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Premature failure in motorcycle engine Suzuki model GSX-R750: Case study.

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ABSTRACT:*The study in question was carried out from the inspection of a failed engine of aSuzuki motorcycle model GSX-R750, about 27,343 km driven. The engine was disassembled and the parts were checked. The crankshaft rod bearing on the third cylinder of the engine was found completely damaged, without the smooth metal cover responsible for friction reducing and also partially broken. The probable causes, listed in specialized technical texts, are problems in the internal distribution of lubrication, improper assembly of the rod bearing or manufacturing deffect of the component. It was concluded, based on the specific bibliography and knowledgement of the author, that the failure did not occur due to operation or maintenance, but by inherent defect in themanufacture of the rod bearing*

KEY WARDS:Premature failures in motorcycle engines, Suzuki Engines, Failure Analysis.

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I. INTRODUCTION

Premature failure in today's motorcycle engines has very low occurrence rates, mainly because manufacturers use continuous improvement quality programs of their manufacturing processes and products. The lack of premature failure in modern engines can be considered as a mandatory attribute according to the model developed by Kano (1996), because when they occur cause great dissatisfaction to the client, but do not bring extra satisfaction when they do not happen.

In this way, it‘s of great importance the correct analysis of the failures causes of vehicles when they occur. The identification of the causes provides corrective actions by the manufacturers and technical assistance network, which will avoid future unsatisfied customers and consequent loss of sales. Correct fault analysis also assures the customer the proper support, identifying, where appropriate, possible unsuitable operating procedures, but mainly reducing the dissatisfaction caused by the unexpected occurrence in the his vehicle.

Failure in an equipment can be defined as an event that stops the proper functioning or use of a product (SILVA; SILVA, 2005). Failure is associated with one or more causes and a mechanism consequence of failure.

In analyzing the causes of a failure in an internal combustion engine, it is not enough to examine the damaged parts, the conditions of the chain reaction and causes must be observed. According to the text distributed by GIRUX-LUBRIFICANTES (2010), the most significant causes in internal combustion engine failures are:

- Design errors.
- Manufacturing errors.
- Use of improper material.
- Improper maintenance.
- Improper operation.

In a study to classify causes of equipment failures (HAMMER, 1993) were identified as:

- Design problems.
- Material selection failed.
- Imperfection of materials.
- Manufacturing deficiency.
- Mounting and installation errors.
- Inadequate operating or maintenance conditions.

The most frequent failure mechanisms are the change in the surface of the sliding parts, clearances and locking of engines parts. According to GIRUX-LUBRIFICANTES (2010), the breakdown represents 49.5% of the occurrences in engines, problems in the rod bearings representing 24.4% of these problems. The same authors affirm that the premature wear of the rod bearingsare caused by:

• Dirt, 47%.due to
• Misalignment, 14%.
• Mounting error, 12%.
• Overcharge, 10%.
• Lack of lubricant, 8%.
• Corrosion, 5%.
• Others, 4%.

In a manual related to premature bearings failures (MAHLE, 2016), the authors report that the causes of these problems may be contamination of the lubricant, oil orifice of the engine block obstructed,misaligned of rod bearing and generalized fatigue. These premature failures are strongly related to the breakage of the oil film between the rod bearing and the crankshaft sleeve and, among the probable causes, the obstruction of the flow channel of the lubricating oil in the engine is the most cited ones (SILVA; SILVA, 2005). In any case, the causes of the failures must be foreseen by the designer.

The researcher Maffei (2007) mentions that in the analysis of failures in sliding bearings in combustion engines the main causes are:

• Excessive workload.
• Absence of proper material selection.
• Manufacturing deficiency.
• Mounting or installation failures.
• Inadequate operating or maintenance conditions.

The same author suggests a visual investigation in the parts with problems, with the purpose to investigate type of the damages or wearings, occurrence of fatigue, cavitation, fretting, chemical effects and manufacturing faults.

Upon inspection of the Suzuki GSX-R750 motorcycle engine, it’s intended to evaluate the possible causes of the failure, based on the checks made during disassembly and observed damaged parts. The analysis will be based on technical texts related to the theme.

II. MATERIAL AND METHODS

The monitoring of the expert inspection was carried out at the Suzuki dealership, on December 16, 2016, in the city of Piracicaba (22º43'30 "south latitude and 47º38'56" longitude west), State of São Paulo, Brazil.

