Degraded and non-degraded mooring ropes jackets: a comparative study of wearing behavior

B. P. Lucas, P. P. Lucas, F. E. G. Chimisso
Federal University of Rio Grande, RS Brazil
Policab – Stress Analysis Laboratory – Engineering School
brunoplucas@yahoo.com.br

ABSTRACT. Nowadays, the use of synthetic ropes for offshore platforms anchorage in deep and ultra deep water is a common practice. Despite these ropes have been used for more than 10 years, they are still an active field of theoretical and experimental research. Nevertheless, little is known about the mechanical strength of the jackets of those ropes.
Although there are many materials in which jackets of ropes can be made, in most cases the same material of the subrope is used for the manufacturing, it may lead to unnecessary costs and it adds nothing to the mechanical strength of the rope. Therefore, it's necessary to look for answers - taking into account the wearing resistance - of jackets made from different materials so that we can drop the cost of the rope in a secure way. It's also important to known the degraded jackets behavior, and also that the ropes are not always been used in the best conditions (new ropes).
The same test methodology used for Rodriguez, N. P. et alii, OMAE, 2006. is applied in this paper, which aims at comparing those results with this found for degraded jackets submitted to the environment action (sun, humidity, rain) for 18 months.

KEYWORDS. Abrasion; Wearing; Synthetic mooring ropes; Jackets; Degraded ropes.

MOTIVATION

With the increase of the exploration of petroleum deposits, which are becoming deeper and deeper nowadays, the mooring, which used to be performed with steel cables, now is starting to be performed with synthetic ropes. These ropes have some characteristics such as lower linear weight and high mechanical strength. Therefore, there are other characteristics that should be studied to use these ropes in order to reduce costs.
Seeing that it is a common practice to use the same material for the jacket and for the rope, using a different and cheaper material for the jacket may be a way to reduce the costs of the mooring, so that it is not necessary to use the same properties of the subrope. It does not have the function of adding tensile strength to the rope, but cover the legs and protect them against the environment and abrasion actions.
Another factor to be considered is the degradation that the rope jacket could suffer when submitted to environment factors, which are current in work conditions. Such factors can be rain, wind, humidity, sun and so on. Thus, this scenario motivates the present study regarding the strength of the jackets. The specimens related above were exposed and submitted to external environment conditions, such as sun and rain, for 18 months and then collected and submitted to abrasion wearing tests. Such exposure condition is shown in Fig. 1.

Figure 1: Ropes exposed to the environment action.

After that, the results obtained for these specimens were compared with the results obtained for ropes jackets of the same materials, but non-degraded. In this context, this paper aims at comparing the superficial wear between rope jackets degraded and non-degraded, made of the same material. This comparison is shown in tables and graphics that relate the number of cycles and the loss of mass of the specimen.

APPARATUS

In order to perform the tests made on this study, we used a wearing test machine. As shown below, this machine offers different environment tests: tension, tension submerged into water and tension plus bending.
The abrasive surface was kept carefully to promote the maintenance of the abrasive power, in a way that the comparison between the results of degraded and non-degraded jackets of same material and architecture became feasible. On Fig. 2 we show an illustration of the machine working. In order to not present considerable abrasive wearing, the pure tension test was not made.

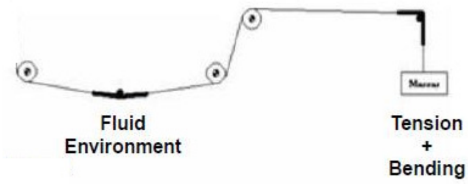

Figure 2: Illustration of the machine.

METHODOLOGY

To promote the reliability of the tests, some procedures were made (according to Rodriguez, N. P. et alii, OMAE, 2006). Some of them are shown below:
Tests in tension + bending and in tension subjected to fluid environment were performed. The load applied in both cases was of 6Kgf (58,86N or 13,23lbf).
The criteria for the specimen wearing analysis considerate the mass loss of the specimen associated with the mechanical resistance loss of the yarns of the jacket.
For that, firstly is measured the mass of the specimen. After that, it is necessary to be done a reference test to make the comparison able. In this test the specimen is submitted to wearing up to the subrope becomes visible. After, tests of 20%, 40%, 60% and 80% of the average cycles of the reference test are performed. Thereby, the broken yarns and filaments are separated and discarded, allowing the mass measurement of the unbroken.
To determine the relative wearing some equations were applied, shown in Rodriguez, N. P. et alii, OMAE, 2006.

JACKET MATERIALS TESTED

The jacket materials below were provided by Cordoaria São Leopoldo (CSL) as ropes of 50 m of length and 14 mm of diameter. The Tab. 1 shows the jacket material mechanical properties.

N	Material	YBL(N)	*DTEX	Tenacity(cN/DTEX)
1	Polyester 10500 Mixed T120	738.4	10500	7.03
2	Polyblend (PP60% + PE 40%)	32.76	598	5.48
3	Polypropylene MONO 0130	40.61	700	5.80
4	Polypropylene MULTI 1400 DTEX	50.32	1400	3.59
5	Polysteel 1670 DTEX	114.09	1670	6.83
6	Nylon 2100 DTEX	146.46	2100	6.97

Table 1: Properties (averages) of the tested materials *DTEX, mass in grams of 10.000 m of yarn

It is important to highlight that the average tenacity is not a significant feature to be considered on the jacket material choice except for, as said before, assembling tensile strength to the rope.

