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# WASTELESS SEWAGE DEOILING

The paper presents a method of a wastewater treatment plant modernization for wastewaters containing petroleum derivatives (mainly oils). In the case described modernization involved oil separator, on which a mechanical device for oil removal has been installed. Polyurethane foam used in mechanical devices performed a role of an oil-absorbing material. The way of utilization of oils recovered in the degassing process or gasification coke and coal have been also described.

## 1. INTRODUCTION

The most common and basic pollutants to be found in engine-house wastewater are oils, greases and petroleum derivatives. These substances get into wastewater during oil and emulsion exchange as well as during the washing of the undercarriages and engines in the steam, diesel and electric locomotives. Harmful effect of oils and greases upon sewerage system is manifested in accumulation of these substances on the walls of the sewer, which may lead to clogging. In the settling tanks, oils and greases make sedimentation of suspensions more difficult and also cause formation of floating sediments — the so-called surface scum. They also impede the removal processes in biofilters and activated sludge because of agglomeration of slime on biofilter media and activated sludge floccules; free diffusion of the atmospheric oxygen to sewage is not possible either. These substances, moreover, toxic to sewage life are hardly biodegradable and exert negative effects on physical and chemical properties of natural water deteriorating its potability as well as its fitness for economic and recreation purposes [1, 5]. The railroad works discharged oily substances to a stream which emptied into large river Y — a potable water source for town X. The oily substances caused many difficulties in operation of a mechanical wastewater treatment plant, the effluent still contained substantial amounts of oils and petroleum derivatives.

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## 2. WASTEWATER SOURCES AND ITS PHYSICAL AND CHEMICAL COMPOSITION

In engine-house oiled wastewater comes from the washing of engines and undercarriages of diesel, steam and electric locomotives, which takes place before each technical survey and repair, as well as from the exchange of oils and cooling emulsions. These wastewaters are drained to an isolated industrial sewerage system where they pass through the closed and open channels of the total length of 500 m to the collector (fig. 1). Wastewater from repair shop (where the survey and greasing of undercarriages takes place), liquid fuel

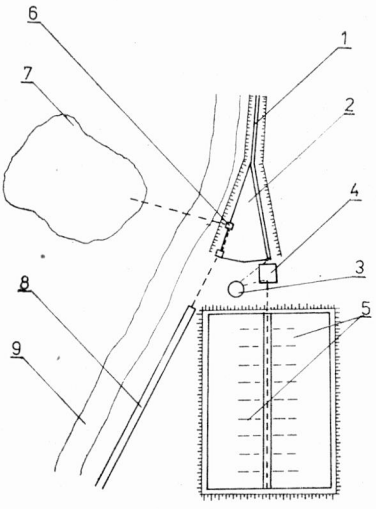


Fig. 1. Layout of the waste treatment plant

1 — inlet sewer, 2 — settling tank of volume 15 m³, 3 — well. 4 — pumping station, 5 — noncutlet dug sewage tanks of volumes 2700 m³ and 2200 m³, 6 — storm overflow, 7 — pond, 8 — ditch, 9 — road

Rys. 1. Schemat zakładowej oczyszczalni ścieków

1 — kanał doprowadzający ścieki, 2 — osadnik o pojemności 15 m³ 3 — studnia, 4 — pompownia, 5 — bezodpływowe zbiorniki ziemne o pojemności 2700 m³ i 2200 m³, 6 — przelew burzowy, 7 — staw, 8 — rów, 9 — droga

Table 1

Physical and chemical composition of raw wastewaters entering the treatment plant

Skład fizyczno-chemiczny ścieków surowych dopływających do oczyszczalni

| Notation | Unit | Value |
|---|---|---|
| Odour | | Z 5 S (oil derivatives) |
| Colour | | grey-black |
| pH | | 7.3-9.0 |
| $BOD_5$ | g $O_2/m^3$ | 2400 |
| Permanganate value | g $O_2/m^3$ | 74-400 |
| COD | g $O_2/m^3$ | 200-4500 |
| Total dry residue | g/m³ | 1400-3000* |
| Total dissolved substances | g/m³ | 660-900 |
| Alkalinity | g $CaCO_3/m^3$ | 100-200 |
| Sulphates | g/m³ | 100-160 |
| Petroleum benzin extract | g/m³ | 410-2200 |

* with oil derivatives.

station wastewater (for diesel locomotives) and rain-water are also let into sewage system. Total amount of wastewater flowing into treatment plant ranges from 200 to 500 $m^3/d$. Physical and chemical composition of wastewater is presented in tab. 1. Wastewaters from the channel before the inlet to the tank *2* (fig. 1) are characterized by low alkalinity, specific odour — due to petroleum derivatives, grey colour, increased permanganate values (PV), COD and considerable amount of substances extracted with petroleum benzine. The latter ones being oils, greases and petroleum derivatives occur in wastewater in a dissolved form, emulsion and macrodispersed suspension. Partial destabilization of some emulsions and stratification of heterogeneous water-oil mixture takes place during the passage of wastewater through the open channel. Hence, in the influent to the sewage treatment plant, some amounts of oils and petroleum derivatives form a separate surface layer.

