Yarn-on-yarn abrasion behavior for polyester, with and without marine finish, used in offshore mooring ropes

S. S. Soares, V. Fortuna, F. E. G. Chimisso
Federal University of Rio Grande, RS/Brazil
Policab – Stress Analysis Laboratory – Engineering School
sasasoares@msn.com

ABSTRACT. In Brazil, the use of synthetic ropes for mooring platforms in deep and ultra deep water has increased. So, the knowledge of the behavior of materials used for the anchoring is very important and motivates our study. A considerable problem with synthetic ropes on load in service is the friction among multifilaments. Apparently to reduce the friction it is applied a lubricant product called Marine Finish. In this study, was investigated the abrasive behavior of polyester multifilament yarn-on-yarn in air environment, with and without the use of this lubricant. To perform it, were taken into account standards rules like as CI - Cordage Institute and ASTM - American Society for Testing and Materials.

The apparatus and devices used for the experiments was made into POLICAB and for the specimens tested was follow the same procedures used by Talgatti, O.L. & Chimisso, F.E.G.. The specimens tests were performed with loads changing from 2% to 6% of the YBL (Yarn Break Load), the tensile strength of multifilament, with constant increment. For both tests (with and without marine finish), curves of life were obtained. This paper aims to present the results of the two specimens used and to verify if they are agree with the suggestions of standards.

KEYWORDS. Abrasion; Marine finish; Yarn-on-yarn; Polyester; Synthetic ropes.

INTRODUCTION

The increasing consumption of oil in the world has been originated by the necessity of developing new research and techniques to extract it from deep and ultra deep waters. Currently, offshore platforms are being used to attend to extreme environmental conditions of extraction. But, to obtain the maximum efficiency of such structures, it is necessary to replace the traditional Catenary Mooring System, which uses steel wire ropes, by another, using synthetic ropes, called Taut-leg. The application of synthetic ropes represents an efficient solution, because they have a relatively long life, lighter linear weight, little or no interaction with the environment, and make easier handling operations when compared the steel wire ropes. However, the use of synthetic ropes for mooring is recent and requires further studies about the material and especially its mechanical properties, including the yarn-on-yarn abrasive behavior of it.

OBJECTIVE

Considering the increased application of synthetic ropes in offshore structures, it has became necessary a not so much degradable cables to be developed, regarding the environmental and even the yarn-on-yarn interactions. To minimize such damage, Marine Finish coated ropes started to be manufactured, using a lubricant that intends to

reduce the yarn-on-yarn abrasion, thus increasing the longevity of these.
In order to acquire more knowledge on the current performance of cables made of Marine Finish was developed a comparative study of polyester multifilament manufactured with lubricant, and polyester multifilament without this lubricant. The procedure was performed in a dry test, from a device optimized for Talgatti LO, according to the rules CI (Cordage Institute) and ASTM (American Society for Testing and Materials).

THE MECHANISM OF YARN-ON-YARN ABRASION

The wear abrasion mechanism was developed in according to the ASTM and CI, with the next characteristics (see Fig. 1): the upper pulleys centerlines are separated by 140 ± 2 mm, the lower pulley centerlines is 254 ± 2 mm below a line connecting the upper pulleys centerline; this arrangement produces an apex angle of 34°. The crank is offset by 25 ± 2 mm to the drive motor shaft, the gear motor drives the crank at between 60 and 70 revolutions/min, the yarn should have three complete wraps producing an inter wrapped angle of 1080º.Design details as shown in Fig. 1. To develop the tests, a workbench was designed with the function to support the device. The abrasion cycles counting were made with an inductive sensor associated to a key contactor and a LPC (Logical Programmable Controller). This equipment gives us the number of cycles during the test and the time when occur the failure of the specimens. So, the LPC shows the result and the motor stop after 5 (five) seconds. The prototypes are shown in Fig. 2.

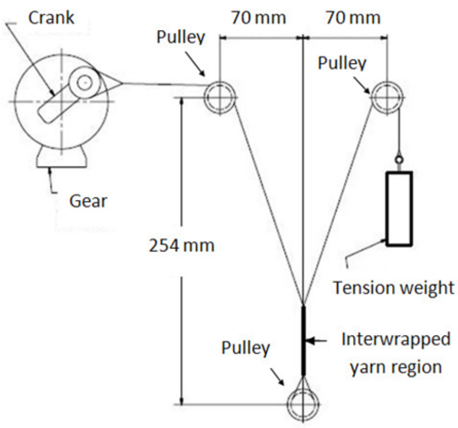

Figure 1: Design details according normative.

