Marine Safety Investigation Unit

Transport Malta

SIMPLIFIED SAFETY INVESTIGATION REPORT

201703/035 REPORT NO.: 05/2018 March 2018

MV *CHODZIEZ*
Main engine damage
in position 42° 45.0' N 004° 47.0' E
31 March 2017

Course of events

Chodziez was enroute on a laden voyage to Marseille, France from Oran, Algeria. On 31 March, at approximately 1200 (LT), the third engineer took over his engineering watch, being his normal 12-4 watch routine as implemented on board.

On 31 March 2017, soon after taking over his watch, he inspected the machinery running condition from the engine control room. He observed that the main engines' loads, propellers, revolutions, exhaust gas temperature, lubricating oil and cooling water temperatures and gearbox oil temperatures were normal and within the makers' parameters.

He then went around the engine-room to visually inspect the running machinery. He observed no abnormal conditions. He also noticed that the oil mist detectors and separators were working fine.

As per normal procedure, the engine-room visual inspection was carried out every 30 minutes.

At about 1457, the third engineer noticed an alarm in the engine control room. A closer look revealed that it was one of the oil mist detectors' alarm. The alarm, which activated due to a high lubricating oil mist in main engine no. 2 crankcase, was soon followed by a low lubricating oil pressure alarm on the same engine.

Upon noticing these alarms, the third engineer pressed the main engine no. 2 emergency stop button. Soon after, he reported the matter to the chief and second engineers.

The three engineers waited for 30 minutes in the engine-control room for the main engine to cool down. Following the delay, the crankcase doors on main engine no. 2 were opened for a visual inspection.

Extent of damage

With the crankcase doors open, the three engineers were able to see inside of the crankcase. The extent of the damage was immediately evident. No. 2 main bearing (Figure 1) had seized. White metal particles were visible on the crankcase walls. Main bearing shells were noticeably damaged and it was also suspected that the crankshaft's main journal no. 3, big end bearing no. 2 and the corresponding connecting rod journal were damaged. Bearing shells were displaced and raised from their housing.

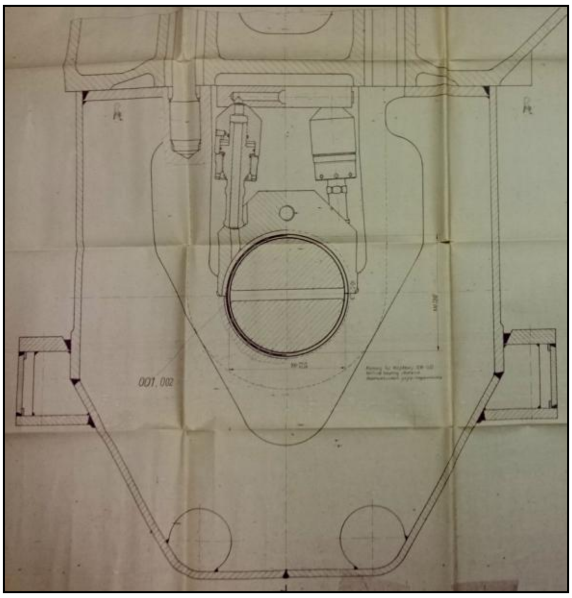

Figure 1: Main bearing assembly

Service engineers were contracted to assess the condition of the crankshaft and a decision was taken to grind the crankshaft in situ. During the grinding, cracks which could not be removed by machining remained visible. Deeper grinding exposed further cracks. In order to minimise the machining costs, the grinding was suspended and it was agreed that the crankshaft had to be replaced.

At the time of the accident, the big end bearing had been in operation for about 2,754 hours. The main bearing had been renewed 1,455 hours prior to the accident. With a recommended renewal time of 12,000 hours, it was evident that both bearings had failed catastrophically, well before the expected end of life.

Cause of the oil mist alarm[1]

Oil mists are potentially hazardous conditions inside an engine in view of the created explosive conditions. The presence of an oil mist is the result of oil vaporisation in the crankcase, caused by either a hot spot or an overheated part within the crankcase[2].

Under normal running conditions, the air in a crankcase will contain oil droplets formed by lubricating oil splashing from the bearings onto moving surfaces. This mixture, however, will not readily burn or explode[3]. The sequence of events leading to an oil mist is as follows.

The natural atmosphere inside the crankcase consists of large globules of oil[4] dispersed through the air. A hot spot (with a minimum temperature of about 360 °C) can vaporise these oil globules. The vapour, rising to cooler parts of the crankcase, is then condensed into an oil mist, consisting of small globules of oil of approximately 2^{-10} nm in diameter. If ignited, an accumulation of this oil mist can cause a heavy explosion.

The safety investigation concluded that the oil mist alarm was therefore triggered by a mist of oil, which was generated by a hot spot, following the failure of the bearing shells.

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1 The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, and to prevent further marine casualties and incidents from occurring in the future.

