Creep comparative behavior of HMPE (high modulus polyethylene) multifilaments when submitted to changing conditions of temperature and load

L. E. N. Caldeira, P. P. Lucas, F. E. G. Chimisso
Federal University of Rio Grande, RS Brazil
Policab – Stress Analysis Laboratory – Engineering School
dadonc@gmail.com

ABSTRACT. The use of synthetic ropes technology has been substantially established on the petroleum field, especially in platforms situated in ultra deep waters. The polyester has been one of the most used materials for this purpose, however other synthetic ropes are offering improvements on the mechanical properties in some aspects. A material that could replace the use of polyester is the HMPE (High Modulus Polyethylene). Even it has a similar tenacity of the steel, it shows a decrease on the weight and dimension of these fibers. However, the creep that was not appreciable in polyester fibers has an important value on the HMPE fibers life. In this paper, experiments on HMPE yarns are made, analyzing the creep behavior in different environments (changing temperature and load); it is wise to expect that these changes can lead to different responses. Three different fibers of HMPE produced by different suppliers were tested, allowing the analysis of the creep behavior of these materials. An apparatus presented on "CREEP ANALYSIS OF HMPE MULTIFILAMENTS IN LOW TEMPERATURE" Rochedo, I. B. et alii, YSESM, 2008, has been used to allow this study.

KEYWORDS. Creep; Synthetic mooring ropes; HMPE.

MOTIVATION

With the increase of the technology, the petroleum has been used every time more. However, this is not a renewable resource of energy and because of this is becoming scarce. The exploration of petroleum in ultra deep water is increasing and together with this, we need a latest technology than the moorage of off-shore platforms using steel cables. So the synthetic ropes become of great importance, highlighting the polyester as the material that is more commonly used for this. Due to the necessity of reduce the weight and the dimension of the rope, new material has been tested to substitute the polyester on this case.

The HMPE (High Modulus Polyethylene) has presented a promissory behavior referent to these issues. But it presented a problem: The creep.

The creep can be defined as the deformation suffered by the material while it is submitted to a constant load. As these ropes made of HMPE will be used in deep and ultra deep water, studies of creep in temperatures closed to this water must be realized. This temperature is about 4°C. Studies in ambient temperatures also were realized. Such conditions provide the analysis of the behavior differences among these ropes in different requests.

The load that ropes are submitted is about 30% of the YBL in extreme situations, like storm conditions. So, tests were realized with a load of 30% of the YBL and also with 15% of the YBL. These variations of the loads and temperatures were chosen to make possible an analysis of the behavior of these ropes, allowing a better study of the life. The table 1 shows the values of these loads:

Material	YBL [N]	30% [N]	15% [N]	[dtex]	Tenacity [cN/dtex]
A	139.4	41.82	20.91	553,3	25.19
B	530.1	159.03	79.51	1795	29.53
C	540.7	162.21	81.1	1766	30.62

Table 1: Characteristics of the materials.

OBJECTIVE

Due the creep has a great importance in the possible end of life of the fibers made of HMPE, tests were performed with three different materials developed in three different countries, specified here as materials A, B and C. A comparison of the creep behavior among these materials, during two weeks of tests for each material and condition, will be established in this paper.

EQUIPMENT AND TEST

For the tests, we used a device developed in POLICAB [1]. This equipment consists on an adapted refrigerator. In this equipment the specimens can be suspended and tensioned by applying a load on the bottom causing a creep.
For the measurement of displacement due to creep is used an inductive sensor connected to a computer software that allows the reading of the test. Fig. 1 shows the apparatus used in the tests.

Figure 1: Apparatus.

To study the creep of materials, conditions were set for the tests.
Offshore, in extreme storm conditions, the cables showed that suffer a maximum load of 30% of tensile strength and it is possible to notice too that, how they are used in deep water, the need for testing at low temperatures is necessary. Therefore, tests were performed with two different applied loads (15% and 30% YBL) at low and ambient temperatures, 4ºC and 20ºC, respectively.
So many conditions have been established with the purpose of having a more complete study of the creep of these multifilaments.

RESULTS

The curves of Fig. 2 to 5 show the results of creep tests for three types of multifilaments. In Fig. 2, there is the condition of 20ºC and 30%YBL indicating that the material A broke in less than 5 days (120 hours). The other specimens showed no break and, until the end of the tests, the strain rate remains approximately constant, whose behavior is characteristic of the stage prior to rupture.

For the others graphics, all the specimens did not broke, but it is observed that the material A presents a greater sensitivity to the creep in relation to other materials. Only in the last condition (temperature of 4ºC and 15% YBL), we observed a similar behavior of the creep for all materials.

