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Analysis of the Sorption Process for Brake Fluid and Diesel after the Application of the Compact Sorbent

Abstract

During car accidents the leakage of petroleum substances together with the vehicle fluids appear. One of the basic duties of the Fire Department in the field of ecological protection is to support the area of car accident with the use of sorbates. Therefore, the aim of the study was to compare the sorption process for the different sorbates in contact with the compact sorbent.

The analysis of sorption process in a laboratory scale was performed with the use of a dedicated installation. Contact of two sorbates with the compact sorbent was investigated. Each time 50 cm³ of the sorbent was contacted with 100 cm³ of the sorbate in the following properties: 100% of brake fluid, 100% of diesel, 75% of brake fluid and 25% of diesel, 50% of brake fluid and 50% of diesel, 25% of brake fluid and 75% of diesel. Finally, the results of the mathematical description of the sorption process with a non-linear regression were prepared.

It was observed that the sorption process for pure brake fluid that contacted with the compact sorbent was stopped after the absorption of 24.80 ± 0.27 g, while, for pure diesel it was stopped after 21.09 ± 0.35 g. The average sorption was equal to 0.83 and 0.72 for brake fluid and diesel, respectively. Furthermore, for a mixture of brake fluid (75%) – diesel (25%) the sorption process was stopped after the absorption of 18.39 ± 0.17 g, while for a mixture of brake fluid (25%) – diesel (75%) it was stopped after 22.06 ± 0.54 g. The average sorption was equal to 0.63 and 0.37 for brake fluid (75%) and diesel (25%), as well as for brake fluid (25%) and diesel (75%). Finally, for the mixture of brake fluid (50%) and diesel (50%) the sorption process was stopped after the absorption of 21.85 ± 0.49 g, with average sorption equal to 0.72.

It was observed that the sorption process was longer for brake fluid compared to diesel. The decrease of brake fluid amount led to the decrease of the sorption value. Moreover, the higher amount of brake fluid was associated with the higher value of the correlation coefficients after the application of fifth degree polynomial adjustment.

Keywords: sorption process, compact sorbent, mixture sorption

Analiza procesu sorpcji dla płynu hamulcowego i oleju napędowego po zastosowaniu sorbentu compact

Abstrakt

Podczas wypadków samochodowych pojawiają się wycieki substancji ropopochodnych, a także płynów eksploatacyjnych. Jednym z obowiązków straży pożarnej jest zabezpieczenie miejsca zdarzenia drogowego. Celem przedmiotowych badań była analiza procesu sorpcji różnych sorbatów przy pomocy sorbentu compact.

Analiza procesu sorpcji dwóch sorbatów w skali laboratoryjnej została przeprowadzona z wykorzystaniem dedykowanej aparatury eksperymentalnej. Za każdym razem kontaktowano 50 cm³ sorbentu compact z 100 cm³ sorbatu o następującym składzie: 100% płynu hamulcowego, 100% oleju napędowego, 75% płynu hamulcowego i 25% oleju napędowego, 50% płynu hamulcowego i 50% oleju napędowego, 25% płynu hamulcowego i 75% oleju napędowego. Co więcej, wyniki eksperymentów zostały opisane przy pomocy nieliniowej regresji.

Zaobserwowano, że proces sorpcji czystego płynu hamulcowego (100%) w kontakcie z sorbentem compact zakończył się po zaabsorbowaniu 24.80±0.27 g sorbatu, podczas gdy proces sorpcji dla czystego oleju napędowego (100%) zatrzymał się po zaabsorbowaniu 21.09±0.35 g sorbatu. Średnia sorpcja wynosiła odpowiednio 0.83 i 0.72 dla płynu hamulcowego i oleju napędowego. Co więcej, dla mieszaniny płyn hamulcowy (75%) – olej napędowy (25%) proces sorpcji zatrzymał się po zaabsorbowaniu 18.39±0.17 g sorbatu. Natomiast dla mieszaniny płyn hamulcowy (25%) – olej napędowy (75%) proces sorpcji zatrzymał się po zaabsorbowaniu 22.06± 0.54 g sorbatu. Średnia sorpcja wynosiła odpowiednio 0.63 i 0.37 dla mieszaniny płyn hamulcowy (75%) i olej napędowy (25%) i płyn hamulcowy (25%) i olej napędowy (75%). Na koniec przeanalizowano proces sorpcji dla mieszaniny płyn hamulcowy (50%) i olej napędowy (50%). Proces sorpcji zatrzymał się po zaabsorbowaniu 21.85±0.49 g sorbatu, a średnia sorpcja wynosiła 0.72.