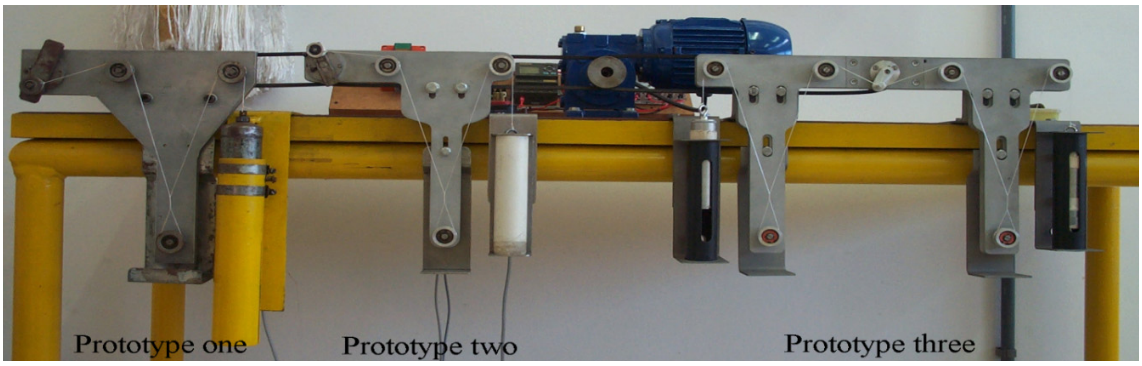

Figure 2: Testing machines

THE TESTS

The tests were made in multifilament of polyester, in accord to the standards CI and ASTM. These normative establish the load, during the tests, between 2 and 6 % of YBL (Yarn Break Load). To determine the YBL were made 10 tensile tests for polyester multifilament with Marine Finish obtaining an average break load of 174.6 N, and also 10 tensile tests for polyester multifilament without finish obtaining an average break load of 169.9 N. For the development of the tests, 10 different loads were applied, in accord to the percentage of breaking load, each load for 8 specimens. So, for each complete test, was made 80 specimens with marine finish, and 80 specimens without marine finish. This was showed in the follow Tab. 1.

%(YBL)	2	2.45	2.89	3.34	3.78	4.23	4.67	5.12	5.56	6
LOAD (grams) With M. Finish	356	435	515	594	673	752	831	911	990	1068
LOAD (grams) Without M. Finish	346	424	501	578	655	732	809	886	963	1039

Table 1: Loads applied.

Follow a statistic analysis was made to obtain the cycles average and the standard deviation of the eight specimens tested for each load. The mean cycles to failure, M, were obtained by Eq.1:

$$M = Ln^{-1} * \left[\frac{LnCTF_1 + LnCTF_2 + \cdots + LnCTF_N}{N}\right] \tag{1}$$

where CTF_N are the cycles to failure for specimen, N is the number of specimen tests, *Ln* is the natural logarithm and Ln^{-1} is inverse natural logarithm. The Ln of standard deviation of CTF, was obtained by Eq.2:

$$Ln\sigma = \sqrt[2]{\frac{(LnCTF_1 - LnM)^2 + (LnCTF_2 - LnM)^2 + \cdots + (LnCTF_N - LnM)^2}{N-1}} \tag{2}$$

where $Ln\sigma$ is the Logarithm standard deviation of cycles to failure and *LnM* is the Logarithm of mean cycles to failure. The upper and lower limits, was obtained by Eq.3 and Eq.4:

$$\text{Upper Limit} = \text{Ln M} + 2\ \text{Ln}\ \sigma \tag{3}$$

$$\text{Lower Limit} = \text{Ln M} - 2\ \text{Ln}\ \sigma \tag{4}$$

RESULTS

The values obtained in the tests and elaborated into the equations above, was showed in the follow Tab. 2 and in the graphics. In the Fig. 3 we can see the behavior of the polyester multifilament with marine finish and in the Fig. 4 the behavior without marine finish. We can observe in the table below the average, the upper and lower limits of cycles to failure for each percentage of the applied load.

% of YBL	Lower Limit With Marine Finish	Average With Marine Finish	Upper Limit With Marine Finish	Lower Limit Without Marine Finish	Average Without Marine Finish	Upper Limit Without Marine Finish
2.00%	25720	27820	30091	21991	22909	23865
2.45%	19161	21441	23992	15923	17012	18177
2.89%	13102	13499	13908	12122	12613	13124
3.34%	10729	11237	11768	9878	10336	10815
3.78%	8182	8693	9236	7845	8450	9102
4.23%	6539	6897	7274	6206	6546	6905
4.67%	4983	5395	5840	4301	4700	5136
5.12%	3555	3823	4112	3019	3234	3464
5.56%	2358	2582	2828	1826	2184	2614
6.00%	1892	2005	2125	1364	1605	1887

Table 2: Average, upper and lower limits of cycles until failure.

