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AN ANALYSIS OF CHOSEN ENGINE FAILURES OF THE "SEISMIC RESEARCH" TYPE SHIPS

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Abstract

This article presents chosen failures, which occurred on one of the ships with the Diesel Electric type propulsion operating as the "Seismic Research" type ship. The specifics of maritime units requires high reliability of both the engine as well as other machines of the ship power system, which leads to their practically continuous uninterrupted operation. This study deals with the occurring failures of timing gear and piston-connecting rod systems of engines of chosen ships of the "Seismic Research" type.

***Keywords**: timing gear system, failure, pitting, diesel engine, seismic research*

1. Introduction

The increasingly rising large scale global power crisis brings about a constant increase of oil prices. This has lead, among others, to intensified searching and mining of this recourse from the sea bed. For the searching purposes, specialized ships of the "Seismic Research" type are applied. Usually, oil searching is currently carried out using the acoustic echo reflected after a "shot" of compressed air. These units belong to the "off-shore" type ships. Each day when the ship is out of service generates loses that no ship owner can afford. However, uninterrupted ship operation is connected with practically uninterrupted operation of its machines.

Specifics of such ship operation and high costs of maintenance make the units stay at sea for up to six months at a time without entering a port.

On most ships, electrical motors of high power, which are driven by electricity generated in the ship electric plant, are used as propulsion. It is the so called "Diesel-Electric" propulsion. This article presents a few non-typical failures noticed on one of the "off-shore" type ships.

Fig. 1. A view of "Seismic Research" type ships [1,2]

2. An analysis of a gear system failure

Four engines of the Bergen Diesel BRG-8 type (with total power of 13 420 KW) were mounted on the discussed unit. Each of the engines drove a separate high voltage current generator of 4 266 kVA.

A cracked cam of the fuel pump was found on one of the cylinders. (Fig. 2) Thus, a decision was made to replace the faulty part of the camshaft. It was feasible thanks to a segment structure of the shaft, which consisted of four parts. The replacement of one of the four segment parts was performed without the help of a specialized service by dismounting the faulty part and mounting a new segment in the same place. Very similar failures occurred on a few sister ships, therefore, the manufacturer concluded that the failure was due to the inappropriately chosen material out of which the cam was made. This lead to a change of record made in the preventive maintenance schedule referring to the frequency of the whole timing gear system surveys of all engines of this type.

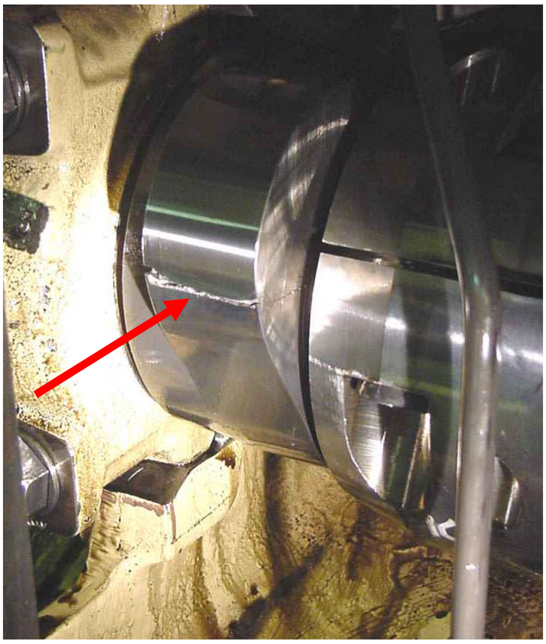

Fig. 2. The crack on the cam of the fuel pump (marked with an arrow)

Despite replacing the cams with new ones, the main problem remained. Most probably it was not caused by faulty material but by the miscalculation of the interference size at cam mounting. When cams were being mounted on the shaft, the shrinkage method with an induction heater was applied (Fig.3). An inappropriate construction size of assembly clearance (negative allowance) caused that after the mounting , the stress was too high. Additional stresses on the cam at operation lead to exceeding the acceptable stresses and resulted in piling up the stress especially at the notch which in this case was the splineway.

