

Pesquisa Científica e Inovação Tecnológica nas Engenharias 3

Franciele Braga Machado Tullio
Lucio Mauro Braga Machado
(Organizadores)



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APRESENTAÇÃO

Em “Pesquisa Científica e Inovação Tecnológica nas Engenharias 3” temos treze capítulos que trazem preciosas contribuições para a inovação tecnológica nas engenharias.

Pesquisas na área de gestão de resíduos, produção de energia limpa, cuidados com o ambiente em que vivemos demonstram que os pesquisadores estão preocupados com a inovação, mas respeitando os recursos naturais.

Na mesma linha, pesquisas na área de logística e mecânica demonstram preocupação com o bem-estar da sociedade sem renunciar aos benefícios proporcionados pela tecnologia. Benefícios presentes ainda na otimização de custos em construção e na utilização de tecnologias de informação móveis.

Esperamos que esta obra seja útil ao progresso da ciência e possa melhorar as pesquisas na área. Boa leitura!

Franciele Braga Machado Túllio
Lucio Mauro Braga Machado

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PETRODIESEL WITH BIODIESEL WATER/OIL SEPARATOR FILTER – LOW PERFORMANCE

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ABSTRACT: The volume of pre filter sold during last five years have led us to evaluate the root cause of it. Initially, it was verified the entire volume of pre filter commercialized increased 9 times from 2005 to 2018. The customer's complaints are related to premature filter plugging and change interval under specification as informed by maintenance manual. Analysis have performed according to SAE J1839 and SAE J905 standards in order to evaluate water separation and filtering performance. It was confirmed a water separation performance reduced, including several cases near 60% with low mileages. Besides, it was noted sludge and wax at filtering media surface in umpteen samples. On the other hand, a comparison between field components with commercial Diesel S10 B10 and diesel S10 B10 with high oxidation stability was done and it was confirmed the filtering media life with high oxidation stability keeps the change interval according specification. The trend with diesel S10 B15 with low and high stability was accomplished too. The media was analyzed with Scanner Electron Microscopy (SEM) in order to understand the influence of wax in water separation performance and effects in injector nozzle.

