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Studies on the Influence of Sorbate Temperature on the Selected Sorbents Sorption Intensity

Abstract

Demand for energy resources such as oil is constantly growingF. There is still a problem of the impact of the developing automotive industry on the natural environment. Potential hazard is contamination of soils and waters by petroleum products transported by the tankers or used as fuel or operating fluids. The aim of the study was to analyze how the sorbate temperature will affect the sorption intensity of selected sorbents used by chemical and ecological rescue units. Greater absorption was demonstrated during the tests performed at a higher initial temperature of the sorbate. The changes in the absorbency varied within the limits: for peat 12–23%, Compakt 6–16% and Damsorb 5–8%.

Key words: influence of sorbate temperature on the intensity of sorption

Badania wpływu temperatury sorbatu na intensywność sorpcji wybranych sorbentów

Abstrakt

Zapotrzebowanie na surowce energetyczne, jak ropa naftowa, stale rośnie. Ciągle więc istnieje problem wpływu rozwijającego się przemysłu motoryzacyjnego na środowisko naturalne. Potencjalne zagrożenie to skażenie gleb i wód przez substancje ropopochodne przewożone cysternami lub stosowane jako paliwo czy płyny eksploatacyjne. Celem badań było przeanalizowanie jak temperatura sorbatu wpłynie na intensywność sorpcji wybranych sorbentów używanych przez jednostki ratownictwa chemicznego i ekologicznego. Większą chłonność wykazano podczas prób wykonywanych przy wyższej temperaturze początkowej sorbatu. Zmiany chłonności wahały się w granicach: dla torfu 12–23%, Compaktu 6–16% i Damsorbu 5–8%.

Słowa kluczowe: sorpcja, temperatura sorbatu, intensywność sorpcji

Introduction

The progressive development of industry is associated with threats to the natural environment. It is connected with leaks of petroleum substances as a result of car accidents involving tanks or unsealed pipelines. Potential hazards are contamination of soils and waters [9]. Most often these are random events and the chemical emergency units called in are to reduce the leakage, prevent its spreading and collect as much of the released liquid as possible. The sorption capacity of the means used for this purpose allows for the quick and effective collection of hazardous substances [10, 12]. Whether the appropriate sorbent will be used significantly simplifies and shortens the time of rescue operations. Absorptivity is the most important feature of any sorbent [8, 13]. It affects the ability of maximum absorption the substance through the sorbent and thus also affects its effectiveness. Absorptivity of the sorbent depends on its porosity, the higher the porosity of the material, the greater its absorbency [2, 7]. The pores in the porous material can be divided into macropores - pores with a diameter larger than 50 nm, in adsorbents are used to transport the absorbed substance from the grain surface to the pores with a smaller diameter, mesopores (transitional seasons) - pores with diameters: less than 50 nm to 2 nm, determine the catalytic and sorption properties of porous materials, micropores – pores with a diameter of less than 2 nm, the basic carrier of sorption properties [1, 11].

Sorbents used for testing

Sorbent Compakt

It is one of the most frequently used sorbents by fire protection units. First of all, it is universal, it works well for sorption of petroleum substances as well as other chemical compounds such as acids or bases. It is a mineral sorbent and is sold as a heavy and hard granular sorbent. It is used on hard surfaces [2, 5].

Fig. 1 shows the structure and granulation of the Compakt.

Fig. 1 Sorbent Compakt [3]

Sorbent Damsorb

This sorbent is often used by fire protection units. It is a universal sorbent of mineral origin. It is used to combat the effects of leakages of various substances (except hydrofluoric acid) from hardened surfaces [5, 11].

Fig. 2 shows the structure and granulation of the sorbent.

Fig. 2 Sorbent Damsorb [3]

Sorbent Peat

Peat is a sedimentary rock formed as a result of transformations of dead plant remains in the conditions of prolonged decaying of the topsoil. It contains less than 60% carbon. It was once used as an energy raw material, and currently used on a small scale as fuel. He found a wider application in horticulture as an organic fertilizer.

Fig. 3 shows the Peat structure.

Fig. 3 Sorbent Peat [3]

Characteristics of sorbates used for testing

Engine oil

Engine oil used for the lubrication of moving parts in internal combustion engines. Its basic components are petroleum distillation fractions boiling at 350°C to 500°C or their synthetic counterparts. Its task is to create a permanent lubricating film that reduces the coefficient of friction, thus preventing the seizure of moving parts. Through the use of additives, increasing the number of alkaline oil protects the engine from corrosion. Additionally, thanks to washing and dispersing additives, it prevents the accumulation of impurities. A mineral engine oil SAE 15W-40 was used for laboratory tests, intended for use in diesel engines of lorries [6].