Results

On Tab. 2 we show the number of cycles and the standard deviation for the reference test (exposure of the subropes). We can observe that the exposure to the environment action, in most of the cases, reduce the wearing resistance of the jackets.

Material	Cycles until the break (Exposed subrope)							
	Non-Degraded				Degraded			
	Dry	S Dev	Submerse	S Dev	Dry	S Dev	Submerse	S Dev
Nylon - 2100 DTEX	41743	12227,84	2518	130,29	284	74,07	866,00	29,40
Polypropilene -1400 DTEX	2825	1023,96	791	254,95	205	33,48	331,33	49,04
Polysteel - 1670 DTEX	956	395,40	1849	62,32	1888	787,91	8084,67	876,11
Polyblend (PP 60% + PE 40%)	1034	227,32	1242	290,25	118	25,24	525	243,31
Polypropilene MONO PH 0130	436	149,81	999	207,59	0	0	0	0
Polyester - 10500 MIXED T120	7296	1418,34	779	86,74	110	23,72	2719	295,02

Table 2: Number of cycles until the exposed subrope

The results obtained are shown in the graphics below, where the curves are developed in a comparison to the reference test results. On Fig. 3 we test the effect of the degradation on a Nylon material. The horizontal axis of Fig. 3, and of all subsequent Graphics, represents the number of cycles of the machine and the Y axis represents the relative wearing of the material.

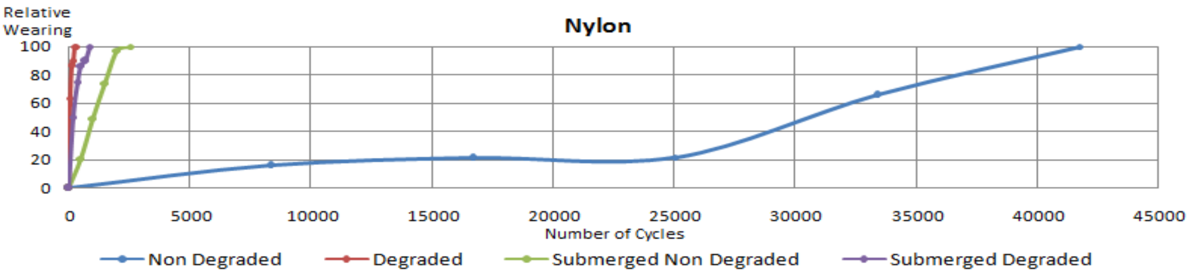

Figure 3: Results for Nylon 2100 DTEX

When Nylon (Fig. 3) is in a water environment, it is clear that the degradation is a relevant factor for the wearing resistance. The difference of behavior (submerged and dry) can be explained through the hydrolytic response of the material. On Fig. 4 the effect of the degradation on the Polypropylene material is tested.
Polypropylene (Fig. 4) is quite affected by the degradation. The best response was reached in dry solicitation for non-degraded and submerged for degraded jackets.
We may notice through Fig. 5 that the monofilament of Polypropylene presented the rupture even before the test in the machine. The material presented a fragile and resected aspect.
On the Fig. 6 is possible to see that the Polyblend also demonstrates that the degraded specimen has a reduction on its wearing resistance. A different behavior is showed on Fig.7, where the exposure to the environment action improved the

Polysteel's wearing resistance. The material seemed to have a surface that offered less friction, maybe a chemical analysis could offer more specific answers.
In Fig. 8, we can see that the degraded Polyester showed a better wearing resistance for the submerged test.