Fig. 3. Warming up of the shaft gear cam with the use of an induction heater

The increased frequency of surveys of the timing gear system resulted in finding another type of failure, i.e. a very pronounced wear of rollers (Fig.4) and cams of the injection pumps (Fig. 5). The service of Rolls-Royce, which is the manufacturer of Bergen-Diesel engines, did not pinpoint the cause of the roller and injection pump cam wear. It replaced them with new ones, which after a relatively short period of operation got identically worn as those before. The author of this study analysed the changes of the surfaces of the studied rollers and cams. The types of faults pointed to classical pitting which is fatigue wear caused by cyclic interaction of contact stress occurring at superficial layers of elements that are rolling or rolling with a slide. at lubricated contact within the Hertzian contact stress limits. Thus, it is the fatigue wear occurring in the presence of oil.

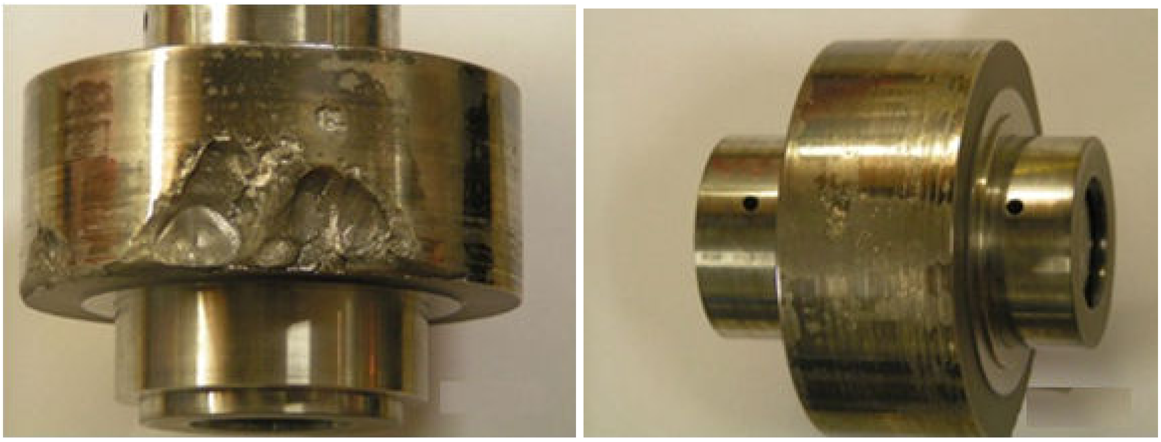

Fig 4. Damaged rollers of a fuel pump

In the first stage, the fatigue was due to the cyclic presence of stress. Initiation of cracks and the appearance of the first micro-crack is usually connected with the place of the highest material stress, i.e. the moveable Bielaiev point [3]. Apart from the possibility of crack initiation at the Bielaiev point, they can also appear on the surface of the material even when the ratio of the tangent force to the axial one is not equal to 1/3. Any surface fault or structure discontinuity may be the source initiating fatigue cracks. During the first stage, lubricating oil slows down the progress of fatigue processes, as it relieves unitary stress in the contact area, which has a beneficial influence on material surface durability. Thus, the effect of wear can only be seen after the system has operated for a period of time. Therefore, the fatigue wear in the presence of oil occurs much later than it is the case for the contact without lubrication [3].