## 3. THE DESCRIPTION AND OPERATION OF WASTE TREATMENT PLANT BEFORE AND AFTER ITS MODERNIZATION

Wastewater treatment plant — WTP (fig. 1) consists of tank *2*, wet well *3*, pumping station *4* and of two earthen tanks without an outflow. Raw wastewaters are fed through the open channel *1* to the tank *2* where oil particles rise to the surface and other solids settle. After the removal of oil layer from the surface, wastewaters are directed to wet well *3* and periodically pumped to tanks *5* and either evaporate to the atmospheric air or infiltrate to the ground. Tank *2* is also connected with the pond *7* to which rain-water and wastewater from maintenance may be directed through a storm overflow. Since before upgrading the removal of oil layer from wastewater surface in tank *2* was done irregularly (manually or sometimes using garbage collector), therefore substantial amounts of oils got to earthen tanks *5* or even to the pond *7*, forming oil layers on the surface or combining with the solid particles formed the bottom sediment saturated with oils, greases and petroleum derivatives. Consequently, the lagooned wastewaters become a potential source of petroleum derivatives infiltration to the neighbouring grounds, water-bearing layers and the river Y water.

The upgrading was to increase the efficiency of deoiling of wastewaters directed to earthen tanks *5* as well as to achieve thermal decomposition of oils and greases removed from wastes. This wasteless method of wastewater deoling consists in mechanical removal of oils from the wastewater surface in flowable double-liquid tank and in degassing of used oils with hard coal in a gas-producing ovens or in their gassification with the coke in central generators. To remove oils from the wastewater mechanical surface oil collector invented in the Technical University of Wrocław [2, 6] was used. Some minor changes in the construction of the tank (fig. 1) were made, i.e. dividing by a partition *8* (fig. 2), of the height of 15 cm from the bottom. In that way the left part of tank *6*, in which the oil collector *7* was installed, operated, as an outlet double-liquid tank. Reduction of the aera of oil in tank *2* (fig. 1) was made to obtain thicker oil layers on wastewater surface and, thereby, to achieve the maximum oil efficiency of oil minesweeper and to shorten its worktime [3]. The installed collector is presented in fig. 3 and tab. 2. The maximum output is 0.27 $m^3/h$. The amount

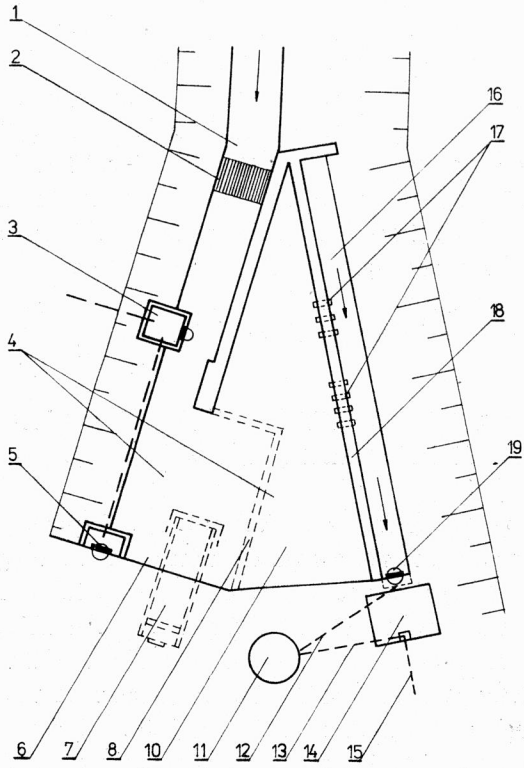


Fig. 2. Wastewater tank

1 — inlet sewer, 2 — grate, 3 — storm overflow well, 4 — wastewater tank chamber before partition, 5 — gate valve for surface water, 6 — left chamber after partition, 7 — waste surface oil skimmer, 8 — partition ,10 — right chamber after partition, 11 — well, 12 — pipeline, 13 — suction line, 14 — pumping station, 15 — pressing ine, 16 — trunk sewer, 17 — syphons, 18 — wall, 19 — gate valve