Proces sorpcji był znacznie dłuższy dla płynu hamulcowego w porównaniu do oleju napędowego. Zmniejszenie zawartości płynu hamulcowego prowadziło do zmniejszenia wartości sorpcji. Co więcej, większa zawartość płynu hamulcowego korelowała z wyższymi wartościami współczynników korelacji dla wielomianu piątego stopnia opisującego wyniki eksperymentu.

Słowa kluczowe: sorpcja, sorbent compact, sorpcja mieszaniny

1. Introduction

Road transport is a significant branch in the developing industries that with the increasing number of vehicles is the main issue for the environmental protection [1]. However, the rising number of cars on roads is associated with the higher number of car accidents which demands the Fire Department engagement [2]. Therefore, one of the basic duties of the Fire Department in the field of the ecological protection is to support the area of car accident [3]. One of the severe consequences of car accidents is the environmental devastation caused by the leakage of petroleum substances as well as other vehicle fluids [4–6]. Therefore, substances called sorbents are considered as appropriate approach of supporting spilled liquid (sorbate) on the road. Depending on the origin of sorbent, we divided them into following types: the organic, the inorganic and the chemical. One of the most important parameters which classifies sorbents, is the absorbency, which is defined as the mass of absorbed sorbate to the mass of the applied sorbent [7, 8]. The oil sorption materials mainly comprises the inorganic mineral products, natural materials, synthetic polymers and polymer-based composites [9]. In the case of sudden leakages, the selection of the proper type of sorbent is mandatory, while the application of the material with the best sorption properties may limit at the costs of operations [10, 11]. Therefore, the aim of the study was to investigate the sorption properties of the compact sorbent in contact with different sorbates.

2. Material and Methods

In this paper we focused on the analysis of the sorption process concerning the compact sorbent (Sintac-Pols) contacting with the different sorbates e.g. brake fluid and diesel. The properties of the applied sorbent were as follow: grain size from 0.3 mm up to 0.7 mm; bulk weight approximately 520 g/L; absorptivity over 100%. Therefore, in the laboratory scale a dedicated experimental set-up was prepared (Fig. 1). The set-up was composed of the following elements: the transparent, plastic container with the capacity equal to 50 cm³ localized below an electronic weight positioned on the antivibration table, and above the Petrie's dish with the capacity equal to 100 cm³. Moreover, the following substances were analyzed: one sorbent (compact sorbent) and two sorbates (brake fluid and diesel). Each time 26 g of sorbent was contacted with 100 cm³ of sorbate in different proportions such as 100% of brake fluid, 100% of diesel, 75% of brake fluid and 25% of diesel, 50% of brake fluid and 50% of diesel, 25% of brake fluid and 75% of diesel.

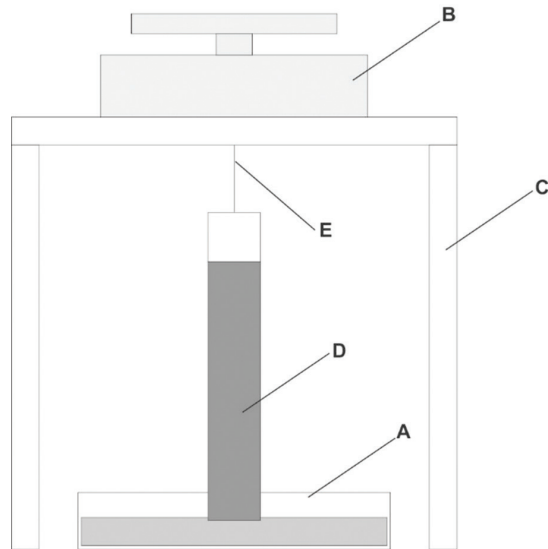


Fig. 1. A dedicated experimental set-up for the sorption process analysis in a laboratory scale was composed of: A – a Petri dish; B – an electronic weight; C – an anti-vibration table; D – a cylindrical container for analyzed sorbent; E – a telescope

The weight of sorbate was monitored every 10 seconds until the electronic weight displayed the same value three times. The temperature of sorption process was approximately 22°C. Moreover, each sorbate or sorbate mixture was analyzed in triplicates. Finally, the mathematical description of the sorption process was showed with a non-linear regression. The following parameters were analyzed: R the square and the standard deviation.