KEYWORDS: Pre filter; sludge; oxidation stability; water separation

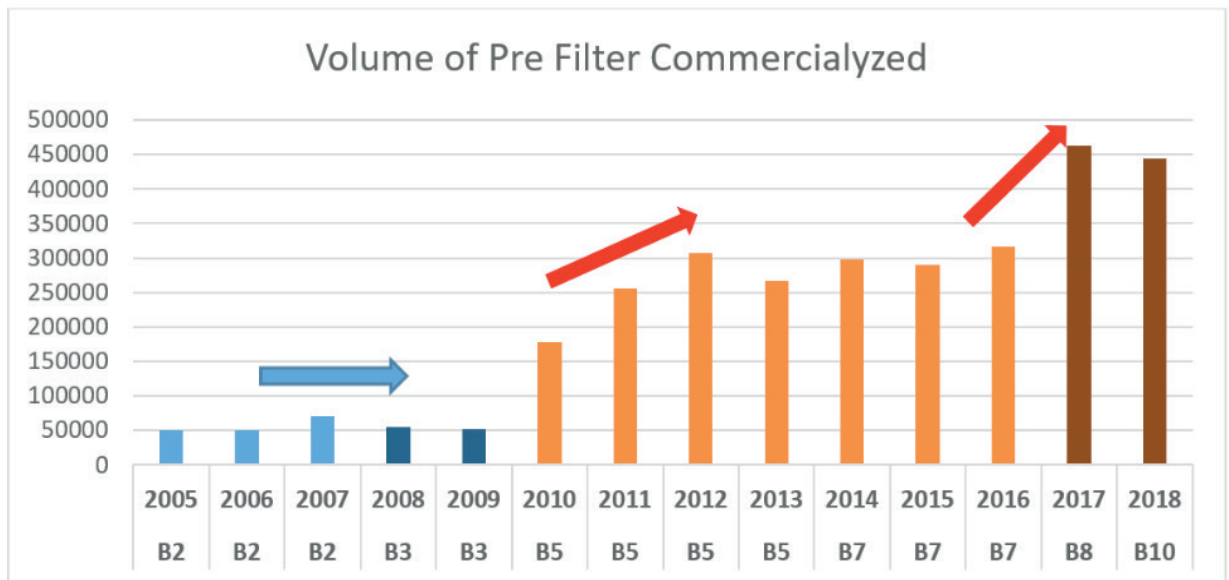
1 | INTRODUCTION

According to Biodiesel Handbook (2005) [2], the vegetable oils and animal fats were investigated as diesel fuels well before the energy crisis of 1970s. However, neat vegetable oils and animal fats are about 10 times more viscous than petrodiesel fuels, and they caused some operational and maintenance problems for diesel engines, so they were eventually abandoned as alternative diesel fuels. In Brazil, was started in 2005 with 2% in v/v until the current 10% in 2019. Some efforts to increase to 15% are ongoing and tests previewed to be done at end of this year. According Brian Sims (Biodiesel Magazine) [17], the use of petrodiesel and biodiesel blend has been practiced in many parts of the world for diesel engines. For example, since October 2005, B2 (B2 = 2 vol % biodiesel in diesel fuel) has become a mandatory use in Minnesota in most of the state's diesel fuel supply, in spite of a temporary snag due to the use of an off-spec biodiesel. "In August 2007, Minnesota governor Tim Pawlenty announced a plan requiring the state to increase its biodiesel mandate incrementally from B2 to B20 by 2015. The governor's proposal calls for Minnesota to move to B5 by 2008, B10 by 2011, B15 by 2013 and B20 by 2015". The American Filtration and Separation Society Conference (2008) affirm that the use of petrodiesel and biodiesel blend still causes some extent of concerns for the end users, especially when the ratio of the blend is increased from B2 to B20.

The Biodiesel Handbook also inform that Biodiesel's storage stability, oxidative stability as well as its high affinity to dissolved water could lead to shortened fuel filter life and deteriorated fuel/water filtration efficiency. Biodiesel is known to have higher cloud point and more unsaturated hydrocarbon content, which tend to lead to earlier wax precipitation and increased intensity of fuel oxidation. The affinity to water is attributed to the more polar nature of alkyl-esters and unsaturated acids which barely exist in petrodiesel, a middistillate of crude oil with boiling temperature ranging from 180°C to 340 °C.

2 | VOLUME OF PRE-FILTER SOLD

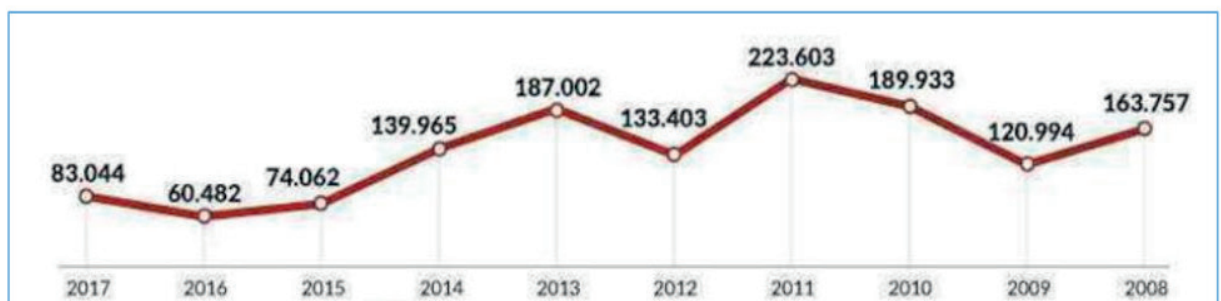
Evaluating the volume of pre filter sold during 2005 to 2018 period and comparing the volume of biodiesel increased during those years. It was noted that the volume of pre filter commercialized increased according to percentage of biodiesel in v/v from 2% until 10%. The graphic 1 show the volume sold trend according to volume of biodiesel increasing.



