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Technical article

Self-lubricating sliding bearings

Standard metallic solutions are complemented by High Tec composite material

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Self-lubricating
sliding bearings

Standard metallic solutions are complemented by High Tec composite material!

Self-lubricating, maintenance-free bearings are considered a standard in offshore equipment for over five decades. Particular applications like Turret, Mooring and Jack-up systems, but also Pipe-Laying, tube handling, drilling, cranes and subsea equipment, represent a broad spectrum for the use of these materials.

Reasons for the versatile use in the offshore sector are primarily the tremendous demands for safety and reliability.

Self-lubricating bearings are used whenever conventional solutions such as greased bronze are not practical, can´t be realized for technical reasons or their function cannot be guaranteed. The focus will primarily be on applications with very high loads but low sliding speeds.

The tribologic process within self-lubricating sliding materials, whether metallic or non-metallic is basically the same:

Micro-movement generates the so-called micro-wear on the sliding surface where the embedded solid lubricant is released. This solid lubricant (which may be graphite, PTFE or certain sulfides) is transferred to the mating material (shafts with rotational or oscillating motions; plates with translational movements) where it forms a stable lubricating film between bearing and shaft and safeguards the function of a bearing system even at high loads.

Traditional solution

In recent years, users were relying almost exclusively on high-strength, corrosion-resistant aluminum-bronze in such cases, with self-lubricating properties generated by the insertion of solid lubricant plugs (usually compressed graphite).

Those materials, like deva.glide® consist of highly wear-resistant copper cast alloys with sliding surfaces comprising uniformly distributed solid lubricant plugs according to the so-called "macro distribution" principle. The arrangement of these plugs is depending on the movement direction.

The general suitability of such solutions has recently been re-confirmed in an article of Edison s.p.a., Italy which was published on the occasion of the ONC in 2009 in Ravenna.

In this paper Mr. Angelo Zuffetti, responsible project manager, extensively describes a project course in the Vega oil field in the Channel of Sicily (Italy).

Until mid 2008, Edison s.p.a. operated their vessel "FSO-Vega," which was continuously anchored for 23 years through a single point mooring system (designed by SBM Monaco).

During the years 2008/2009 the "single hull" design vessel had to be replaced by FSO Leonis (double hull) according to the European Environmental Marine Regulations.

During the necessary adjustment work on the existing mooring system also the large radial spherical bearings (design deva.glide ID 1200 mm) by Federal Mogul DEVA were overhauled and then brought back into use with FSO Leonis for another 15 years. This corresponds to a total operational life of 38 years!

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Photo: Deva image bank

FSO Leonis moored at SPM System = 4 items

This proven bearing concept will be intensively used as well in the future with the main focus on large spherical bearings and cylindrical bearings with inner diameters of 500 mm to 3500 mm.

From a technical point of view, however, it is most crucial to ensure that there is sufficient movement in this kind of bearing system over the entire life in order to achieve an "overlap" between the lubricant depots. Only this way a uniform lubricant film can be continuously built up on the mating material.

Therefore it is technically no longer appropriate to use this system for applications with primarily small angular or micro-movements like in fair leads and fair lead chain stoppers.

Contemporary Solutions

Improved alternatives to the "bronze with plugs" within the family of metallic materials are for instance deva.metal ® and deva.bm ®. Both materials produced by a specific sinter technology are essentially different as the solid lubricant is uniformly dispersed in the metallic matrix and their lubricant type & quantity can be customized for specific applications.

Important selection criteria's are typically the specific load, the sliding speed, size & number of movements, and of course for offshore, corrosion resistance due to the environmental conditions.

Main advantage of these two modern systems over the traditional solution "with plugs" is that always - even during micro-movements - a sufficient amount of lubricant is supplied and the self-lubricating function is safeguarded, since solid lubricant are homogenously embedded in the sliding layers. Additionally, deva. bm ® as thin-walled design offers its user advantages when space is limited or a maximum allowable wear of ≤ 1.5 mm can´t be exceeded. Examples are universal joints, crane application, swivel stacks,

Image 1 (deva glide +micrograph= 2 items)

Image 3 (deva.metal + micrograph) A family of self lubricating sliding materials each containing dry solid lubricants. The particular alloy will be adapted in accordance to the individual operating conditions.

offloading systems and smaller spherical bearings (≤ 300 mm) in general.

Advanced options by High Tec composite materials

Meanwhile, however, not only metallic bearing materials are used in the offshore area. Moreover heavy-duty, durable polymeric composite systems play an important role in the decisive process towards a suitable bearing material these days.