3. Results

This paper investigates the sorption process for five different cases in the laboratory scale. First, two pure sorbates (100% brake fluid and 100% diesel) were contacted with the compact sorbent (Fig. 2a). The results of the sorption process were presented as an amount of sorbate in the function of time. It was observed that the sorption process for pure brake fluid (100%) contacted with the compact sorbent was stopped after the absorption of 24.80 ± 0.27 g brake fluid in time equal to 8900 s (Fig. 2a). While, for pure diesel (100%) contacted with the compact sorbent, the sorption process was stopped after the absorption of 21.09 ± 0.35 g in time equal to 3180 s (Fig. 2a). The average

sorption was equal to 0.83 g/g and 0.72 g/g for brake fluid and diesel, respectively. Next, brake fluid and diesel were mixed in different compositions. At first the overload of one of the components in the mixture was analyzed. Therefore, the following compositions of sorbates were analyzed: brake fluid (75%) – diesel (25%) and brake fluid (25%) – diesel (75%) (Fig. 2b). It was observed that the sorption process for brake fluid (75%) and diesel (25%) contacted with the compact sorbent was stopped after the absorption of 18.39 ± 0.17 g brake fluid in time equal to 5810 s (Fig. 2b). Meanwhile, for brake fluid (25%) and diesel (75%) contacted with the compact sorbent sorption the process was stopped after the absorption of 22.06 ± 0.54 g in time equal to 3590 s (Fig. 2b). The average sorption was equal to 0.63 g/g and 0.37 g/g for brake fluid (75%) and diesel (25%), brake fluid (25%) and diesel (75%), respectively. Finally, brake fluid and diesel were mixed in the same proportions (brake fluid (50%) – diesel (50%)). It was observed that the sorption process was stopped after the absorption of 21.85 ± 0.49 g brake fluid in time equal to 3640 s (Fig. 2b), with the average sorption equal to 0.72 g/g.

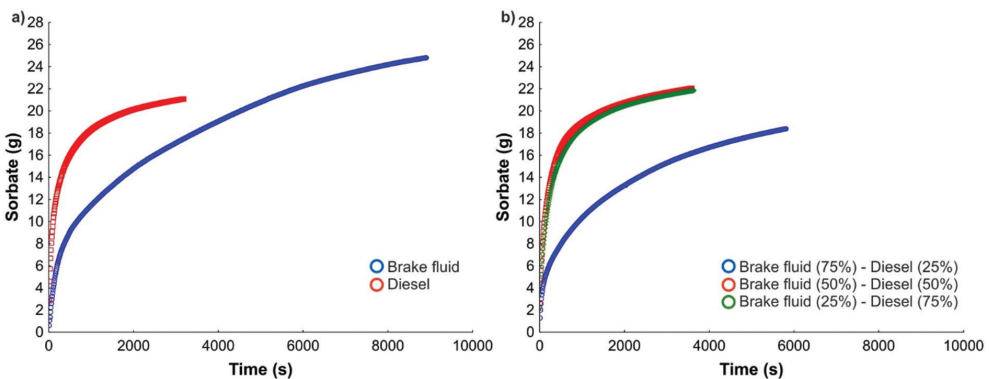


Fig. 2. Experimental results of the sorption process for two sorbates in contact with compact sorbent: a) brake fluid (100%), b) diesel (100%)

Moreover, the mathematical description of the sorption process with the use of fifth degree polynomial function was applied (Table 1). It was observed that for brake fluid in pure solution (100%) as well as in mixture (brake fluid 75% and diesel 25%) the correlation coefficient was in range 0.92–0.95. Furthermore, when the amount of diesel was equal to brake fluid (50%) or higher (75%) as well as for the pure solution (100%) the correlation coefficient was in range 0.81–0.83.

Table 1. Non-linear description of the analyzed sorbates for different process conditions.