Graphic 1: Volume sold trend according to volume of biodiesel increasing (Source: Parker Hannifin).

The volume sold increased 4,6 times (50.000/year to 230.000/year in average) from B3 in 2009 between period 2010-2016. The truck and bus production volume in Brazil increased in 2011 cause Euro 5 program (Proconve P7) and the aftermarket parts keeps the same trend until B7 in 2016. In 2017 new increment volume was noted when changed to 8% v/v and the volume of pre filter increased in 48,39%. The Trucks and Buses field backlog and production volume from 2008 to 2017 does not match relating of total pre filter commercialized and specifically during Brazilian crisis period (2015 to 2018).

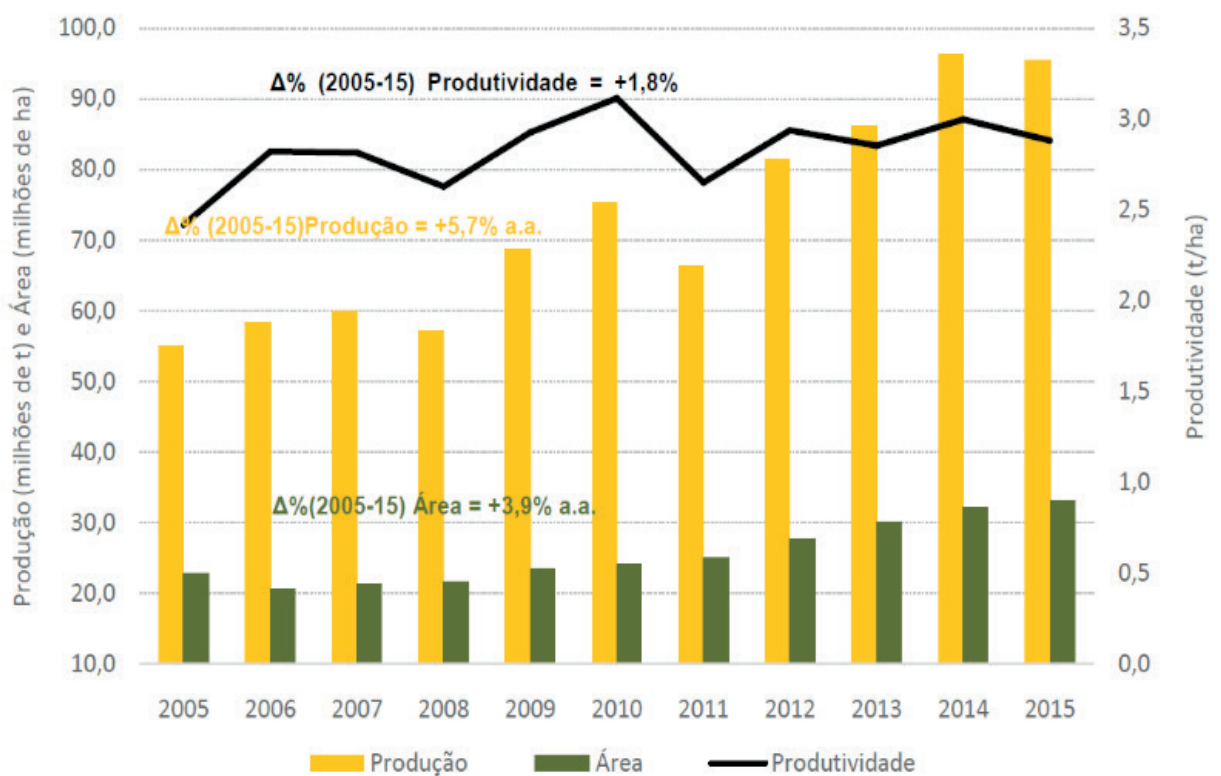
According to electronic magazine OTTO IN 2012 [1] the fuel contamination could be the responsible to cause some expensive and complex problems and, in some cases, could impact in water separation process. The Biodiesel Handbook [2] also inform that low oxidation stability reduce life and water/oil separation efficiency in diesel pre filter.