Rys. 2. Zbiornik ścieków

1 — kanał doprowadzający ścieki, 2 — krata, 3 — studzienka przelewu burzowego, 4 — komora zbiornika przed podziałem, 5 — zasuwa do kanału wody powierzchniowej, 6 — lewa komora po podziale, 7 — urządzenia do usuwania olejów z powierzchni ścieków, 8 — przegroda, 10 — prawa komora po podziale, 11 — studnia, 12 — rurociąg, 13 — rurociąg ssący, 14 — pompownia, 15 — rurociąg tłoczny, 16 — kanał zbiorczy, 17 — przelewy syfonowe, 18 — ściana, 19 — zasuwa

Table 2

Technical data: oil skimning device
Dane techniczne urządzenia do usuwania olejów z powierzchni ścieków

| Parameter | Unit | Value |
|---|---|---|
| Engine | | S23-26b |
| Belt length | cm | 763 |
| Belt width | cm | 30 |
| Belt thickness | cm | 3.0 |
| Immersion depth of the device in wastewater | cm | 30-80 |
| Full rotation time of the belt | min. | 5.45 |
| Rate of belt feed | m/s | 0.021 |
| Thickness of oil layer in a settling tank | cm | 20-40 |
| Efficiency of the device | $m^3/h$ | 0.27 |

of oil removed ranged from 0.20 to 0.40 $m^3/d$. Thus, its worktime is about 1.5 h per 24 h. Collected oils are transported by a belt conveyor to a squeezer (fig. 3) from where they flow down gravitationally to a water truck which, finally, carries them to gas-works where they are neutralized. Wastewater after mechanical deoiling, i.e. from the tank *10* (fig. 2), flow through storm overflows *17* to the channel *16* and to a cumulative well *11* and then they

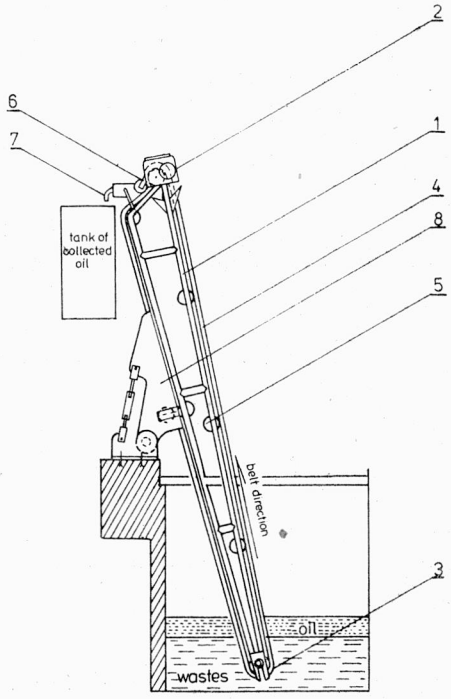


Fig. 3. Oil skimmer

1 — frame, 2 — driving unit, 3 — stretch unit, 4 — belt, 5 — support rolls, 6 — couch (press), 7 — outlet gutter, 8 — support construction

Rys. 3. Urządzenie do usuwania olejów z powierzchni ścieków

1 — rama, 2 — zespół napędowy, 3 — zespół napinający, 4 — taśma, 5 — rolki podpierające, 6 — wyżymak, 7 — rynna odpływowa, 8 — konstrukcja wsporcza

Table 3

Physical and chemical composition of wastes entering the earthen evaporation tanks
Skład ścieków w dopływie do zbiorników ziemnych

| Notation | Unit | Range, amount |
|---|---|---|
| Colour | | grey-yellow |
| Odour | | Z 3 S |
| pH | | 7.3-9.0 |
| $BOD_5$ | g $O_2/m^3$ | 380 |
| Permanganate value | g $O_2/m^3$ | 75 |
| COD | g $O_2/m^3$ | 180-920 |
| Total dry residue | $g/m^3$ | 830-1160 |
| Total dissolved substances | $g/m^3$ | 690-900 |
| Petroleum benzine extract | $g/m^3$ | 40-140 |

are pumped through a pipeline *15* to the earthen evaporating tanks. Physical and chemical composition of wastewaters in the inlet to the tanks is given in tab. 3. The wastes had practically no oils, while the concentrations of petroleum derivatives, both in a dissolved and in a permanent (stable) emulsion form, determined as ether extraction range from 40 to 140 g/m$^3$ (tab. 3).