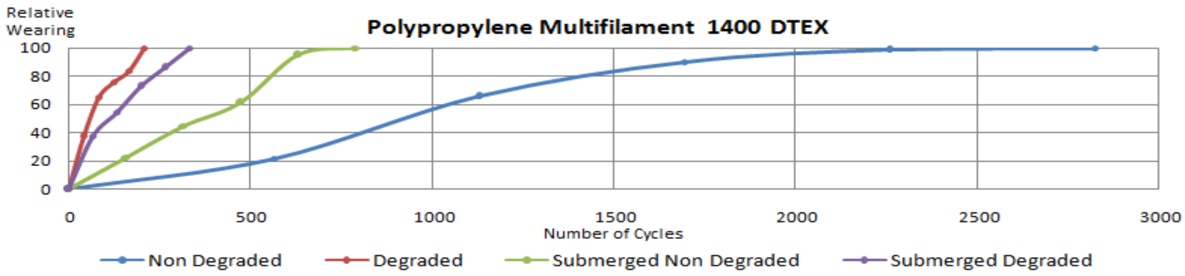

Figure 4: Results for Polypropylene Multifilament 1400 DTEX

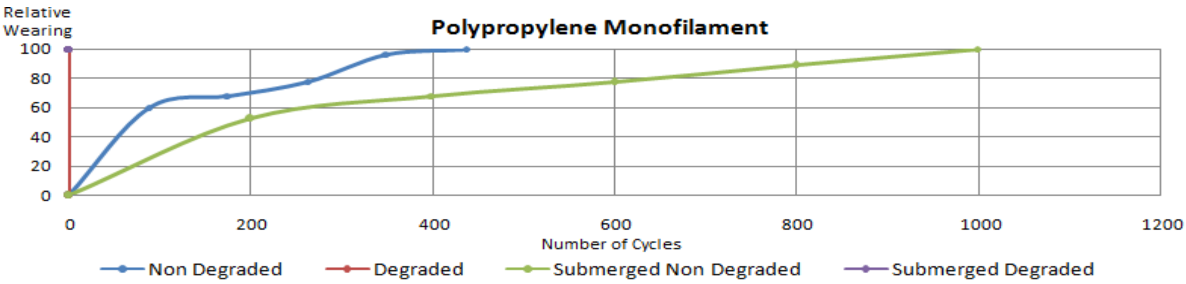

Figure 5: Results for Polypropylene Monofilament 0130

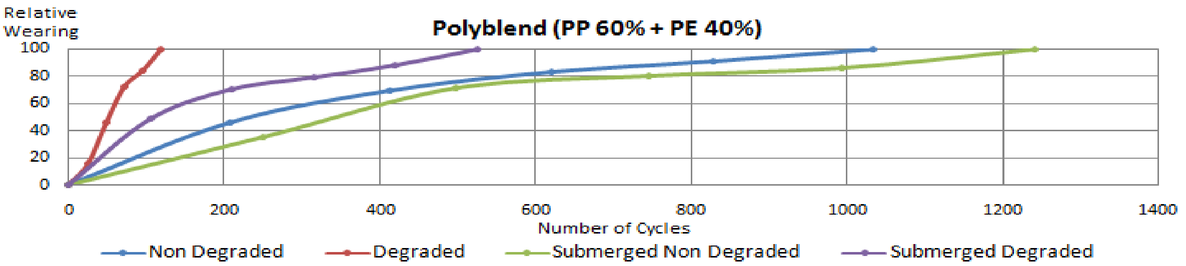

Figure 6: Results for Polyblend

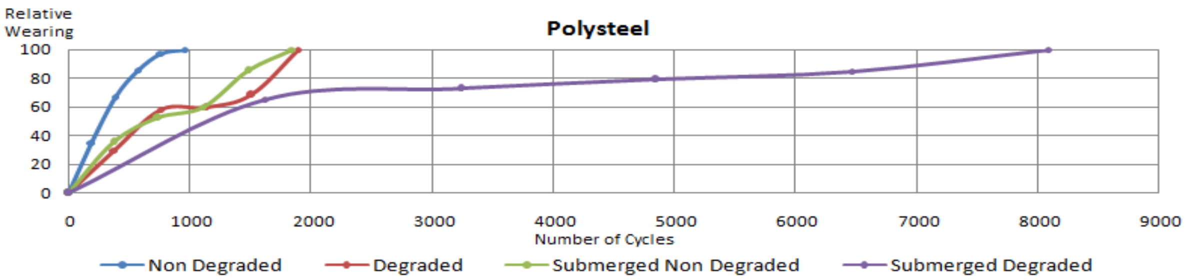

Figure 7: Results for Polysteel

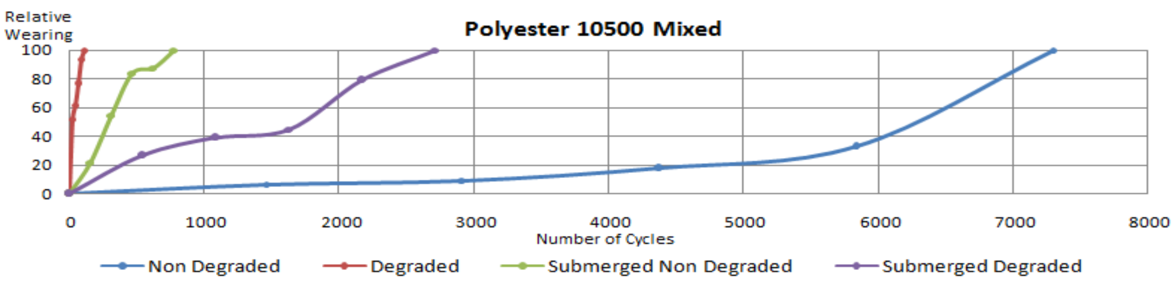

Figure 8: Results for Polyester 10500 MIXED

Conclusions

By means of this work we could assure that the degradation on the environment does not cause the same effect on the wearing resistance in all the materials tested. The Polyester (only submerged) and Polysteel materials, when degraded, for instance, showed a better wearing resistance compared to the non-degraded materials. On the other hand, all other materials did not show the same behavior, as it was proved on Tab. 2. This work presents some perspectives; it could serve as reference for novel works and maybe help the industry.

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