The fluid for the radiators of internal combustion engines

The fluid for the radiators of internal combustion engines dissipates the heat generated by the engine, which affects the proper operation of the engine. The fluid must be stable so that no deposits will precipitate during operation as they can build up on the internal components of the cooling system, making it difficult to exchange heat. As a result, overheating may occur, followed by engine damage. The fluid used for testing meets the requirements of product certification, and thus meets the requirements of the PN-C40007 standard, based on the ethylene glycol base, which is a harmful and toxic substance. It acts depressively on the central nervous system and irritates the nasal and conjunctival mucous membranes. It can get into the human body through the respiratory tract, the skin and by swallowing from the digestive tract. Many glycol poisonings end in death. Poisoning is caused by the products of its metabolism that occur in the liver. It causes metabolic acidosis, which leads to kidney failure. In the case of ethyl glycol poisoning, the cause of death is the toxic shock [4, 14].

Research methodology and test stand

The research consisted in calculating the bulk density of the sorbents used and their sorption. The sorbents used during the tests were Compakt, Damsorb and Peat, while sorbents used automotive fluids that change the temperature during operation of the engine (engine oil and radiator fluid) with the characteristics described above.

In the first series of tests, the initial temperature of the sorbates was 22 ± 1°C and in the second series 50 ± 1°C.

Fig. 4 presents a research stand.

Fig. 4 Research stand

Source: own study

Findings

Figures 5 to 9 show graphs of sorbates dependence at 22°C and 50°C for selected three sorbents.

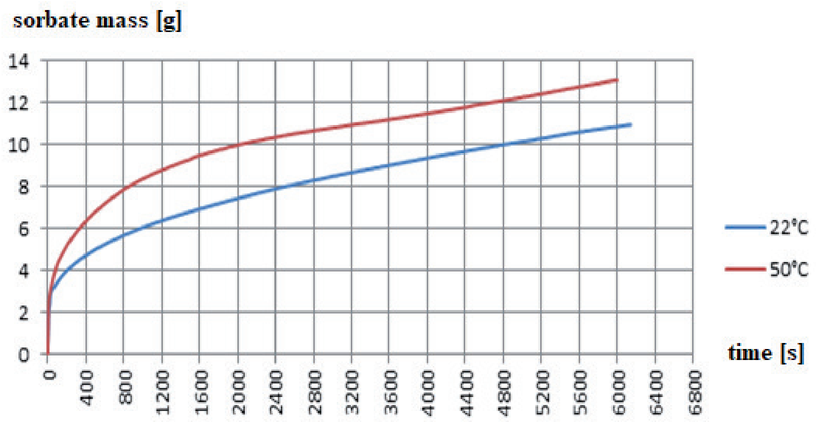

Fig. 5 A graph of engine oil sorption at 22 and 50°C by sorbent Compakt as a function of time

Source: own study

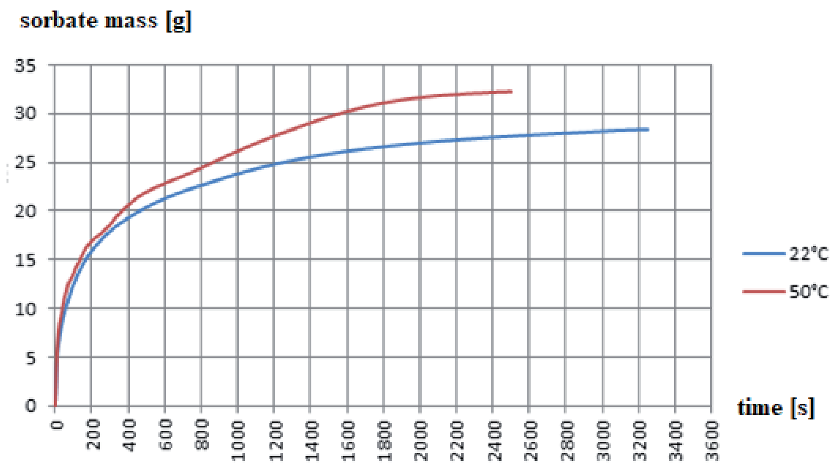

Fig. 6 A graph of radiator fluid sorption at 22 and 50°C by sorbent Compakt as a function of time