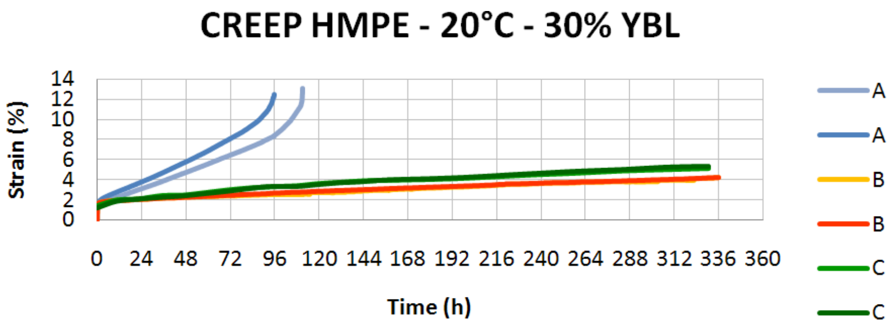

Figure 2: Strain of HMPE materials at 20ºC and 30% of the load.

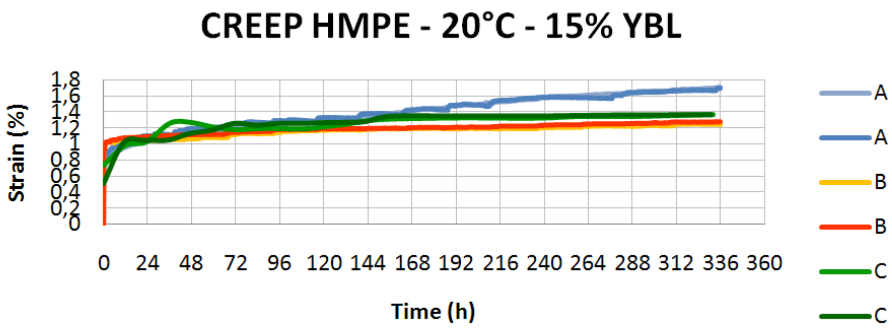

Figure 3: Strain of HMPE materials at 20ºC and 15% of the load.

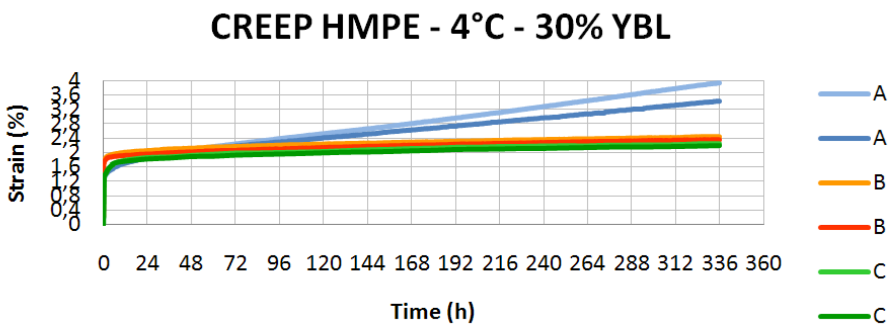

Figure 4: Strain of HMPE materials at 4ºC and 30% of the load.

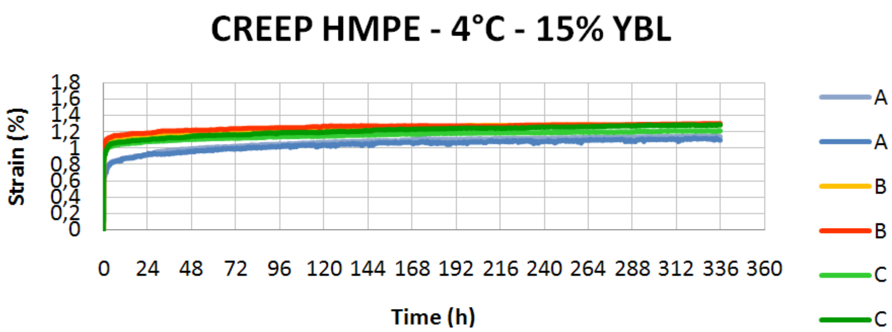

Figure 5: Strain of HMPE materials at 4ºC and 15% of the load.

CONCLUSION

In this paper, we presented a series of tests, developed at POLICAB – FURG, with the objective of studying the behavior of the multifilaments of different materials submitted to creep at different test conditions. Of three materials analyzed, in general, it was observed that the material A showed an higher creep deformation, reaching the break at ambient temperature of 20ºC to a load of 30% YBL.

The materials B and C apparently have similar results with similar creep behavior. More tests will be made in the next months and a new equipment will be designed to develop more concluding remarks.

ACKNOWLDGEMENTS

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

REFERENCES

[1] B. Rochedo, G. A. C. Vieira, F. E. G.Chimisso, 2008, In: 7th YSESM – Youth Symposium on Experimental Solid Mechanics, Wojcieszyce, Poland (2008).
[2] C. J. M. Del Vecchio, Light Weight Materials for Deep Water Moorings, PhD Thesis, University of Reading, London, UK (1992).
[3] M. Silva, F. E. G. Chimisso, In: COBEM – 18th International Congress of Mechanical Engineering, Ouro Preto, Brazil (2005).
[4] P. Smeets, M. Jacobs, M. Mertens, MTS Oceans (2001)