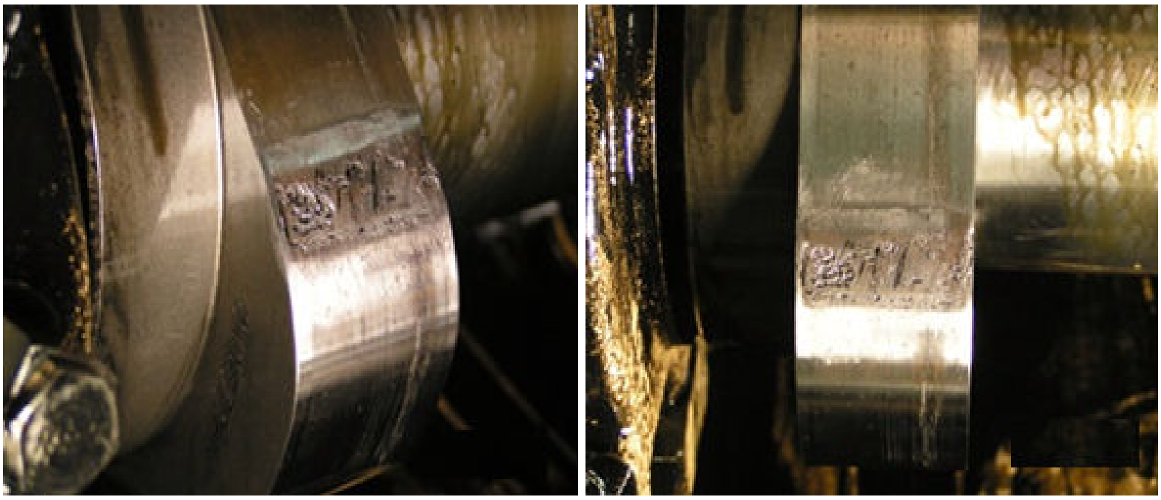

Fig. 5. Damage of a cam

In the second stage, fatigue cracks get bigger and spread to larger parts of the material. Oil plays a pronounced negative part in the process of crack expansion. The oil, which is present in the contact area within the Hertzian contact stress limits is a subject of high unitary pressures and gets into existing surface crevices. **The ability of oil to penetrate them is higher when its viscosity and surface tension are lower. Thus, highly processed oils, containing dispersing additives and detergents are more penetrable** and such oils are used in the lubricating systems of ship engines. Oil as a non-compressible liquid is pumped under high pressure into a crack (at pressure-circulation lubrication) and it acts as a wedge and enlarges the crack. Improvement additives of high physical and chemical adsorption properties, get adsorbed on the crack surfaces and lower the surface energy and decrease the continuity of material inside the crack that was due to adhesion. . Thus, oils with surface active additives are characterized by strong wedge-like activity and because of this play a part in crack spreading [3].

When a roller is rolling on a cam, "surface areas" of both elements are alternately compressed or stretched . The stretched particles, strongly connected to the base, tear some parts of the material, which as a result of fatigue cracking lost or diminished its cohesion with its own specimen.

Analysing the problems connected with wear of elements on the discussed unit and also on twin ships, a conclusion can be drawn that calculations and construction of the whole gear system should be checked again.

3. The failure of the piston – connecting rod system of the Bergen Diesel engine

During seismic measurements of oil resources, a burst of a cylinder block of one of the engines took place. One of the engine systems got almost completely torn apart. It also became the cause of fire in the engine room. Additionally, the so–called secondary damages appeared – not only the elements of the engine but also other machines in the engine room suffered. The base of the connecting-rod got completely severed. (Fig. 6).

Fig 6. The photographs show the severed connecting-rod bases of the Bergen- Diesel engines on one of the "Seismic Research" type ships.

An analysis of the condition of particular elements was carried out in order to find the source and cause of the damage. It was noticed, among others, that the nut of the connecting-rod bolt at the time of the damage was not in its proper position. Attention was focused on the appropriate tightening of the connecting-rod bolts [4]. The area where the nut contacts the connecting-rod showed pronounced deformations, which rather did not appear at the time of the failure. After a complete analysis the following conclusions were reached:

- the main cause of the failure was the insufficient (at the proper time) tightening of the nut of the connecting-rod bolt,.

The subsequent stages of the damage were as follows:

- insufficient initial tightening of the nut caused its further loosening and gradual shearing of the securing nut;
- when the nut was completely loose, additional shearing and stretching forces were acting on the bolt at engine operation, and at the same time the lubricating oil valve was getting opened or closed depending on which direction the piston (TDC-BDC "*Top Dead Centre – Bottom Dead Centre*") was moving;
- the above were the main reasons of disappearance of the lubricating oil in the cylinder barrel and of the cooling oil at the piston head;
- because of lack of lubrication and piston head cooling, the piston got stuck in its barrel and as a result the whole connecting-rod base was severed, the piston pin cracked and the engine cylinder block burst;
- until the moment when the engine was fully stopped, the spinning crankshaft "threw" parts of the connecting-rod outside.

Conclusions

This article presents atypical kinds of wear (or failures) in a Diesel- Electric engine on one of the "Seismic Research" type ships. The general conclusion which comes to mind when analysing damages occurring on the discussed ship confirms that neither the ship type nor the extensive operation of the engine or systems is the main cause of failures. The basic problem lies in construction errors or the quality of spare parts, or as it was the case in the most expensive failure of the piston-connecting rod system – a mistake at mounting dependent only on human omission (or ignorance). The last one rarely happens in the case of Polish crews. Engineering officers – graduates of Polish maritime academies are equipped in knowledge much more extensive than that of the so called "cheap crews", and the savings that a ship owner may make employing them, might by insignificant in comparison to the consequences of failures and subsequent costs connected with them.

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