2 Danger also exists if there is an overheated part adjacent to the crankcase.

3 Crankcase lubricating oil normally has a high closed flashpoint (over 200 °C).

4 Large oil globules have a diameter ranging between 100 nm and 300 nm.

Probable cause of the shell bearing no. 2 failure

Four bearing shells (two pairs top and bottom segment), coded '2DK', '2GK', '3DR' and '3GR' were received by the MSIU and taken to an independent materials engineering laboratory for failure analysis[5]. The bearing shells corresponded to big end bearing no. 2 (upper and lower bearing shells) and main bearing no. 3 (upper and lower bearing shells).

It should be noted that due to the absence of information pertaining to the assembly/disassembly, in-service operating conditions, and access for inspection of the respective counterfaces, it was not possible to determine with absolute certainty the ultimate cause(s) of this failure.

However, the microscopical examination of the bearing surfaces suggested that the failure of the bearings could be broadly attributed to two phenomena:

i. big end bearing no. 2: extensive galling initiated by its assembly misalignment; and

ii. main bearing no. 3: delamination of babbitt material due to reduced adhesion strength and / or fatigue.

It was also considered possible that the delamination of the babbitt material caused the other failure (i), or at least facilitated its extensive occurrence.

The damage on bearing no. 2 is typically known as 'hot short'[6]. The appearance of the bearing surface included wiping, severe galling and blackening from heat. The lining had been removed from several areas. The galling phenomena observed in bearing no. 2 was a severe form of adhesive wear that could have occurred with sliding between metals, resulting in high friction and thus elevated operating temperatures. In this case, extensive galling could be distinguished by localised macroscopic roughening and the creation of several protrusions above the original bearing surface. Areas which included both plastic flow and material transfer were also identified (Figure 2).

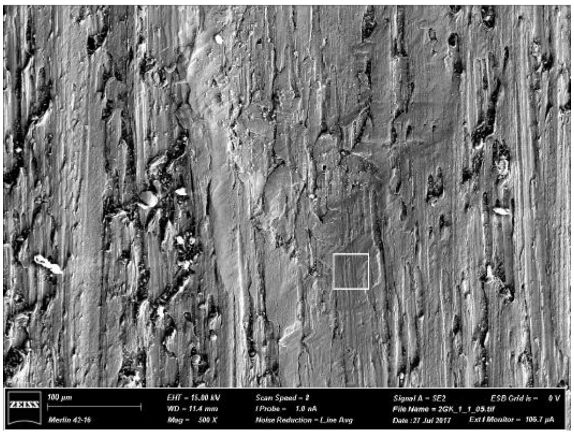


Figure 2: Areas with plastic flow and material transfer

It should be noted that galling is generally not a problem when there is lubrication, unless the lubrication breaks down. Conversely, there is generally an exposure to galling when there is no lubrication and is especially dominant when the tribopair is made of large surfaces sliding past one another. However, for such devices to experience wide-spread galling, out-of-round conditions or errors-inform (*i.e.*, unintended high spots) are necessary since these create local high-stresses. A common manifestation of a galling problem is seizure of the mating parts.

[5] Multiple images of the shell bearings were taken. Selected areas of interest where damage and cracks were visible on the bearings were marked and cut with an Automa E 200 saw. Micrographs of the selected areas were then taken with a Remet stereo microscope. Damaged areas, which required further analysis, were imaged at higher magnifications using a scanning electron microscope (SEM) equipped with an Energy Dispersive Spectrometer (EDS) for element analysis. Smaller specimens suitable for the SEM inspection were prepared. These were adhered to an aluminium stub via conductive carbon tape and then transferred to the SEM for analysis. SEM imaging was carried out using a voltage of 15 kV and probe current of 1.0 nA. EDS analysis was carried out at several locations. The exact wt % of light elements (typically below an atomic number, Z, of 11) cannot be accurately measured using EDS. Hence, in this analysis, the light elements carbon, nitrogen and oxygen can only be considered as indicative.

[6] Hot Shortness is a condition where a metal that operates at an excessively high working temperature, having low mechanical strength, will have the tendency to crack rather than to deform.

Another aspect to the galling phenomena observed could be related to the soft top Al-Sn metal layer. It is known that the size of the gall can be related to the amount of deformation that can take place before fracture. The larger the amount of deformation, the larger the gall, *i.e.*, the low surface hardness and high ductility would have allowed this mechanism.

The wavy surface topography may have also facilitated this effect. However, both surface topography and material selection are intended by design for good operation of these bearings; for instance, these features / characteristics are necessary for lubrication purposes. As a result, it is plausible (assuming that these bearings are well designed to serve their intended purpose and generally survive for a minimum lifetime of 12,000 hours) that the cause of failure is out-of-roundness and/or misalignment in the bearing assembly. It was therefore proposed that misalignment led to overloading and thus failure of shell bearing no. 2.