## 4. COMPOSITION AND CALORIFIC VALUE OF OILS REMOVED FROM WASTEWATER

Petroleum derivatives removed from engine-house wastewater are a mixture of light, middle and heavy oils, being, thus composed of the machine, compressor, lubricating, gear, emulsive and diesel oils and various greases. The composition of that mixture varies quantitatively and qualitatively. Therefore, oils removed from sewage are not purchased for they are not willingly regenerated in petroleum-treatment plants. Their storage in dumping ground is no solution either. Having in mind their wasteless neutralization and energy recovery, it seems reasonable to process them thermally into gaseous fuel, e.g. town or generator gas, provided, however, that a gas-works is situated near the waste treatment plant. Oils removed from engine-house wastewater contain 84–86% of coal, 11.5–13.1% of hydrogen, 0.3–1.1% of sulphur, 0.2–0.4% of ash and 1.3–2.3% of water, while their calorific value ranges from 38.94 to 43.96 MJ, i.e. from 9 300 to 10 500 Kcal/kg and their ignition temperature ranges from 378 to 569 K. Due to high ignition temperature, high calorific value and low concentration of sulphur, ash and water, the oils can be degassed with hard coal to produce town gas during the so-called wasteless neutralization of waste oils and greases which are useless for regeneration.

## 5. DEGASSING OF USED OILS IN MIXTURE WITH HARD COAL

Experiments of oil degassing with hard coal were performed on industrial scale in gas-producing ovens with skew chambers at temperature ranging from 1 173 to 1 323 K. The effects were positive and now the gas-works takes up total amount of oils from the purified engine-house wastewater. Those oils are transported to gas-works and sprayed on coal dumps prepared for degassing. Preliminary measurements show that 1 kg of oil from engine-house wastewater gives about 2 Nm$^3$ of gas characterized by caloriic value ranging from 3 600 to 4 200 Kcal/Nm$^3$, i.e. from 15.07 to 17.58 MJ [7]. As the treatment of engine-house wastewater in the railroad works allows the oil recovery amounting to 0.3 m$^3$/24 h, of density 0.864 kg/dm$^3$ on the average, i.e. about 260 Nm$^3$, then about 520 Nm$^3$ town gas can be obtained. Oil gassification with coal neither had a bad influence upon the condition of chambers and oven fittings nor changed technological parameters of coal gassification, nor the quality of the coke. It follows among others from the fact that the voluminal ratio of oil to 24 h coal charge is negligible being 1 : 1 000 000. The presented investigations are concerned with the amount of oil which may be added to 1 t of coal without detrimental effects on coal degassing process or quality of coke. From the so far

performed investigation it follows that gas-works production capacity in degassing of the used oil is quite significant. It is probably not the only method which can be employed for neutralization of used oils in a gas-works. In this plant the oils can be also gassified with coke in central generator to produce the so-called generator gas for heating the gas-producing ovens.

The experiments on oil gassification with coke will be carried out in a rotary grate generator (fig. 4).

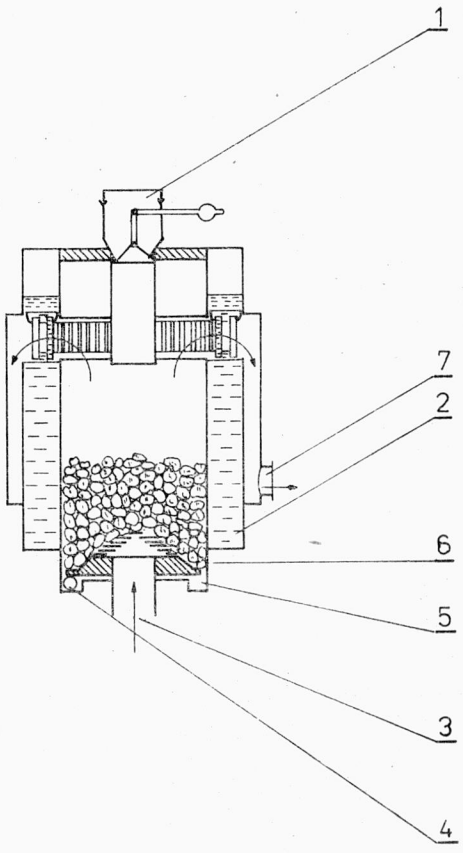


Fig. 4. Scheme of rotary grate generator

1 – charge (larry), 2 – water jacket, 3 – air with steam, 4 – grate drive, 5 – slag, 6 – rotary grate, 7 – gas

Rys. 4. Schemat generatora z rusztem obrotowym

1 – zasypnik, 2 – płaszcz wodny, 3 – powietrze z parą wodną, 4 – napęd rusztu, 5 – żużel, 6 – ruszt obrotowy, 7 – gaz

## 6. EFFECTS OF WASTEWATER TREATMENT PLANT MODERNIZATION

Engine-house wastewaters contain mostly oil-water emulsion used in cooling systems. By installing traditional oil collectors, where wastewaters are produced, only floating oils can be removed. In that case, wastewaters flow along a long channel (slow-flow), emulsion gets destabilized to a great extent so that a better removal of oils can be achieved.

