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# Diagnostics of Iveco Stralis 440ST Truck Tractor Unit Engine and Identification of the Cause of its Malfunction

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**Abstract:** ***The article concerns the case of the Iveco Stralis 440St truck tractor unit engine failure and the methodology of the technical expert applied to identify the cause of failure. The engine has repeatedly exhibited failures –leaking crankshaft spring - energised seal and consequent engine oil leak, which has been repeatedly repaired at a car service station. Repeated engine failures resulted in the disputes between a vehicle owner and a car service station, finally leading to an agreement on finding the cause by an invited technical expert. To determine the cause, a vehicle was on the car service station premises, where a technical expert was present and according to his instructions, diagnostic and subsequent disassembly works were done. The outcomes of the investigation proved serious damage to the engine piston unit.***

**Keywords:** Tractor unit, service, repeated engine failure, diagnostics, damage detection.

## 1. Introduction

There are often cases in the repair practice when the service station fails to diagnose the correct cause of the vehicle failure, which occurs repeatedly, sometimes with a time delay, even after the repair had been made. The article deals with one of these cases, when the engine of Iveco Stralis truck tractor unit, type ST has repeatedly failed, which was manifested by the spillage of the engine oil at its rear part. A vehicle has been serviced repeatedly four times at a car service station, crankshaft spring-energised seal at a flywheel being changed. A car owner was not satisfied with this procedure since each such repair had to be paid and expressed the view that the cause of the repeated engine failure must have been repairable. The dispute between the owner and a car service station reached the stage, when a technical expert was called upon to review the technical condition of the engine and identify the cause of its repeated failure. The task was challenging as it had to be done considering the cost-effectiveness in terms of the operations and a vehicle standstill time, which meant a financial loss of the owner. For this reason, the technical expert proceeded step by step as follows: an inspection of the engine and diagnostics have been carried out, the oil condition has been evaluated and based on the results and their analysis, dismantling works have been initiated. All operations have been documented and recorded by a video camera.

## 2. Vehicle Data

Make and type: Iveco Stralis truck tractor unit, type 440 ST
Mileage: 173 485 km

## 3. Initial Operations

**Visual inspection:**
A detailed visual inspection of the vehicle and its engine has been carried out. Findings revealed no incompleteness, however there was engine oil found on the front part of gearbox housing – Figure 1.

View of NMV, make Iveco Stralis,

View of the front part of a gearbox housing (clutch – engine flywheel) that is contaminated with oil – oil leaking from an engine through a spring-energised seal.

**Figure 1:** Vehicle condition detected during a visual inspection

Vehicle start evaluation
At the start and while the engine was running it was clear that:

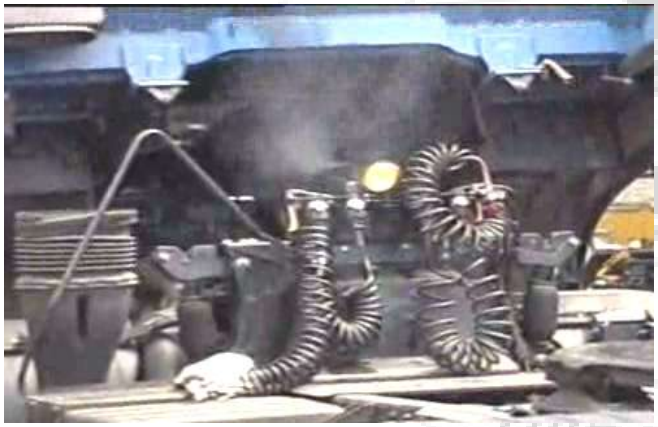
- Start – engine turning by an engine starter has taken unreasonably long time
- Then, the engine started running irregularly – one cylinder did not work properly and the engine emitted smoke excessively
- After the engine had warmed up, the above-mentioned characteristics weakened

- During the inspection, a hose leading from the plug of the opening for pouring engine oil was found, from which the smoke comes out when an engine is running – oil combustion products- the blowing rate being dependent on the engine speed.