Source: own study

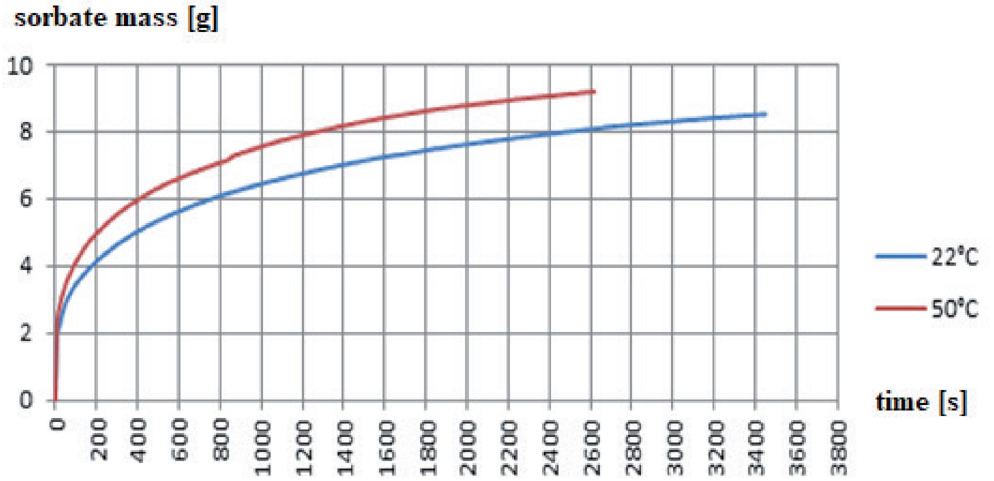

Fig. 7 A graph of engine oil sorption at 22 and 50°C by sorbent Damsorb as a function of time

Source: own study

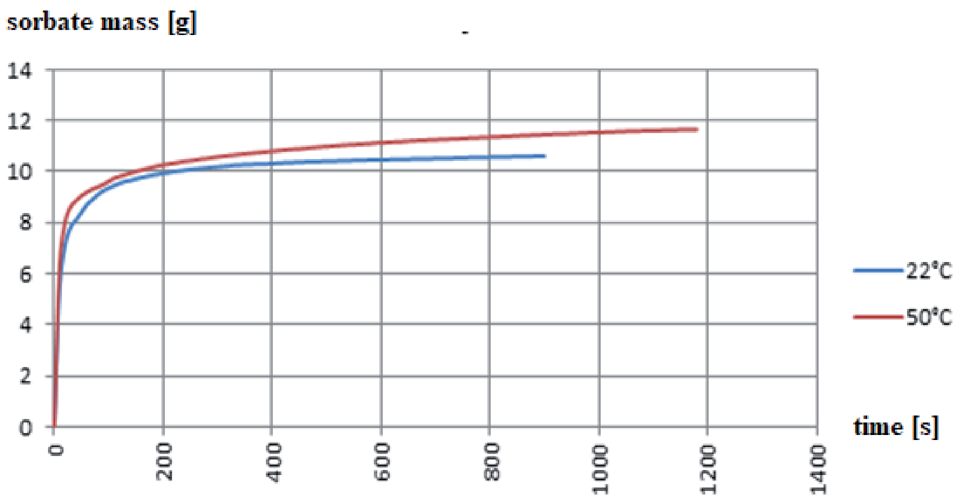

Fig. 8 A graph of radiator fluid sorption at 22 and 50°C by sorbent Damsorb as a function of time

Source: own study

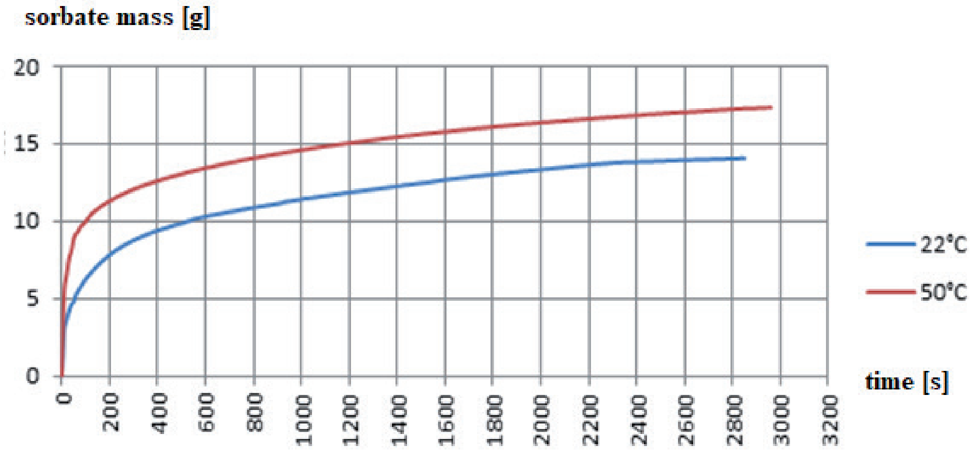

Fig. 9 A graph of engine oil sorption at 22 and 50°C by sorbent Peat as a function of time
Source: own study