Graphic 2: Trucks volume production from 2008 to 2017 (Source: Anfavea).

3 I SOCIAL, ECONOMIC AND ENVIRONMENTAL ANALYSIS

The Energy and Mines Ministry (MME) informed in October 2016 [3], the trend reported in April of this same year through National Petroleum, Natural Gas and Biofuel Agency (ANP), if the investment to expand the national production of petrodiesel and biodiesel does not happen faster, it will be necessary to import around 24,6 billions of liters in 2030 in order to attend the diesel engine vehicles demand. The demand planned for 2016 is around 93,6 billions of petrodiesel liters included the 7% of biodiesel mixed (6,5 billion liters of biodiesel) than it is possible to conclude the production estimated demand of 18 billion liters of biodiesel could exceed at around 11,5 billion liters that correspond 47% of total importation. Certainly, will contribute to increase at Brazilian Commercial Balance in a positive balance. The graphic 3 show the historic production, planting area and Brazilian soybean production between 2005 to 2015 according to CONAB [4]. It is verified the annual production growing in 5,7%/year and the biodiesel production should be increased in order to support the demand in case of biodiesel mixed in petrodiesel increased as well.



Graphic 3: Production historic, crop area and Brazil soybean production. Source: CONAB

The table 1 shows diesel consumption demand in Brazil increased. The soybean agribusiness production previewed between 2016 to 2030 increase in 300% and this growing condition bring some necessities as investments, employees generation, growth of cities, per capita incomes, facilities improvement by tax and cities investment.

Premissas/Projeções	2016	2020	2025	2030	Unidade (milhões)	Δ% 2016-30 (a.a.)
Mistura obrigatória	B7	B10	B15	B20	%	-
Composição de matérias-primas						-
<i>Óleo de soja</i>	77	77	77	77	%	-
<i>Sebo bovino</i>	18	15	11	8	%	-
<i>Óleo de palma</i>	0	2	5	8	%	-
<i>Outros</i>	5	6	7	7	%	-
Volume de diesel B	55	64	76	90	m ³	3,9%
Volume de biodiesel	3,9	6,4	11,4	18,0	m ³	12,6%
Volume de biodiesel de soja	3,0	4,9	8,8	13,9	m ³	12,6%
<i>Óleo de soja para biodiesel</i>	2,6	4,3	7,7	12,2	t	12,6%
<i>Soja processada para biodiesel</i>	14,1	23,4	41,8	65,9	t	12,6%
Volume de biodiesel de sebo bovino	0,7	1,0	1,3	1,4	m ³	5,8%
<i>Sebo para biodiesel</i>	0,6	0,8	1,1	1,3	t	5,8%
<i>Abates equivalentes</i>	27	37	48	55	cabeças	5,8%
Volume de biodiesel de óleo de palma	0,0	0,1	0,6	1,4	m ³	-
<i>Óleo de palma para biodiesel</i>	0,0	0,1	0,5	1,3	t	-
<i>Área plantada necessária</i>	0,00	0,03	0,11	0,25	ha	-

Table 1. Raw material prediction for Biodiesel. Source: ABIOVE

The Management Center and Strategic Studies (CGEE) [5] from Science, Technology and Innovation Ministry (MCTI) 2004, soybean agribusiness estimative is the responsible to employ 4,7 million people direct and indirect in several areas as a production, transport, distribution, process and industrial raw material.

The Brazilian Company for Research and Agricultural (Embrapa) [6], inform that his production volume indicators for future is near to North American market. The United States production in 2017/2018 was 119,5 million of tons and in Brazil 117 million of tons and Gross National Income (PIB) indicator of agribusiness represent 20% of all Brazilian economic activity.

