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Case study

Evaluation of failures in mechanical crankshafts of automobile based on expert opinion

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ABSTRACT

In this study, mechanical crankshaft failures for automobiles are evaluated based on experts' opinion. This was done using data obtained using techniques based on oral interviews and questionnaire administration on mechanical failure of crankshafts from the experts working in the areas of automobile maintenance and crankshafts reconditioning. The data collected were analyzed using statistical methods based on probability. With this technique, probability of failure for each category of automobiles namely private, commercial cars and buses were evaluated. The results obtained show that private cars had lowest failure rate at the initial stage while commercial buses had the highest failure rate. At later periods all categories of automobile crankshafts considered had their failure rates converged steadily with stable reliability. Application of 6-sigma continuous improvement tool to the process indicated a further reliability improvement through improved oil lubrication system, especially in the thrust bearing. This showed that increased enlightenment campaign among the various stakeholders in automobile industries will improve on the choice of reliable mechanical crankshafts.

1. Introduction

Transportation is a very important factor in the economy of every country as every business transaction is made possible by means of transportation either by air, sea or land. Generally transportation by land is most common because of its low cost. Automobile such as lorries, buses, cars among others, are being used to carry out land transportation assignments. Therefore, automobile industry played a significant role in economic development of any nation in the areas of transportation of raw materials and finished goods to/from the production industries. Improved performance of the transportation sector, therefore, will have positive effects on the national economy [1].

The heart of an automotive vehicular system is the crankshaft because vehicular movement would seize if it fails. Automobile crankshaft failures and their associated problems have increased with the developments in automotive industries as many brands/models of vehicles are on sale in recent time [2]. The automobile crankshaft failures have led to increase in the death and disability rates of people in many quarters due to vehicular accidents they caused. Despite this development, awareness campaign on automobile safety was less than one given on some killer diseases such as malaria, tuberculosis infection among others, which have, in some cases, fewer reported cases of death or disability than the one reported from automobile crankshaft failures (accident) [3].

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The crankshaft is located below the cylinder on an in-line engine: at the base V on a V-type engine; and between the cylinder banks on a flat engine [4]. As the pistons move up and down, the crankshaft is turned. The piston travels down, on the intake stroke; up, on the compression stroke; down, on the power stroke; and up, on the exhaust stroke [4,5].

It is a general believe that crankshaft failure has been on the increase in recent years. The increase was attributed to rapid increase of car ownership, low expansion rate of roads, and poor engine maintenance culture. Laxity from monitoring authorities or agencies (police, road safety corps, etc.), to see to the compliance to the basic traffic rules especially in the areas of vehicular roadworthiness also contributed to the crankshaft failure [6]. Failure analysis of crankshaft has been dealt with by many researchers [4–7]. However, many of these efforts failed to consider practical aspect of failure analyses based on expert opinions. In this study, the automobile crankshaft failure and its associated factors are analyzed using experts' opinion. The outcomes are used to determine the level of monitoring and enforcement of maintenance rules by the concerned authorities at preventing premature failure of crankshafts.

2. Materials and methods

The survey of crankshaft failure using questionnaire administration and oral interviews of experts in the selected crankshaft maintenance shops in Akure, Nigeria was carried out. The brands/models (labelled k) of vehicles covered in this paper are private cars, commercial cars, and commercial buses. Private cars', commercial cars' and buses' crankshafts are maintained by maintenance shops A, B, and C, respectively. These maintenance shops were selected in Akure because they have necessary facilities and experts to carry out automotive maintenance/crankshaft inspection activities. The actual names of the vehicle brands/models and maintenance shops are concealed to safeguard their information and integrity. The average number of serviced vehicles was established per year based on throughputs in the stated shops for the years 2007–2013, and they are 49, 34 and 98 respectively for the brands categories – private cars, commercial cars, and buses. Total number of crankshafts required reconditioning or rejected after inspection (out of the stated categories of serviced vehicles) as a result of failure are recorded annually by experts. Causes of failure of crankshafts were also identified by the experts. The ages and kilometres travelled of the serviced vehicles were also estimated from which the vehicular ages 9–13 years (mean 11 years old) and/or kilometres covered 150,000–250,000 km (mean 200,000 km) were obtained. To be considerate in the analysis, the mean vehicular ages and/or distance covered were made constant across all brands throughout the periods of investigation. The data obtained from the maintenance experts are summarized in Table 1. Probability of crankshaft category k failure at year i, $P^k(i)$ was obtained using Eq. (1), while that of reliability or probability of success at year i, $R^k(i)$ was computed based on Eq. (2) [8–10]. Due to variable annual maintenance service demands (throughputs) across the mechanical workshops theoretical failure probability evaluation statistics based on certain standard distributions [11,12]

Table 1
Crankshaft failures data from maintenance experts (2007–2013).

k	Brand/category k of vehicle specialized on	Maintenance workshop	Years	i	Serviced vehicles per year, S_i	No. of failure per year, f_i	Identified causes of failure	Proposed remedy
1	Private cars	Workshop (A)	2007	1	49	12	OL, OD, TBM, PR, AO, OPP, SSF, PM, BOF, OPS	IOLS, IAI, IMS
			2008	2		10		
			2009	3		8		
			2010	4		7		
			2011	5		5		
			2012	6		4		
			2013	7		3		
2	Commercial cars	Workshop (B)	2007	1	34	10	OL, OD, TBM, PR, AO, OPP, SSF, PM, BOF, OPS	IOLS, IAI, IMS
			2008	2		8		
			2009	3		6		
			2010	4		2		
			2011	5		1		
			2012	6		3		
			2013	7		4		
3	Commercial buses	Workshop (C)	2007	1	98	30	OL, OD, TBM, PR, AO, OPP, SSF, PM, BOF, OPS	IOLS, IAI, IMS
			2008	2		26		
			2009	3		16		
			2010	4		10		
			2011	5		7		
			2012	6		5		
			2013	7		4		

OL, oil leakage; OD, overloading; TBM, thrust bearing misalignment; PR, poor reconditioning; SSF, poor shaft surface finish; AO, adulterated oil; OPP, oil pump problem (i.e. improper oil supply to the engine); PM, poor maintenance practice; BOF, bad oil filter; OPS, oil pan seal problem; IOLS, improved oil lubrication; IAI, improved automotive innovations; IMS, improved maintenance system.