Sorbates	Fitting function	R [-]
BF (100%)	$f(x) = 2.0997 + 0.0175x - 1.8946 \cdot 10^{-5}x^2 + 1.1207 \cdot 10^{-8}x^3 - 3.1893 \cdot 10^{-12}x^4 + 3.4383 \cdot 10^{-16}x^5$	0.92
D (100%)	$f(x) = 6.1278 + 0.0369x - 4.5302 \cdot 10^{-5}x^2 + 2.7727 \cdot 10^{-8}x^3 - 8.0286 \cdot 10^{-12}x^4 + 8.7782 \cdot 10^{-16}x^5$	0.83
BF (75%)/D (25%)	$f(x) = 3.3733 + 0.0115x - 6.0449 \cdot 10^{-6}x^2 + 1.9221 \cdot 10^{-9}x^3 - 3.0208 \cdot 10^{-13}x^4 + 1.8101 \cdot 10^{-17}x^5$	0.95
BF (25%)/D (75%)	$f(x) = 5.8357 + 0.038x - 4.23 \cdot 10^{-5}x^2 + 2.3053 \cdot 10^{-8}x^3 - 5.8986 \cdot 10^{-12}x^4 + 5.6896 \cdot 10^{-16}x^5$	0.81
BF (50%)/D (50%)	$f(x) = 4.7482 + 0.0369x - 3.9002 \cdot 10^{-5}x^2 + 2.0563 \cdot 10^{-8}x^3 - 5.1451 \cdot 10^{-12}x^4 + 4.8747 \cdot 10^{-16}x^5$	0.82

Fit – fitting function, R – correlation coefficient. BF – brake fluid, diesel D – diesel

Finally, the graphical presentation of fitting functions for the sorption process was presented on Fig. 3 – Fig. 5. For both pure sorbates better fitting for brake fluid compared to diesel was observed, which was manifested in a shape of fitted function. For the brake fluid, the fitting function was positioned almost in axis of the experimental results ($R = 0.92$) (Fig. 3a). While, for diesel results swirls in shape of the fitting function were observed ($R = 0.83$) (Fig. 3b).

Similarly, the mixture of analyzed sorbates was observed. Each time when the higher amount of brake fluid was in a mixture, the fitting function almost reflected

the shape of the experimental results (Fig. 4a). On the other hand for the mixtures where diesel was the main component (Fig. 4a) or the amount of diesel was equal to brake fluid the swirls in shape of fitting function were observed (Fig. 5).

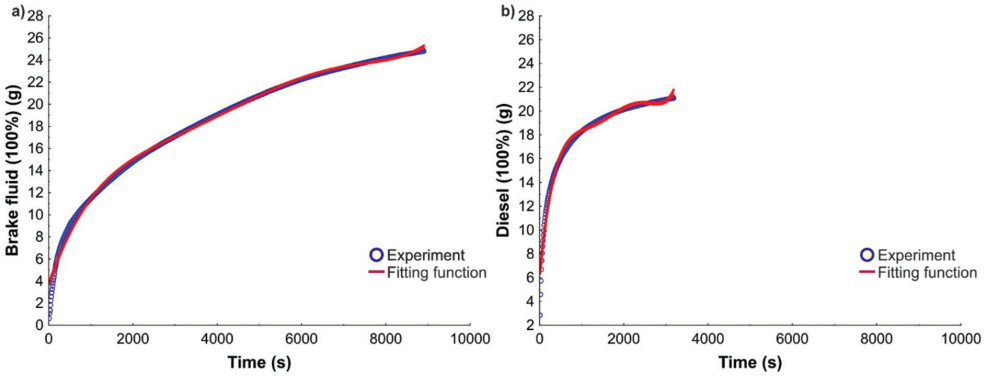


Fig. 3. Experimental results of the sorption process described with the mathematical function (Table 1): a) brake fluid (100%), b) diesel (100%)

