylinders to achieve the uniformities of firing intervals and small ratio of maximum to mean torques. If the non-uniformities in the driving torque exist, the torsional vibrations in the crankshaft may be excited, resulting in fatigue failure of crankshaft. The usual remedy to this problem is by installing any devices to damp the torsional vibrations. These devices are known as dampers or absorbers such as frictional dampers, tuned absorbers and pendulous absorbers.

No. of Cylinder	F	M_p	M_e
4	2,4,- -	2,4,6,8,- - -	2,4,- - -
6	None+	3,6,9,- - - -	None+
8	4, - -	4,8,12, - - -	4,- - - -

Table 1-1 Unbalanced Harmonic Orders for In-line Engines

where +: Sixth-order inertia forces and couples negligible

F: Reciprocating inertia force

M_p: Gas pressure torque reaction

M_e: Inertia couple due to inertia torque of reciprocating parts

Engine Type	No. of Rows	V Angle	Verti Force	Horiz Force	Rocking Moments	Remarks
V12	6	60	None	None	None	-
V8	4	90	4	2	2,4	Shaft 0-180-180-0
V8	4	90	4	None	1,4	Shaft 0-90-270-180
V8	4	90	4	None	4	4 cranks at 90 with counterbalance

Table 1-2 Unbalanced Orders of Inertia Forces in V-Engines

Purpose of This Study

This investigation determined the performance and vibration characteristics of Mitsu "80" 4G52 engine equipped with second mode counterbalancing system as compared to Ford 2261 E, a conventional engine.

Presentation of This Study

The presentation is laid out as following:

Chapter I introduces readers to the existing problems of vibration in 4-cylinder in-line engine and appropriate previous works of how to solve the problems of vibration. In Chapter II, theory of reciprocating engine vibration is discussed with formulae presented for single cylinder before going to 4-cylinder in-line engine and finally the dynamics of counter balancing system. Chapter III describes the experimental methods. Chapter IV shows experimental results mostly in graphical presentation with the discussion of experimental results relating to appropriate theoretical formulae. Chapter V is the conclusion of this work followed by suggestion for further work in Chapter VI.

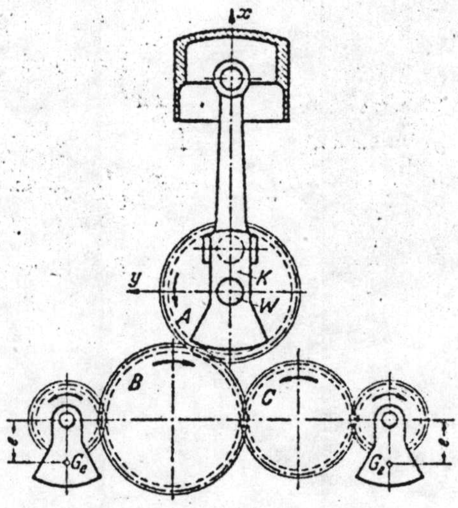

Fig.1-1 Second mode vertical force balancer in rail vehicle

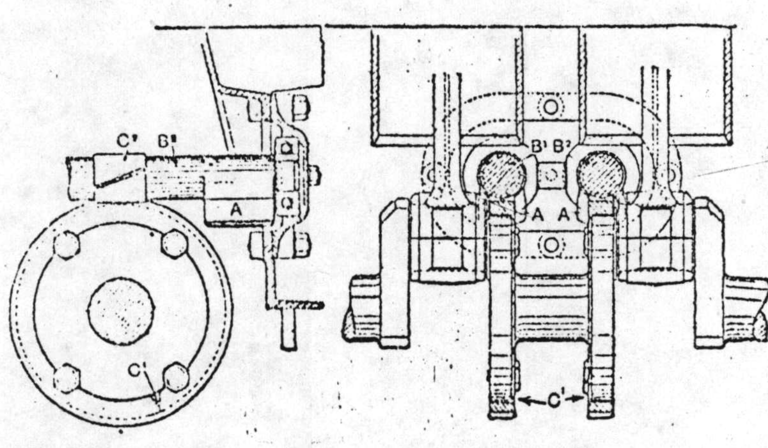

Fig. 1-2 Lanchester second mode vertical force balancer