Within a sewage treatment plant area there was no room to build traditional oil collectors. The modernization presented in this work solves that problem using for this purpose the already existing areas and buildings. Partition of the tank *2* (fig. 1) allows oil removal

in two outlet tanks. In the first tank *6* (fig. 2) oils are thickened so that their removal is easier. The second tank *10* (fig. 2) is an additional and protective one from which the oils may be also removed. The operation of device for oil collector from wastewater surface is not affected by extremely varying wastewater level.

Significant decrease in the amount of oils pumped to earthen evaporating tanks *5* (fig. 2) allows to restore biological processes, which became a part of the total biodegradation process taking place in sewage treatment plant.

From the economical assessment of the efficiency of the device for removal of oils from wastewater surface in a sewage treatment plant, referred to economic assessment of the introduction of classical oil collectors (EPS-65 type) [4], it follows modification performed gives 2.5- fold saving in total expenditure. Such factors as investment outlay, direct labour costs, oil collectors service costs and costs of sewage pond purification referred to 12-year exploitation were taken into account.

Calcualation of saving effects of the devices for oil removal referred to those obtained with traditional oil collectors, concerning natural environment protection being not taken into account, gives 300 thousand zlotys during one year. Moreover, the additional energy from petroleum derivatives neutralization has been obtained.

## 7. CONCLUSIONS

1. Oils and greases belong to petroleum derivatives valuable for the modern industry and national economy. These substances, however, are at the same time the most toxic water and wastewater pollutants and are very troublesome to be removed from natural waters and wastewaters.

2. Oils, greases and petroleum derivatives which do not fit regeneration should be neutralized (e.g. thermally) to recover thermal energy and obtain final combustion products being less harmful to waters and atmospheric air.

3. The investigations have shown that one of the efficient methods for neutralization of oils removed from wastewater is their degassing with hard coal in gas-producing ovens as this process yield light gas (town gas), i.e. highenergy gaseous fuel.

4. Slight amounts of oils with respect to coal charge does not affect the quality of coke and does not change technological parameters of coal degassing in chambers of gas producing ovens.

5. In view of numerous gas-works operating in this country, oils, and greases degassing, there are technological possibilities for processing of large amounts of oils and petroleum derivatives (removed from wastewater) to high-energy gaseous fuel.

6. Installation of mechanical devices for oil removal from wastewater surface gives positive effects in removal of petroleum derivatives.

7. The performed modernization due to mechanical devices for removal of oils from the surfaces allows to reduce total expenditure with respect to traditional separators.

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## BEZODPADOWE ODOLEJANIE ŚCIEKÓW

W pracy przedstawiono sposób modernizacji oczyszczalni ścieków zawierających produkty naftowe (zwłaszcza oleje). Modernizacji podlegał separator oleji, na którym zainstalowano mechaniczne urządzenie do ich wyławiania. W mechanicznym urządzeniu zastosowano piankę poliuretanową jako materiał sorbcyjny oleji. Opisano także sposób wykorzystania odzyskanych oleji w procesie odgazowania lub zgazowywania węgla i koksu.

## ABFALLFREIE ENTÖLUNG DER ABWÄSSER

Im Bericht wird die Modernisierung einer Abwasserreinigungsanlage in der Ölprodukte vorkommen beschrieben. Modernisiert wurde in erster Linie der Ölseparator wo eine mechanische Einrichtung zur Ölbeseitigung installiert wurde. Das Öl wird durch einen Polyurethanschaum sorbiert und nachfolgend ausgepresst. Die z.Zt. beste Beseitigungsmethode des rückgewonnenen Öls, ist die gemeinsame Ent-bzw. Vergasung mit Kohle und Koks.

## БЕЗОТХОДНОЕ ОБЕЗМАСЛИВАНИЕ СТОЧНЫХ ВОД

В работе представлен способ модернизации станции очистки сточных вод, содержащих нефтепродукты (в частности масла). Модернизации подвергался масляный сепаратор, на котором было установлено механическое устройство для улавливания масел. В механическом устройстве применён пенополируетан в качестве сорбционного материала масел. Описан также способ использования уловленных масел в процессе дегазации или газифицирования угля и кокса.