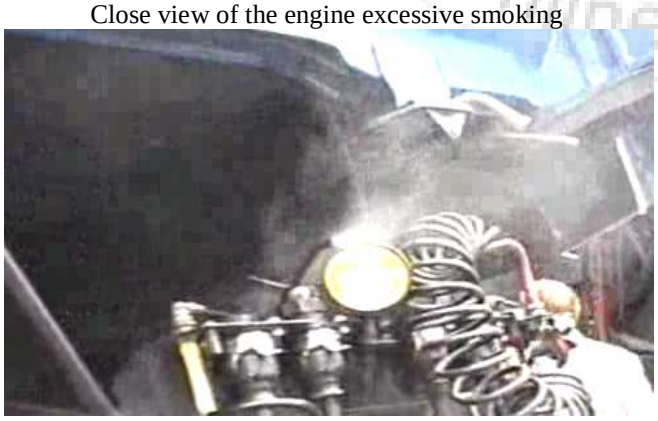
In assessing these findings, the following can be deduced:

- One of the engine cylinders does not work properly, the pressure occurring in the cylinder in the combustion process enters the engine housing, i.e. crankcase, oil bath, cylinder head cover and generates the pressure acting on their sealing elements, rubber elements and spring-energised seals.

View of a vehicle with a running engine and excessive smoke

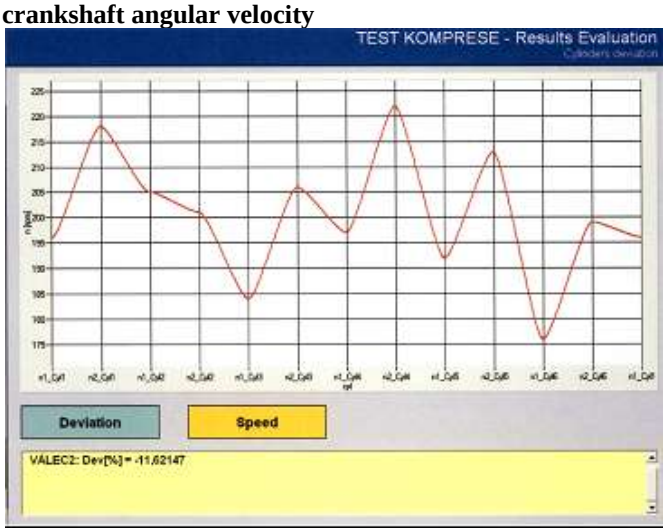


Close view of the engine excessive smoking



Detailed view of excessive smoke in a motor running

**Current measurements of the change in engine crankshaft angular velocity**

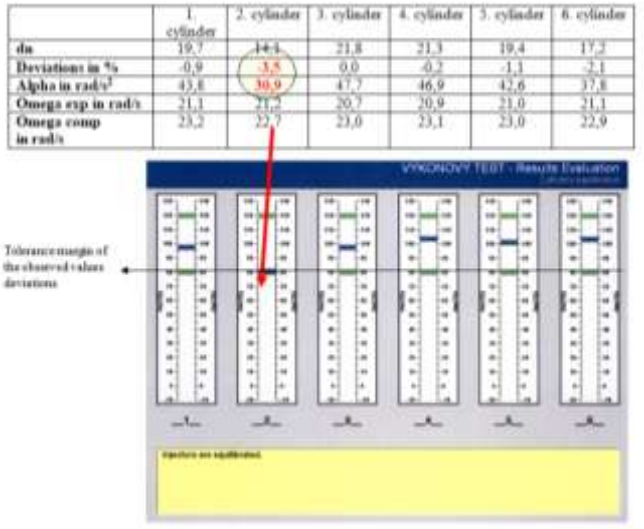



Detected irregularities in a crankshaft angular velocity

Control test of engine cylinder compression conducted at last repair (A) 52 days ago. Current control test of engine cylinder compression (B)

When the engine was tested, the results of the engine control test carried out at the last engine repair 52 days ago were available. The tests were compared yielding the results as follows:

- The result of the compression control test A shows the difference in the performance of the 2nd cylinder and other five ones, but the observed deviation of the functionality decrease is within the manufacturer published tolerances (-3,5%)
- The difference in acceleration of a crankshaft (Alpha v rad/s$^2$) is obvious but cannot be evaluated as a failure.