The dealers’ technicians, supervised by the technical representative of the manufacturer, performed disassembly. Records were made by visual observation of the defective parts found, which were photographed as they were reached. Dimensional measurements of the parts were not performed.

The analyzes were performed comparing the appearance of the defective parts found with examples defined in the specialized bibliography, by inference based on the author's knowledge, the service manual of the vehicle in question and other bibliographical references.

III. RESULTS AND DISCUSSION

Motorcycle engine Suzuki model GSX-R750, chassis No. 9CDGR7DAJ9M004778, engine No. R731-BR104056, manufacture year 2009, was the subject of the disassembly for fault mechanism evaluation, occurred on January 2, 2014, in which the odometer of the vehicle registered 27,393 Km, and of its probable causes.

Disassembly (Figure 1) was performed in sequence as indicated in the motorcycle service manual (SUZUKI MOTOR CORPORATION, 2006). The engine was removed from the chassis of the motorcycle and placed on a bench.

Figure 1 - Engine disassembly by technical Suzuki dealers.

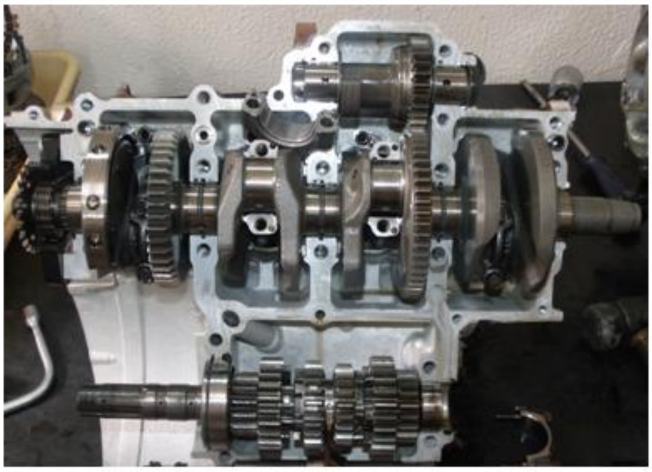

Figure 2 - Semi disassembled engine.

One of the possible place of the failure was on rod bearings, so the lower part of the motor was disassembled to access these components (Figure 2).

The identified failure mechanism was found only in the third-cylinder connecting rod bearing. The rod bearing was without the smooth metal and partially broken (Figure 3), which produced excess play in the set and grooves or marks on the crankshaft (Figure 4).

Figure 3 - Connecting rod bearing of the 3rd cylinder.

Figure 4 - Damaged sliding surface on the crankshaft.

IV. 3.1 Assessment of probable causes

Before any evaluation of what has been found during the inspection of damaged parts, it is important to evaluate the operating conditions during the occurrence of the engine failure, as well as the performance of the previous maintenance to the event, as mentioned in the Girux Lubricants manual (GIRUX -LUBRIFICANTES, 2010).

According to the driver's report when the symptoms of the fault appeared, the engine speed and temperature were among the recommended parameters of use, there was a change of engine noise and the warning symbol was displayed on the motorcycle panel, which, according to the vehicle's manual, indicates low oil pressure (SUZUKI MOTOR CORPORATION, 2009). The oil pressure in this engine model is taken in the main oil distribution chamber (Figure 5) and, according to the manufacturer; the pressure drop may have been caused by an insufficient amount of oil in the engine, a defective oil pump, clogging in the distribution circuit or use of an incorrect type of oil. However, all of these possible causes would also cause engine overheating (SUZUKI MOTOR CORPORATION, 2006), but during the fault the panel indicated a temperature of 87 ° C, indicating that there were no engine heating problems. On the other hand, the motor failure analysis manual also indicates bearing wear and leakage in the oil pump discharge line as factors that may cause the lubricating oil pressure drop (GIRUX-LUBRIFICANTES, 2010).