In both graphics we can see the small standard deviation so, we conclude considering a good performance of the device.

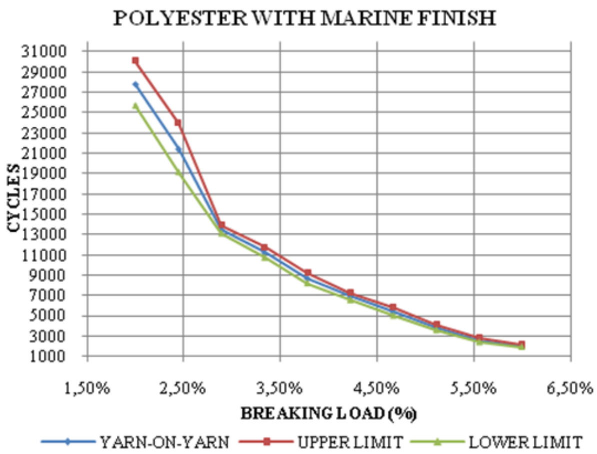

Figure 3: Marine Finish.

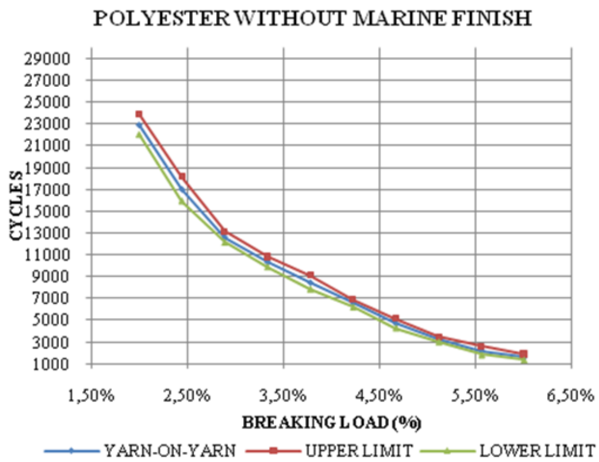

Figure 4: No Marine Finish.

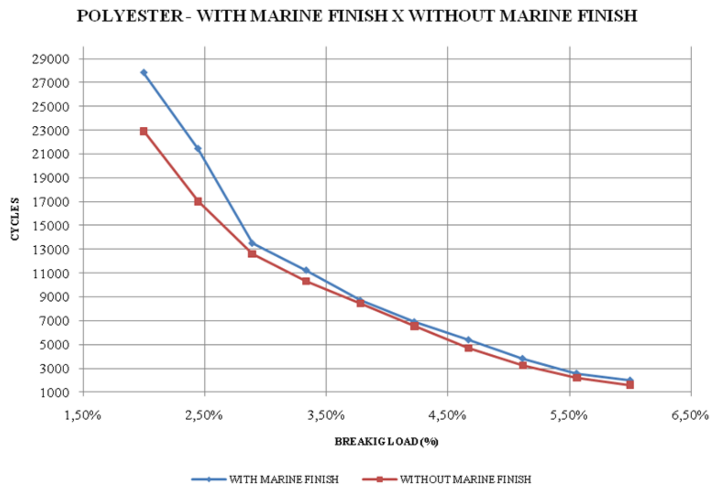

Figure 5: Comparative tests.

CONCLUDING REMARKS

The obtained results of the tests are into according to the suggestions of the Standards. It's possible to observe the multifilaments with Marine Finish presented a little better performance than the ones without marine finish. This is not sufficient to conclude regarding the efficiency of the lubricant in dry tests. The follow of the research, in the future, will be to realize the tests in wet (salt water) conditions to analyze the real performance of the multifilaments of polyester, with and without the lubricant, when used in mooring ropes.

ACKNOWLEDGEMENTS

The authors are grateful to POLICAB – EE – FURG for sponsoring this work and also to PETROBRAS for supplying of the materials.

REFERENCES

[1] ASTM STANDARDS – Designation: D 6611- 00.: Standard Test Method for Wet and Dry Yarn-on-Yarn Abrasion Resistance (2007).

[2] Cordage Institute: Test Method for Yarn-on-Yarn Abrasion, Wet and Dry – CL 1503 - 99 (1999).
[3] J. F. Flory, M. GKSOY, J.W.S. Hearle, In: 2nd International Conference on Polymeres in a Marine Environment, Inst. of Marine Engineers, London, (1989) 197.
[4] O. L. Talgatti, F.E.G. Chimisso, In: 7th YSESM, Wojcieszyce, Poland (2008).