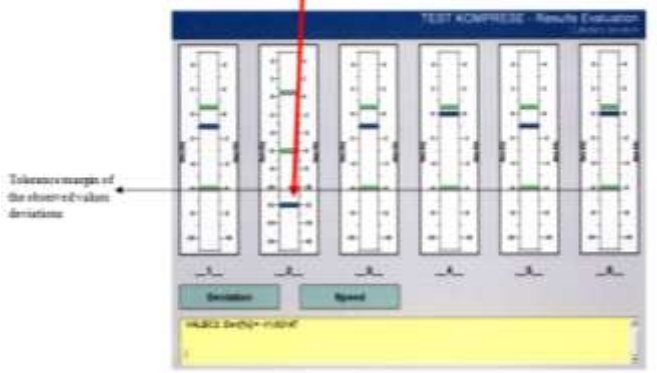


| | 1. cylinder | 2. cylinder | 3. cylinder | 4. cylinder | 5. cylinder | 6. cylinder |
|---|---|---|---|---|---|---|
| da | 19,7 | 14,5 | 21,8 | 21,3 | 19,4 | 17,2 |
| Deviations in % | -0,9 | -3,5 | 0,0 | -0,2 | -1,1 | -2,1 |
| Alpha in rad/s$^2$ | 43,8 | 30,9 | 47,7 | 46,9 | 42,6 | 37,8 |
| Omega exp in rad/s | 21,1 | 21,2 | 20,7 | 20,9 | 21,0 | 21,1 |
| Omega comp in rad/s | 23,2 | 22,7 | 23,0 | 23,1 | 23,0 | 22,9 |

- The result of the compression control test B shows the significant difference in the performance of the 2nd cylinder and other five ones, and the observed deviation of the functionality decrease is above the manufacturer published tolerances (-3,5%)

- The difference in acceleration of a crankshaft (Alpha v rad/s$^2$) is detected and indicates the deceleration of a crankshaft at the time of the 2$^{nd}$ cylinder activity.

| | 1. cylinder | 2. cylinder | 3. cylinder | 4. cylinder | 5. cylinder | 6. cylinder |
|---|---|---|---|---|---|---|
| da | 22,2 | -3,0 | 22,6 | 24,3 | 20,9 | 23,4 |
| Deviations in % | -0,9 | 11,6 | -0,7 | 0,0 | -1,4 | -0,4 |
| Alpha in rad/s² | 48,2 | -9,4 | 46,1 | 53,4 | 44,3 | 43,8 |
| Omega exp in rad/s | 20,5 | 21,5 | 19,2 | 20,7 | 20,1 | 18,4 |
| Omega comp in rad/s | 22,9 | 21,1 | 21,6 | 23,2 | 22,3 | 20,8 |



Observed deviation of the values in cylinder compression test B, suggests in a significant way that the 2$^{nd}$ cylinder run did not correspond with the engine´s technical condition and was significantly degraded. Since this test is based on the evaluation of the angular velocity change and the crankshaft angular acceleration, it may be considered an indirect indicative evaluation of the engine piston unit.

## 4. Disassembly Operations

Subsequently, disassembly operations have been initiated and documented. In successive steps the following parts have been disassembled:

- Valve lid
- Cylinder head
- Oil bath
- 2$^{nd}$ cylinder piston
- Connecting rod bearings

View of the engine block, cylinders and pistons after the disassembly of a cylinder head

Detailed view of the 2$^{nd}$ cylinder piston bottom after the disassembly of the cylinder head

Fragments of the 2$^{nd}$ cylinder piston found in the engine oil bath after dismantling

View of the piston and connection rod of the 2$^{nd}$ cylinder after dismantling

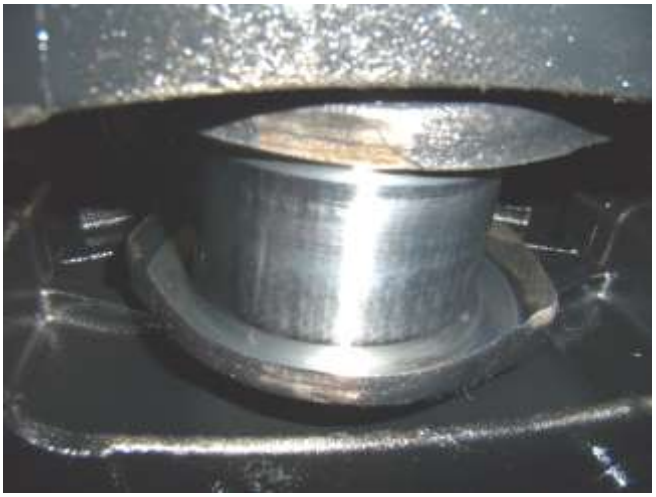
Detailed view of 2$^{nd}$ cylinder piston immediately after dismantling

Detailed view of the 2nd cylinder piston after partial cleaning of carbon deposits