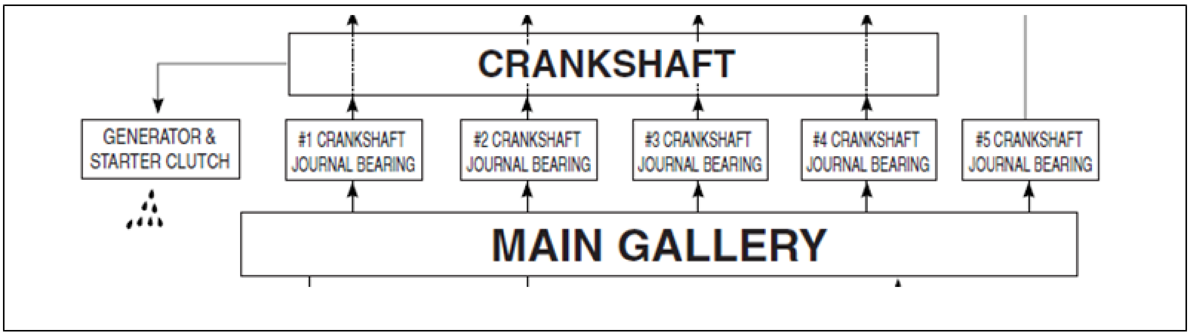

Figure 5 - Part of the schematic of engine diagram for lubrication distribution (SUZUKI MOTOR CORPORATION, 2006).

When analyzing the third-rod bearing of the engine as shown in figure 3, there are signs that, when compared with examples presented in the literature (Figure 6), may be caused by insufficient lubrication, it is verified that the smooth metal was eliminated, which can also be caused by material fatigue (SILVA; SILVA, 2005).

Figure 6 – Rod bearing worn caused by reducing lubricant film (MAHLE, 2016).

The possible cause for oil film reduction in the damaged bearing may be insufficient vertical clearance, oil dilution, long idling engine, partially obstructed oil gallery, incorrect choice of bearing thickness, inverted mounting, oil pump malfunction (MAHLE, 2016). According to Silva e Silva (2005), fatigue (Figure 7) can be caused early when there is no complete metallurgical union between the base metal and the smooth metal.

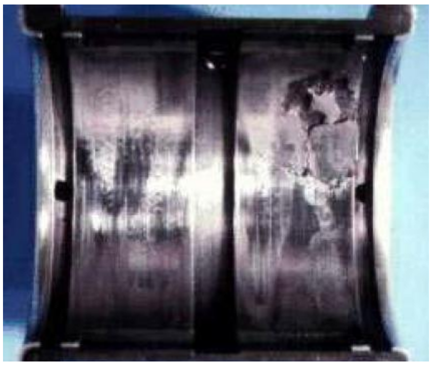

Figure 7 - Example of a premature fatigue failure in a rod bearing (SILVA, SILVA, 2005).

When evaluating the hypothesis of reduction of the lubricant film as the cause of the failure, it must be considered that the other bearings of the crankshaft and of the other connecting rods did not present problems. This excludes the possibilities of problem in the oil pump, oil dilution and of the long idle engine, as it would cause problems in all rod bearings. Thus, insufficient vertical clearance, partial obstruction of the lubricant distribution, incorrect choice of rod bearingthickness and inverted bearing assembly, could have caused premature failure of a single rod bearing.

Regarding insufficient clearance or incorrect choice of the bearing thickness, there has already been a change in the information in the service manual for the correct definition of the bearing for the main crankshaft bearings (SUZUKI TECHNICAL SERVICE DEPARTMENT, 2006). This information means that there may have been incorrect information on the selection of bearing on the assembly line and this possibility could extend to the connecting rod bearings.

These probable causes, the only one that could be the responsibility of the owner of the vehicle would be the partial obstruction of the oil distribution chamber if the lubricating oil and the oil filter had not been regularly replaced as instructed in the owner's manual. However, the owner performed scheduled maintenance on a regular basis, requesting the services exclusively from the service authorized by the manufacturer.

Partial obstruction of the oil flow could have caused the problem, if the crankshaft channel leading the oil received from the engine block to the third bearing rod, shown schematically in Figure 8,was stopped. If the third crankshaft bearing obstructed the oil passage hole, for example inverted mount, this problem could also occur, but no evidence of this type was found at the inspection. The crankshaft bearings have a hole in which the oil flows from the engine block to the channel in the crankshaft (Figure 9), which leads the lubricant to the bearing of the connecting rod, the channels in the crankshaft being independent for each connecting rod.