4 | SPECIAL CARE FOR DIESEL PRE FILTER WATER/OIL SEPARATOR SCRAP

The “Meio Filtrante” magazine edition July/August 2007 [7] already present concerning about rightly filtering media scrap and the environmental responsibility must be required. According to the Meio Filtrante magazine, the main factor to be considered by legislation is the final disposal. The element disposal should be done by the waste generator responsibility and he should be done in right way avoiding possible environmental problem. In practice, the company that acquire and use the element media should disposal according current legislation.

Data from National Federation for the Distribution of Automotive Vehicles (FENABRAVE) [9] inform the total Truck and Bus Brazilian fleet is around 2,5 million of vehicles and the volume of pre filter replaced is 5 times/vehicle. According to Parker Hannifin company could produce diesel pre filter the current contaminated elements

media annual volume represent around 10 million/year and the mass of by each one is around 1,2 kg. In this way the total volume disposal per year is around 12.000 tons.



Image 1. Pre-Filter water/oil separator disposal without right care. Source: Meio Filtrante Magazine, published in July/August 2012.

The Brazilian Association of Volkswagen Truck and Bus Distributors (ACAV) [10], request special attention for right disposal residues from Truck and Bus maintenance. The main materials identified are lubricant oil, oil filter, diesel filter (main and pre filter), air filter and tires.

The wrong destination could promote an environmental concern. In this way, the ACAV inform all Brazilian dealers to take care at those components disposal in order to avoid soil and water table contamination.

5 | PRE FILTER ENGINEERING ANALYSIS

It was done several pre filter water/oil separation analysis at test bench, see image 2, with durability test parts and field parts.

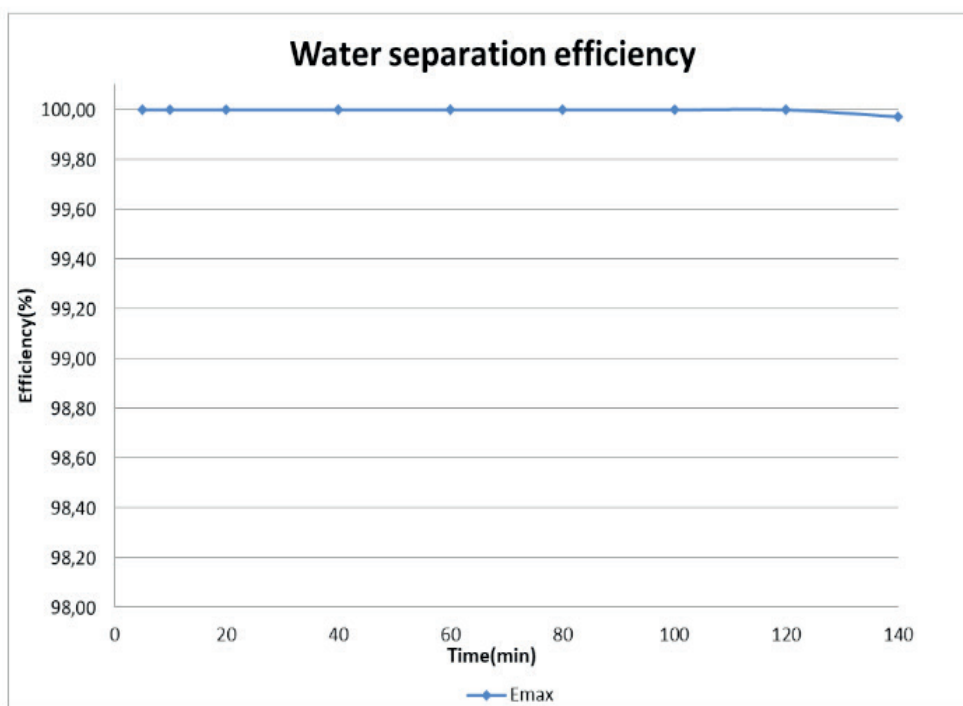


Image 2. Water separation test bench analysis according to SAE J1839. Source: Parker Hannifin

We verify life performance difference regarding to water separation between pre filters with S10 B10, S500 B10 and S10 B15 with high and low oxidative stability. The main idea is linked at sludge formation during durability test according to high and low oxidation stability, reducing the water separation efficiency. Biodiesel is a hydroscopic fluid according to Biodiesel Handbook [2], the water could pass through the media element, in ppm, by mechanical drag and carried to injectors. This condition makes the injectors performance reduction. Vehicles with long period without engine start could reduce the oxidation stability and also the pre filter life. The injectors life reduction is a consequence of that.