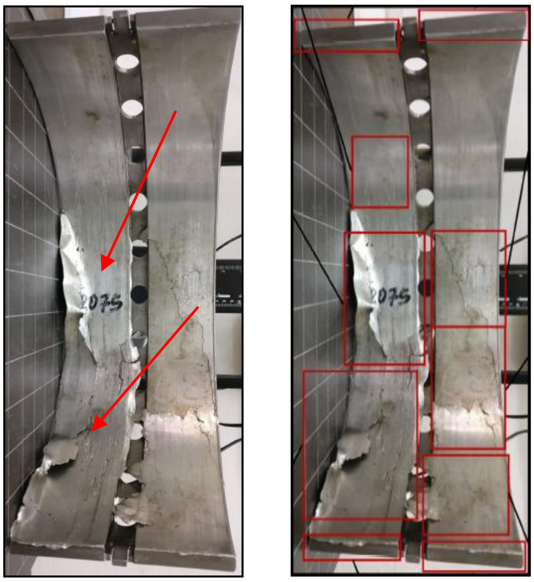
Apart from mis-assembly, excessive crushing can also lead to similar failure morphology, specifically the extreme wear areas along the bearing surface adjacent to both parting lines. This can also be related to overheating of the bearing (which was evident in the various micrographs taken during the analysis of the bearing shells) as heat was generated by the extensive friction of the sliding couple.

Reduced lubrication between the pair can also be the result of a misaligned bearing, and plugged or broken oil passages, prohibiting proper oil flow. Although in this case, breaching of the lubrication film had occurred across the entire bearing surface, the resultant wear was not entirely uniform. The analysis showed that wear damage was more significant and complete removal of the babbitt metal has occurred on the ends rather than at the centre of the bearing. This pattern could again be related to mis-alignment between the crankshaft and the bearing. It is worth noting that although the surface of bearing no. 2 had been clearly subjected to extensive wear damage, no gross delamination of the Al babbitt had occurred.

The possibility of ingress of foreign material could not be completely ruled out. EDS analysis and SEM did not show the presence of embedded materials in the remaining soft Al layer. Nonetheless, the extent of damage may have concealed the presence of, say, iron oxide or other debris on the surface. Foreign material can lead to corrosion damage via the creation of local galvanic pairs with the liner material.

Probable cause of the shell bearing no. 3 failure

The babbitt material was observed under optical and electron microscopes. Yet again, no foreign material was found embedded in it; instead, a clean separation from the steel backing could be observed (Figures 3a, 3b).



Figures 3a and 3b: Clean separation on the bearing shells

Figures 3a and 3b show that large areas of the babbitt metal had spalled away from the backing and other areas could be readily lifted off with minimal force. Furthermore, the analysis also showed extrusion of the lining material out of the bearing edges.

In this case, the failure of the overlay was only partly attributable to fatigue. Fatigue damage overlay is usually visible in the form of a continuous network of cracks, followed by partial flaking of the coatings. In this case, the amount of cracks visible in the remaining lining material did not relate well to the large scale delamination observed for this bearing. However, in the case of Al-based linings (such as this one), it was considered possible that any fatigue cracks formed on the surface and spread inside the lining, had reached the steel back via propagation along the bond line between the lining and the steel.

Other safety issues

Although stopping the main engine was by far the best thing to do, the safety investigation had no evidence that the bridge was informed prior to this action. In this respect, although the second main engine would have ensured a degree of propulsion and manoeuvrability, the engineering OOW was not aware as to whether there were navigational hazards in the area that could have compromised the safety of the vessel.

Moreover, there was also no evidence to indicate that the flow of lubricating oil had been increased after the main engine had been stopped. Increasing the flow of oil is necessary to help reduce thermal stresses caused by the stopping of the main engine and to gradually cool down of the failing parts and avoid welding of parts.

SHIP PARTICULARS

Vessel Name:	*CHODZIEZ*
Flag:	Malta
Classification Society:	Polish Register of Shipping (PRS)
IMO Number:	8302301
Type:	Ro-ro Cargo
Registered Owner:	Pol-Malta Shipping Ltd.
Managers:	Polskie Line Oceaniczne S.A.
Construction:	Steel
Length Overall:	147.38 m
Registered Length:	135.21 m
Gross Tonnage:	15,666
Minimum Safe Manning:	13
Authorised Cargo:	Roll-on/Roll-off

VOYAGE PARTICULARS

Port of Departure:	Oran, Algeria
Port of Arrival:	Marseille, France
Type of Voyage:	Short International
Cargo Information:	Roll-on/Roll-off
Manning:	18

MARINE OCCURRENCE INFORMATION

Date and Time:	31 March 2017 at 14:57 (LT)
Classification of Occurrence:	Serious Marine Casualty
Location of Occurrence:	42° 45.0' N 004° 47.0' E
Place on Board	Engine-room
Injuries / Fatalities:	None
Damage / Environmental Impact:	Damage to equipment
Ship Operation:	On passage
Voyage Segment:	Transit
External & Internal Environment:	Southeasterly wind force 4, slight sea state from the South Southeast. Good visibility.
Persons on board:	18