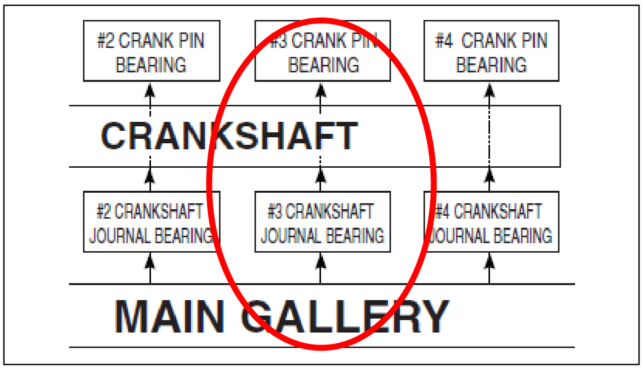

Figure 8 - Crankshaft bearing lubricating oil distribution scheme (SUZUKI MOTOR CORPORATION, 2006)

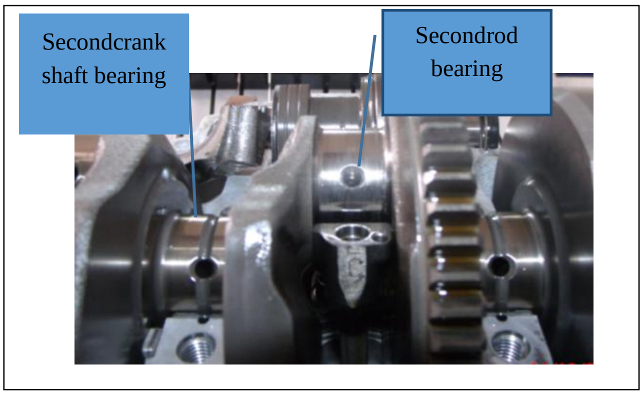

Figure 9 - Transmission points of the lubricating oil between the engine block and crankshaft.

The use of a non-original oil filter could not have caused the obstruction of one of the oil distribution channels by specks; in this case, in addition, the filter was replaced on 12/23/2013. Therefore, a few days before the occurrence of the engine problem.The owner's manual (Figure 10)does not mention restrictions on the use of third-party filters provided they are compatible. What's more, specialized motorcycle forums claim that the filter used on the engine in question, FRAM PH6018, performs well (SUZUKI ONLINE, 2016). In addition, the manufacturer of the oil filter used in the vehicle, Sogefi Filtration do Brasil Ltda., is certified: ISO / TS-16949: 2009 quality system, in its environmental management system by ISO- 14000: 2004 and in its occupational health and safety management systems by the OHSAS-18001: 2007 standard, which confirms the quality level of its products and processes.

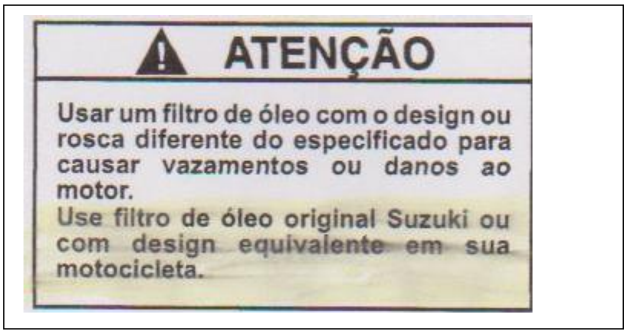

Figure 10 - Highlight the owner's manual page specifying the type of oil filter (SUZUKI MOTOR CORPORATION, 2009).
“Caution: Using an oil filter with a different design or thread may cause leakage or damage to the engine.
Use original Suzuki or equivalent design oil filter on your motorcycle“.

Failure of the rod bearing due to fatigue could have caused the symptoms reported by the owner of the vehicle, noise other than the engine and the appearance of the insufficient oil pressure-warning signal, as the resulting excessive slack would cause this loss of pressure.

V. CONCLUSION

The follow-up of the engine disassembly for technical expertise under lawsuit was carried out at the request of the owner of the motorcycle. By performing this task, it was possible to identify the mechanism of failure in the engine, characterized by the total and premature wear of the third rod bearing, causing excessive play and crankshaft marks in the corresponding position. It was stated that the other parts of the engine were in perfect condition.

Among the probable causes it is evident that they could not have been caused by the regular use of the motorcycle, normal wear and tear of the components or by the periodic maintenance performed on the frequency and specifications directed by the manufacturer.

In the assessment of the causes, it is concluded that it must have been originated by one or all of the following possibilities: insufficient rod bearing vertical clearance, incorrect choice of rod bearing thickness or failure due to fatigue. A manufacturing fault is then found, where a nonconforming component is hidden, collapsing within 300 hours of engine use.

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