Pre filter maker evaluate 221 parts from field claim and the previews information from dealers is fueled with S10 B10 only in all cases and the main claim is pre filter low performance. Customer replacement with 15.000 km in average and the normal service maintenance interval is around 60.000 km but depending of vehicle application could be around 40.000 km. The oxidation stability according to Rancimat EN15751:2014 standard in average were 4 hours and the expectative is around 20 hours according to ANP resolution 30/2016. The lead time from diesel oil recovered and received for analysis could make the worse result. However, the total lead time between costumer claim and analysis is 2 months in average. Then it can be considered a normal lead time for this kind of warranty analysis cycle.

All evaluation was done at test bench according to SAE J1839 standard for water separation performance and the results in average minimum ere 30%. The minimum specification for approval is 95% and the supplier specification is 98% according to graphic 5.



Graphic 5. Water separation efficiency – New element media. Source: Parker Hannifin.

The SAE J1839 procedure as follows:

- Regular flow rate – 120 GPH;
- Add 18,9 ml/minute of water at inlet filter side;
- Remove samples with 1cc at outlet filter side according intervals 5, 10, 15, 20,..., 140 minutes.
- The efficiency is determined with Karl Fischer results.



Image 3. Photovolt Aquatest 2010, Karl Fisher method. Source: Parker Hannifin

5.1 Tests with S10 B10, S500 B10 and S10 B15 – High and Low Oxidation Stability

Were tested 5 vehicles with Diesel S10 B10 and oxidation stability with 46 hours in average, according to Rancimat – DIN EN 15751:2004. The mileage tested in each vehicle is 40.000 km in average and the water separation performance found out was 90% in average, see image 4.



Image 4. Filtering element media after test with diesel S 10 B10 with 46 hours of oxidation stability. Water separation efficiency with 90% in average. Source: Volkswagen Truck & Bus.

Were tested 5 vehicles with S 500 B10 and oxidation stability with 14 hours in average, according to Rancimat – DIN EN 15751:2004. The mileage tested in each vehicle was 30.000 km in average and the water separation performance found out was 50% in average, see image 5.



Image 5. Filtering element media after test with diesel S 500 B10 with 14 hours of oxidation stability. Water separation efficiency with 50% in average. Source: Volkswagen Truck & Bus.

Were tested 1 vehicle with S10 B15 and oxidation stability with 4,5 hours, according to Rancimat – DIN EN 15751:2004. The mileage tested was 7.000 km and the water separation performance found out was 34%, see image 6.



Image 6. Filtering element media after test with diesel S10 B15 with 4,5 hours of oxidation stability. Water separation efficiency with 34%. Source: Volkswagen Truck & Bus.

It was tested 1 vehicle with S10 B15 and oxidation stability with 27 hours, according to Rancimat – DIN EN 15751:2004. The mileage tested was 20.000 km and the water separation performance found out was 95,5%, see image 7.



Image 7. Filtering element media after test with diesel S10 B15 with 27 hours of oxidation stability. Water separation efficiency with 95,5%. Source: Volkswagen Truck & Bus.

5.2 Pre filter SEM analysis

It was decided to evaluate the element media at Scanner Electron Microscopy (SEM) in order to evaluate the fibers characteristics in a new media, tested in vehicle

and keeping good water performance at test bench and tested in vehicle with low water separation performance at test bench.