Detailed view of 2nd cylinder piston after partial cleaning of carbon deposits

Detailed view of 2nd cylinder piston after partial cleaning of carbon deposits

View of the 2nd cylinder connecting rod bearing (bearing bushing of a connecting rod) – 2nd part of a bearing (clamp)



Detailed view of the engine crankshaft –connecting crank pin of the 2nd cylinder connecting rod

**The evaluation of the disassembly works outcomes**

**Findings:**
2nd cylinder piston damaged, broken
Connecting rod bearings of the 2nd cylinder: damaged
Connecting rod bearings of 4th cylinder: damaged
The crankshaft of 2+4 connecting rod: damaged

Damage to the 2nd cylinder piston:

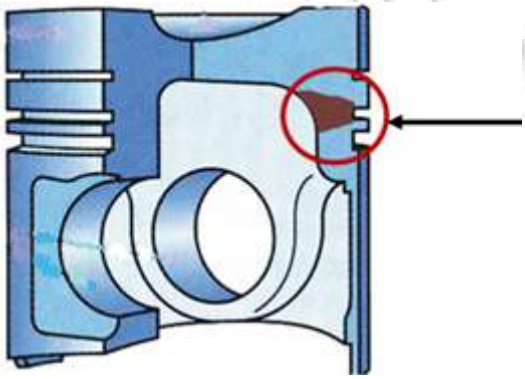
Carbon deposits on the piston bottom – the result of incorrect combustion

Carbon deposits on the piston above the piston rings – the result of incorrect combustion

Damage to the piston detected after removing carbon deposits and piston ring fragments

The fragments of the 2nd cylinder piston found in an oil bath – traces of blows on the moving parts of an engine

Marking of the damage to the 2nd cylinder piston – a broken part is marked black

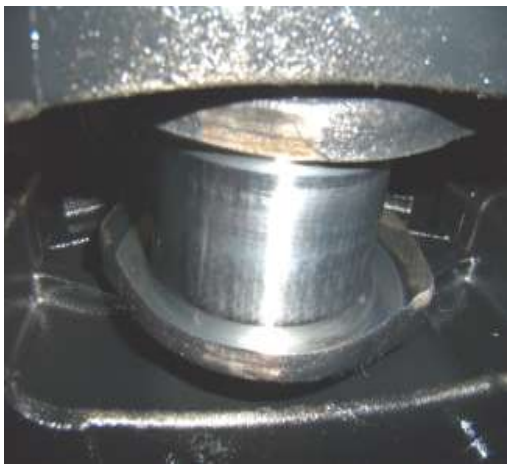


The evaluation of the damage to 2nd cylinder piston and the course of damage:

Based on the character and type of the damage to the 2nd cylinder piston, a following possible course of engine failure can be deduced:

- During the engine run, a part of the 2nd cylinder piston was broken off from its inner side in the zone of piston rings due to the fabrication-related defect, or the defect of the piston material of the engine 2nd cylinder
- In the broken part, the burning fuel started to penetrate to the inner zone of an engine and the piston rings started to overheat locally consequently beginning to break
- When the burning fuel was flowing around piston rings, the carbon was deposited significantly on the piston in the piston rings zone
- As a result, we cannot rule out the possibility that a certain amount of fuel entered the engine zone unburned and mixed with engine oil (this can be assumed because the volume of the oil was not reduced)

Damage to the connecting rod bearing of the 2nd and 4th cylinders and a crankshaft in the connecting crank pin of the 2nd and 4th cylinder:



We can assume that the above-mentioned damage occurred because of the reduction in the engine oil quality in

connection with increased stress of said parts in irregular engine run, i.e. as a direct consequence of the damage to the 2nd cylinder piston, since this involves abrasive damage to the parts mentioned.

The evaluation of the repeated engine failures – a leak in the spring- energised seal of the crankshaft at the flywheel

According to the holder information, the engine has been repeatedly repaired, since the oil has been flowing through the spring -energised seal at a flywheel.

## 5. Conclusion

By these methods and measurements, it has been observed that: regarding the detected damage to the engine piston unit, i. e. to the engine 2nd cylinder piston and connecting rod bearings, while we cannot rule out the damage to the crankshaft assembly (increased clearance) and due to the consequences of damage, i. e. the burning fuel leak and its penetration into the engine oil compartment and formation of the pressure therein, I consider the repeated oil leakage through the crankshaft spring energised wheel a direct consequence of the damaged piston of the engine 2nd cylinder.

It is clear from the article that the investigation procedure proved to be effective and no action was taken that would not yield the result.

## References

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