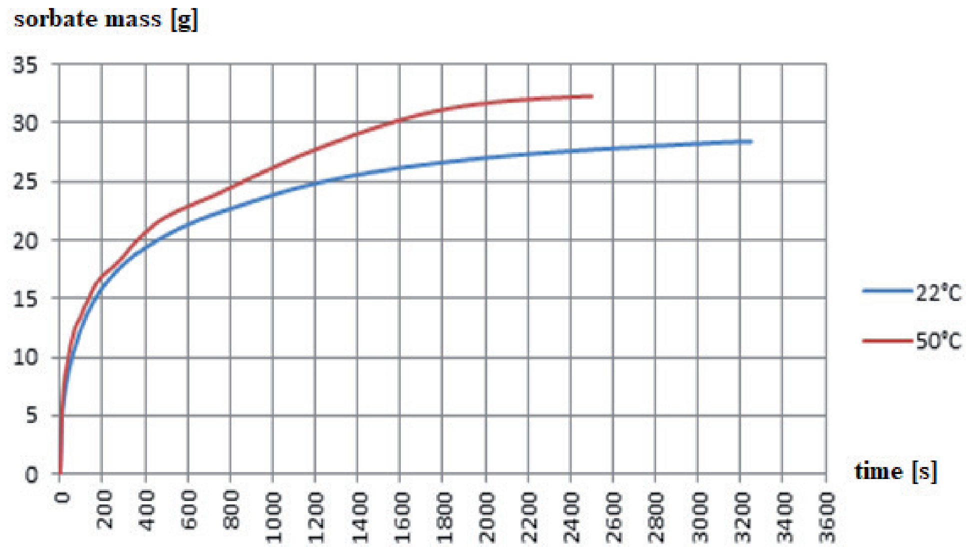

Fig. 10 A graph of radiator fluid sorption at 22 and 50°C by sorbent Peat as a function of time
Source: own study

Analysis of the results obtained

Figure 11 compares the bulk densities of the sorbents tested.

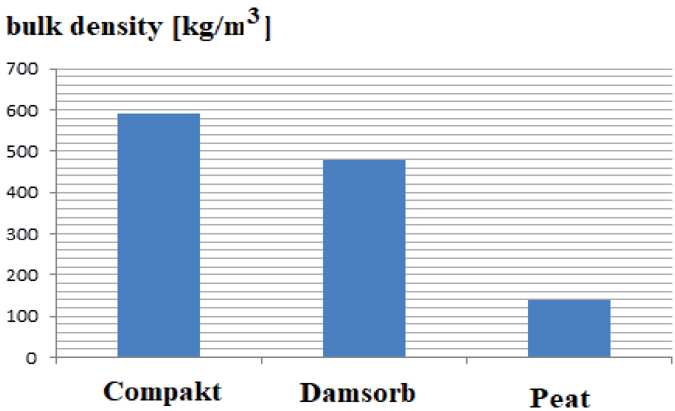

Fig. 11 Comparison of bulk densities of the sorbents tested

Source: own study

Compakt and Damsorb are universal sorbents of mineral origin, their bulk densities are similar, there are also similarities in structure of grains figures 1 and 2. Peat, on the other hand, has a much lower bulk density than the other two sorbents, it results from the variation in the structure of grains and peat blocks and the loose spaces between them after pouring into the measuring syringe.

