DAMAGE ANALYSIS OF AUTOMOTIVE TURBOCHARGERS

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1. Introduction

This paper presents the results of one part of research on Innovation Project, with emphasis on often fails to work of turbochargers which is used for passenger vehicles, [1].

Turbochargers are widely used in trucks and diesel engines. There are also some gasoline fueled cars and other special purposes vehicles that use turbochargers. A small turbocharger, Fig. 1, consists basically of a compressor and a turbine coupled on a common shaft, [2].

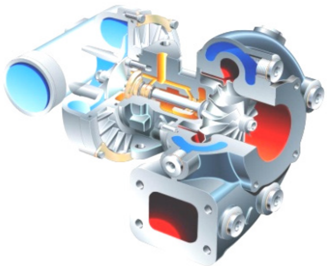


Fig.1.: Turbocharger

The most important factor in the design of an automotive turbocharger is the initial cost. Engineers aim to undercut the cost of producing larger engines capable of providing the same power. Even though truck engines operate at modest break-mean effective-pressure (~14 bar) and hence at lower boost pressure (up to 2.5:1), they work at much higher exhaust temperature [3]. Because of truck engines heavy operations, they demand good acceleration and high torque over a wide speed range. They also require a high level of reliability and efficiency.

There are several ways to reduce cost of turbocharger. Should be kept simple design and selected materials need to satisfied the working conditions. One should bear in mind that using Inconel Alloys, Iron, Bronze, etc.

The compressor impeller, Fig 2, in most automotive type turbochargers is made of aluminum. Aluminum is also used for the compressor casing, unless the compressor impeller is made from other material than aluminum. On the other hand, the turbine rotor should withstand a much higher operating temperatures that could be as high as 1000 K, or more. Therefore, the most convenient material to use for that purpose is 713C Inconel, a high nickel alloy.

The turbine rotor casing should also withstand high temperatures, but not resist as high pressure as the turbine. There are three different types of materials used for the turbine rotor casing depending on their operating temperatures. S.G. iron, spheroidal graphite, is used for operating temperatures up to 975K, high-silicon S.G. iron is for temperatures up to 1000K, and high nickel cast iron for temperatures above 1000K. The shaft is usually made of high-carbon steel to allow induction hardening of journals, [2].

Fig. 2. Compressor impeller

Most of turbochargers for commercial vehicles incorporate simple journal bearings. They use the engine lubricating oil system for their bearings to assure low cost and simplicity of maintenance, instead of having a separate system. Ball bearings are not used for most commercial engine applications because of their short life and difficult access for replacement. Special high performance engines in automotive racing applications, can afford the added expense of ball bearings.

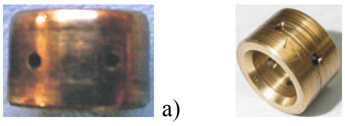
2. Damage Analysis

When there is damage on turbocharger the most important is to find the cause of failure, because that is the only way to solve a problem with turbocharger. Researching in project, [1], and bearing in mind researching manufactures of turbocharger, Garrett, Holset, Mitsubishi, Schwitzer, Borg Warner, Hella, etc. damage of turbochargers can be divided into four major groups.

2.1 Oil Contamination

Fine particle contamination, may not be noticed in oil visually, but causes polishing of the bearing surface and tell tale rounding of the outer edges.

Often the compressor end bearing may be worn to a taper on the outside diameter.



a) b)

Fig. 3. Oil contamination, small part a),large part b).

Large particle contamination, oil borne large particles, may cause impact damage and deep scoring as shown, Fig. 3. b). The bearing bore may also be scored, usually to a lesser extent, The shaft and centre housing are usually damaged slightly less, being harder materials. The light scoring right was caused by large oil borne contaminations.

2.2 Lack of Lubrication

Marginal lubrication where the oil supply to the turbo is reduced, for instance when gasket materials partially block an oilway or inlet flange. Characterized by extreme discoloring of shaft journals, Fig. 4.

Fig.4.: Lack of Lubrication

Chemical contamination causes heavy wear of bearing/shaft and excessive temperature. The visual indications are very much the same as for Marginal lubrications.
Total Lack of Lubrications for similar causes, will show similar damage, but more extreme. Damage happens very rapidly.

2.3 Exceptional Operating Conditions

Typical damage is high temperature at the bearing journals, on severe examples, the oil burns and “cokes” the shaft. Often the back face of the turbine wheel is slightly concave, usually accompanied by an “orange peel” – very clear signs of overspeeding and overboosting.

Fig.5. Overspeeding/Overboosting

Overspeeding can also cause the loss of a portion of turbine blades. The damage may look similar to *foreign object damage*, but is often accompanied by cracking at the exducer blade root and in extreme cases, the wheel can burst due to overspeeding. Minute stress crack appear as the wheel is “stretched” beyond its designed limits and these gradually increase during overspeeding cycles followed by a final rapid failure.

2.4 Foreign Object Damage

Hard foreign object–this damage was caused by foreign object entering the compressor. The object may bounce around in the compressor inlet causing the type damage, seen Fig. 6a. Salt or sand causes severe erosion and corrosion, eventually leading to blade failures.

a) b) c)

Fig.6. Foreign object damage

Soft foreign object such as clothes or even *paper* wipes can cause damage, Fig.6b. Typically, the blades bend backwards and in extreme cases sections of the blade may break away due to metal fatigue.
Hard foreign object entering the turbine will damage inducer blades as shown, Fig. 6c. Even small objects such as rust scale, from manifold, can cause considerable damage to such high speed components.

3. Conclusion

This paper is the basis of the turbocharger, as well as four basic types of damage. What is the analysis of these defects and their causes, a conclusion which can be done is to fail to work turbocharger for passenger vehicles are due to problems outside of the turbocharger.

In fact the most turbo failures are caused by problems outside of turbocharger.

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