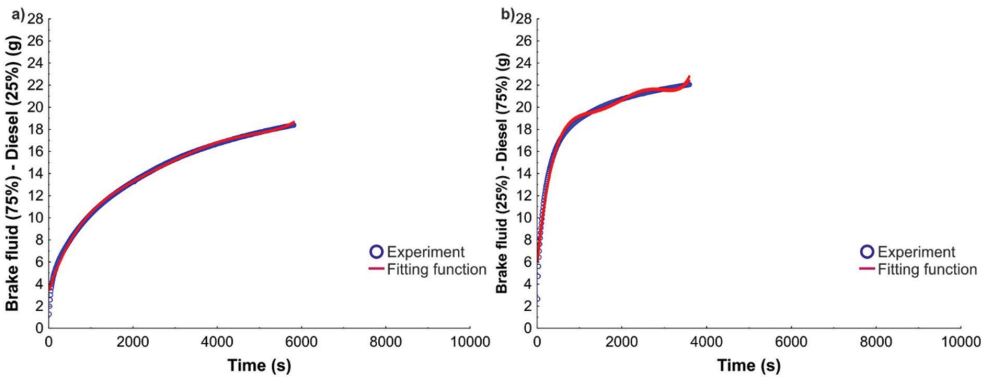


Fig. 4. Experimental results of the sorption process described with the mathematical function (Table 1): a) brake fluid (75%) – diesel (25%), b) brake fluid (25%) – diesel (75%)

Moreover, it was observed that the time of the sorption process decreased with the higher amount of diesel. For pure diesel, the sorption process lasted approximately 3180 s, while for the mixture (brake fluid 25% and diesel 25%) it was approximately 5810 s. In contrast the sorption process for pure brake fluid was the longest and lasted approximately 8900 s.

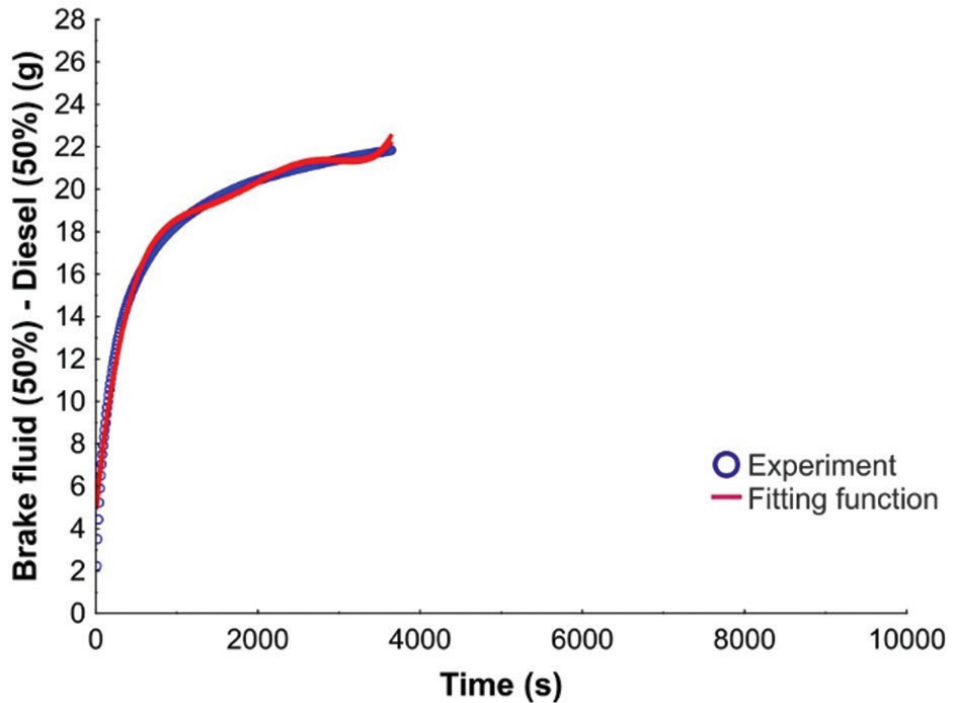


Fig. 5. Experimental results of the sorption process described with the mathematical function (Table 1): brake fluid (50%) – diesel (50%)

4. Conclusions

It was observed that the sorption process was extended for brake fluid compared to diesel. The decrease of brake fluid amount in the mixture resulted in a decrease of the sorption value. Furthermore, when diesel volume was higher compared to brake fluid, a dynamic increase of the sorbat sorption in the first step of process was observed. Moreover, the increase of diesel amount in the mixture resulted in a decrease of sorption time.

Acknowledgement

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