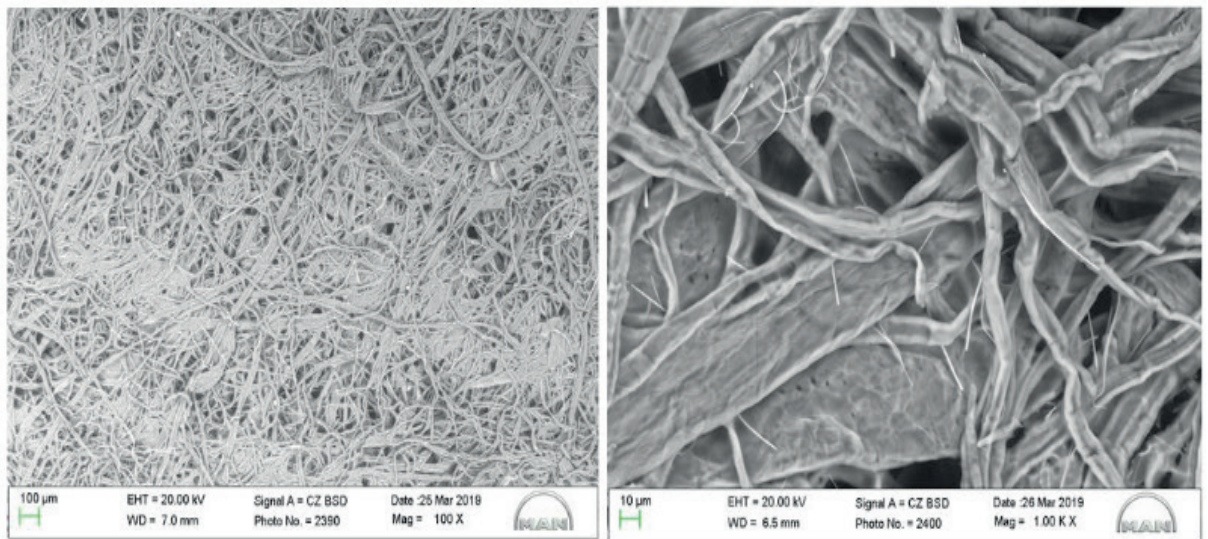


Image 8. New filtering element media 100X and 1000X. Source. Water separation efficiency with 98%. Source: Volkswagen Truck & Bus.

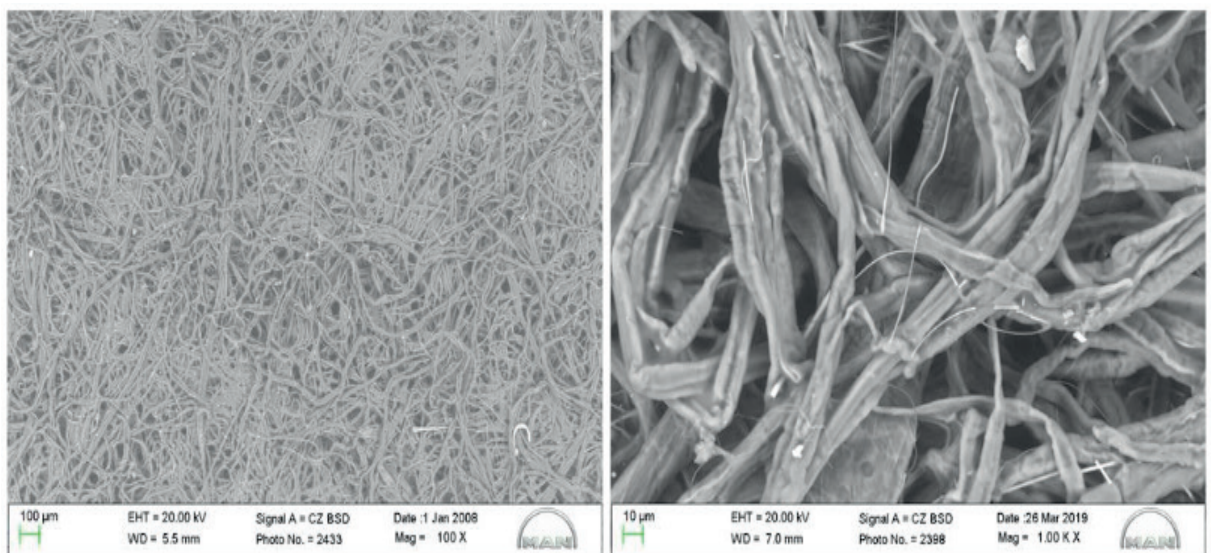


Image 9. Filtering element media tested with S10 B15 with 27 hours stability. Total tested: 20.000 km. Imagens with: 100X and 1000X. Source. Water separation efficiency with 95,5%. Source: Volkswagen Truck & Bus.