Their suitability also for applications involving sustained high loads, low sliding speeds in comparison with metal solutions is supplemented, where other properties are required.

Significant increased demands in a very low wear rate, in a high corrosion resistance (especially seawater), in a low weight and, above all, in a most consistent coefficient

Comparison between the main options for offshore applications						
Property		Unit	Brass + plugs	Sintered bronze with solid lubricant	Bi-metallic	Composite
Maximum specific load		Mpa	300	260	280	230
Maximum permissible speed		m/s	0,4	0,4	1	0,2
pU factor most		Mpa x m/s	1,5	1,4	1,0-2,0*	1,5
Minimum hardness axis		HB / HRC	180 / 300*	180 / 45*	180	180
Roughness axis		Ra (um)	0,2-0,8	0,2-0,8	0,2-0,8	0,4-1,0
Coefficient of friction***	Dry		0,10-0,13*	0,10-0,22*	0,05-0,18*	0,03-0,12
	Wet		0,08-0,12*	0,09-0,20*	0,08-0,12*	0,04-0,13
Galvanic corrosion			low	low*	low**	not
Resistance	Misalignment		good	good	reasonable	excellent
	Mechanical shock		good	reasonable	reasonable	excellent
Swelling by water absorption			not	not	not	not
Suitable for micro-movements			not	yes	yes	yes

Image 6 (Table): material comparison

* depends on alloy ** steel resistant to sea water *** depends on the operating conditions

Image 4 (deva-bm + micrograph) A thin-walled bi-metal material comprising a steel backing (seewater resistant) with a sliding layer of deva.metal®. The latter is either graphite or PTFE.

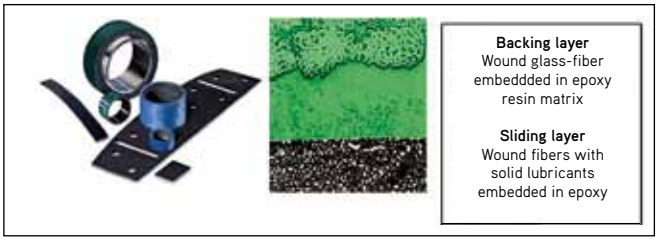

Image 5 (deva.tex +micrograph) deva.tex® is a self-lubricating, glass-fibre reinforced composite bearing material which is produced using a special filament winding technology. The base material guarantees high strength, while the sliding layer contains special non-abrasive fibres and solid lubricants ensuring excellent tribological properties even in damp environment or in the event of edge loads. The solid lubricants were developed for underwater application to ensure extremely low friction coefficients and wear rates.

of friction at low levels have caused a shift of mind set in offshore applications. The keyword here is "Subsea".

Therefore alternative solutions based on "High-Tec polymers" are gaining increasing importance and approaching areas where metallic materials were used successfully for decades.

deva.tex ® 552 as an example has been developed specifically for under water applications.

Current examples for that kind of new approach in the offshore/subsea market are various riser applications like tensioning systems, hang-offs and connectors or sliding plates for turret systems, stab connectors for ROV´s just to mention a few.

The currently most severe changes can be found in Fairleads / Fairlead-chainstopper. Valid for decades, solutions with plugged bronze are increasingly replaced by high-tec composites.

Those kinds of applications shall be designed by today´s expectations for 20-25 years lifetime, therefore demanding essentially low friction values and wear rates.

However, demands for safety and reliability are also valid for fiber-wound material, so form stability non-delamination & non-swelling properties are "a must" for a filament material!

The simplified table below will show the main technical properties of the 4 choices and their general advantages / disadvantages as a first guideline.

Many of the above mentioned material properties are dependent on the specific operating conditions. The coefficients of friction, for example, can vary significantly depending on load in some cases.

Also, when designing "dry sliding bearing" solutions, criteria such as dissipation of frictional heat, corrosion, abrasive & shock loading and edge pressure play a crucial role in determining the most suitable bearing material. This is why only general information can be given in this report.

Conclusion:

The completion of proven metallic bearing concepts with new, modern plastic composite systems allows the engineer to develop a technically more customized solution for any given task.

This becomes increasingly important in order to meet environmental and economic requirements – provided of course that users / customers are reviewing traditional approaches accordingly and make themselves intensively familiar with the pros & cons of both material groups.

Therefore, it is always recommendable to get in touch with the according vendors early enough to enquire for their technical support. ■