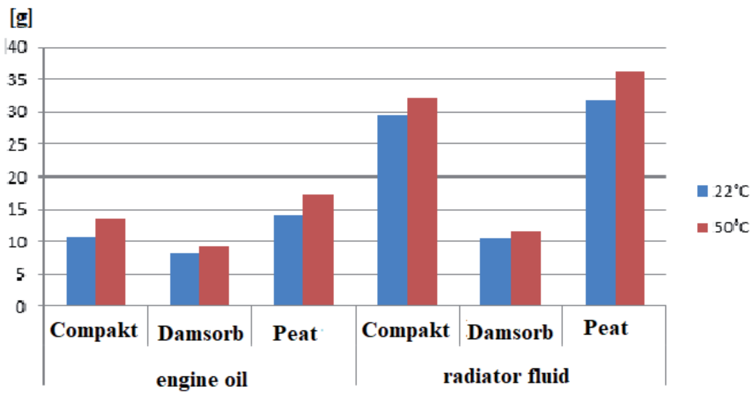

Fig. 12 Comparison of absorbed masses of engine oil and radiator fluid

Source: own study

Each of the sorbents absorbed a larger mass of sorbate at higher initial temperature. Compakt and peat absorbed much more refrigerant fluid than engine oil. Damsorb absorbed a similar mass for both liquids.

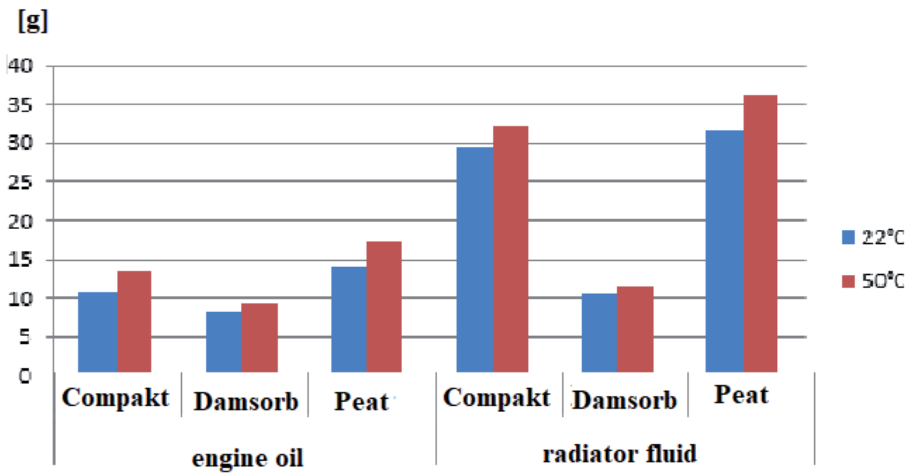

Fig. 13 Comparison of sorption of engine oil and coolant fluid at 22 and 50°C for three selected sorbents

Source: own study

Peat after him Compakt and then Damsorb showed the greatest sorption. The last two showed similar sorption of engine oil. Nevertheless Compakt showed a higher sorption than Damsorb for radiator fluid. Each of the tested sorbents absorbed less mass of engine oil than radiator fluid. Compakt and Damsorb sorbents in the tests showed sorption lower than declared by the manufacturer. It is connected with the fact that the sorbent is immersed in the liquid only on 1–2mm and absorbs liquid only through small holes in the test vessel instead of the entire volume as it is in the conditions of use. Also, immersing the syringe when it is too deep can lead to rapid absorption of the sorbate and early interruption of the sorption process.

Summary and conclusions

Three sorbents were used in the research: Compakt, Damsorb and Peat, and two operating fluids: engine oil and radiator fluid, which during the experiments had different initial temperatures, ie: 22°C or 50°C.

It was shown that the highest sorption in relation to both liquids was found in peat, which has the lowest specific gravity. Its use, taking into account its natural origin and availability, can significantly reduce the cost of shares. The next is Compakt, followed by Damsorb. Both of these sorbents absorbed similar masses of engine oil at both lower and higher temperatures. Whereas during the sorption of radiator fluid, Compakt absorbed much more mass from Damsorb.

All sorbents showed greater absorbency during tests performed at a higher initial temperature of the sorbate. Changes in absorbency parameter for a higher temperature ranged: for Peat 12–23%, Compakt 6–16% and Damsorb 5–8%. Changes in the absorbency parameter were mainly caused by a change in viscosity as a result of heating the sorbate to a higher temperature. In the case of liquids, the viscosity decreases with increasing temperature, this relationship is easily observed for viscous liquids, e.g. engine oil. Increasing the temperature also reduces the surface tension of the liquid, which has a decisive influence on the saturation of the capillary space of the sorbent with liquid. The lower surface tension at the solid-liquid interface is the better wetting of the capillary wall absorbed by the liquid and absorbing its greater mass.

During chemical and ecological rescue actions, first of all, one should identify a dangerous substance and determine what properties it has, then use a sorbent with appropriate operational parameters. This will affect the effectiveness of the activities carried out.

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