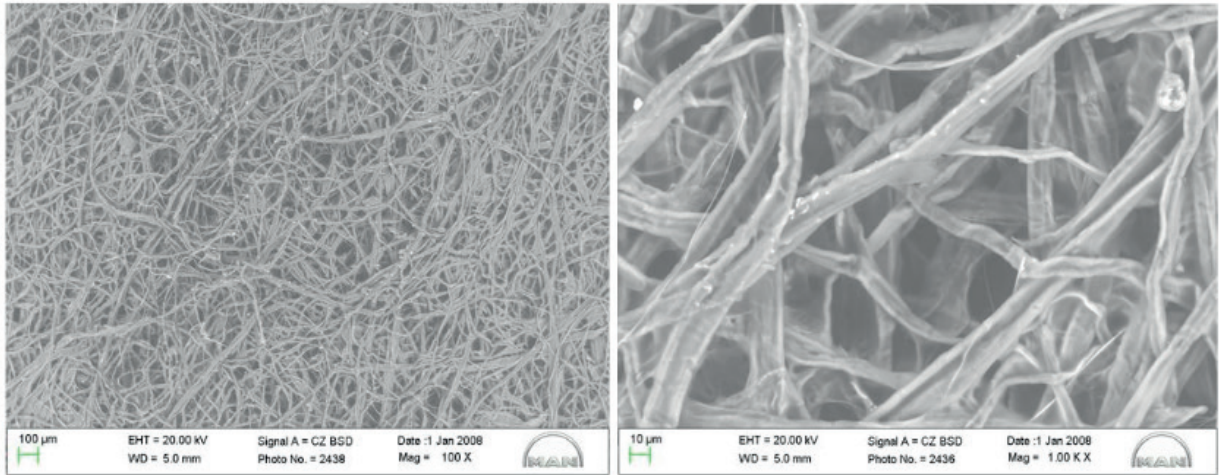


Image 10. Filtering element media tested with S10 B10 with 46 hours stability. Total tested: 73.000 km. Imagens with: 100X and 1000X, Water separation efficiency with 65%. Source: Volkswagen Truck & Bus.

The element media showed at image 10 was replaced after pressure sensor send a replacement signal to the cluster. The analysis regarding water separation efficiency was 65%.

6 | CONCLUSION

- The trend regarding the biodiesel percentage mixed at petrodiesel is a reality and this condition bring several economic and social benefits [9] to Brazil as an employment, per capita incomes and city tax collection increasing. The results could impact directly in education, health, safety and quality of life of inhabitants. Other aspects linked are transport, processing and biodiesel production are responsible for direct and indirect employment increase as well.

- The media filtering elements analysis evaluated with biodiesel oxidation stability over and lower than 20 hours shows a loss water/oil separation efficiency when the oxidation stability is lower than 20 hours. Then it will be necessary implement the 20 hours at Brazilian resolution as soon as possible. No other parameters were affected.

- It is necessary to include at National Policy of Solid Waste the diesel pre filter water/oil separator disposal in order to avoid water and soil contamination. The current Policy does not get this item defined as a reverse logistic.

- The National Policy of Solid Waste could include electrical energy by co-generation with an opportunity.

- The analysis by SEM show the possible reduction of water separation as a result of biodiesel hygroscopic characteristic and the water goes through by mechanical drag. This condition reduces the water separation performance at filtering media with low mileage when the oxidation stability is low. With oxidation stability over 20 hours no water oil separations was noted.

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 **Atena**
Editora

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