Reclaiming property of magnetic adsorbent for oil spill recovery and pollution control

환경오염방지 유출오일 회수용 자기흡착제의 재생회복 특성

Soh Deawha*, George Ksandopulo**,
Lim Byongjae*, Nina Mofa**, Tlek Ketegenov**

Abstract

Data on the oil spill recovery from the water surface by light floating electromagnetic plants using a new magnetic adsorbent are given. The feasibility scope for further oil recovery from such gathered mixtures(oil + adsorbent), reuse of this magnetic adsorbent and its property reclaiming and recycling were shown. The basic conception of the oil spill recovery and efficiency of this method were set forth.

Key Words: Nano-composite magnetic adsorbent, oil spill recovery, electromagnetic trawl, powder property reclaiming

1. Introduction

The cleaning of the natural and artificial water reservoirs and sewage treatment are the most urgent environment protection and ecology problems, so that the development and implementation of new more efficient technologies of diverse contaminant wastes and pollutants removal and disposal are now the most vital and removal and disposal are now the most vital and important tasks by their application urgency. A. special attention attracted to these problems is caused by the fact of increased occurrences of the disasters resulted of the sea cargo vessel accidents which have led to the substantial sea water pollution by the oil and petroleum products that in addition have fatal consequences on the local on the local flora and fauna within such disaster regions. To recover oil spillages from a large water surface there are used the diverse cheap hydrophobic adsorbents [1]. Also, for such applications there are used the wastes of the paper and wood working industries, inorganic powder materials, the powders on the diverse slag and ash base inclusive. The oil spillages with spreaded up adsorbents are recovered as a rule by mechanical methods using the nets with floats of adsorbing materials or the adsorbents are encased in the net sheath. Then such adsorbents saturated by the oil are destructed.

We elaborated a new hydrophobic adsorbing material. It has a very low bulk density, extensive particle surface, quite low specific weight and at same time it is magnetizable. The powder particles have a very characteristic structure, i.e., inorganic nucleus-carrier coated by layers of diverse compounds notable for their adsorbing hydrophobic and magnetic properties. Also, such particles are the carries of considerable electrostatic charges

* Myongji University, Korea
E-mail : dwhsoh@mju.ac.kr
** Combustion Problems Institute, Kazakstan
E-mail : icp@nursat.kz

which promote the coagulation of the oil spillage spots and their magnetic property ensures a magnetization of the mixture be recovered. So that, at the same time the powder owing to the specific structure features of its particles carries out a number of functions required to ensure an efficient oil spillage recovery that is its advantage over the known current materials which are the compound mixtures of diverse purpose : coagulant, adsorbent and magnetic.

This new magnetizable adsorbent and its application enables to solve the problem of oil spillage recovery from the water surface by a new manner, to passe from a mechanical recovery method to a more advanced magnetically controlled technology based on the use of the light floating plants.

2. Analysis of the magnetic adsorbent structure and properties

The new magnetic adsorbent is produced by processing of the quartz bearing mixtures of the oxides and some organic and inorganic additions promoting modification of the quartz particle surface features and ensuring its adsorbing and magnetic properties in the special mills. The adsorption properties of the quartz powder mechanically processed in the mills of diverse types are well known and are widely implemented in the industrial practice [2]. The magnetization of the quartz powder exposed to the mechano-chemical processing is a new occurrence of principle. The quartz particles acquire such property at the processing and depending on the mixture composition.

The value of the magnetic permeability of this powder material depending on the varied factors is varied factors is varied within the range from 5 to 30. The measured value is a some efficient characteristic of the multiphase mixture of the dispersion particles of complex morphology those dimension vary from 10 to 100 ㎛.

The measurements are carried out within the region of low electromagnetic fields up to 1600 A/m within the frequency range up to 500 Hz. The value of magnetic permeability powder in our experiment conditions varies within the range from 33 to 5 at the apparent density ρ =0.957 g/㎤.

In case of iron oxide dilution by non-magnetic screened quartz those particle disperse is up to 100 ㎛, the magnetic permeability of the quartz-magnetic mixture(50 : 50, ρ =0.934 g/㎤) being constricted and varying from 8.0 to 1.5 within the range of measured 10 - 500 Hz frequencies. With increase of the mixture content of quartz up to 70 % the apparent density increases up to 0.879 g/㎤ and the values of the magnetic permeability decrease down to 4.5 - 1.0 respectively. The measurements of the magnetized mono-phase quartz powder revealed that its magnetic permeability is up to 6.0 - 2.0 within 500 Hz frequency range. In case of iron powder those particles are coated by a dielectric layer (water glass) the magnetic permeability in our experiment conditions is up to 7.5 - 1.2. So, the values of the magnetic characteristics of the quartz exposed to the mechano-chemical processing are consistent with level of the magneto-dielectric composite(iron powder with dielectric coating). In case of quartz mechano-chemical processing by oxide mixture its magnetization is considerably increased (up to 25 - 30).

The spectral analysis by EPR method of the magnetized quartz particles revealed the formation of the ferromagnetic clasters on the quartz, surface those SHF energy sorption intensity within low magnetic fields range varies depending on the processing conditions (mill power intensity, exposure duration) by 2-3 times. The modifying additions will promote this effect by 6 times even more.

The processes of structure transformations occur on the surface of the deformed quartz particle by amorphous of the surface layers, by Si-O bond splitting and by formation of diverse chemical compounds which are an integral part of the mechanical melting process enabling to synthesize both the known and absolutely new compounds [3,4]. The final stage of the process is an attention of the nano-composite particle. The nucleus of such particle is a quartz crystal and the surfaces are the amorphous and organo-metallic formations of ferromagnetic properties. To our thinking the

mechano-chemical magnetization of quartz is related with its piezoelectric properties.

Practically at the same time, there are occurred the crystal deformation (compression) and crystal compounds formation on its surface fixing such deformation that interferes relaxation of mechanical displacements and hence consolidates electrical polarization in the particle. So that on the particle surface there is accumulated the electrical charge and magnetic formations(clasters) are formed in the electrical field that promotes magnetic polarization and enhances particle with a deformed crystal nucleus and ferromagnetic surface of diverse micro-structures. The material synthesized by this method may be classified as a magneto electrics category[5] those states and properties are determined by the nucleus structure and the surface layers of few tens nanometers thickness.

3. Experimental Results of the Oil Spillage Recovery

Several alternative methods of material preparation are elaborated differing in compositions, efficiency and economical features. The new magnetic adsorbent powder is notable for its relatively efficient magnetization value and for four compositions presented in this paper immediately after its preparation the above mentioned value is equal to 35(Ⅰ), 22(Ⅱ), 18(Ⅲ), and 25(Ⅳ). In process of its aging especially during the first month such values are decreased(by 17-22%) and then its properties are stabilized.

The prepared compositions are differing in the magnetic, adsorption characteristics and in capacity to coagulate oil spots that is ensured by diverse additions introduced in the mixture during its mechanical processing.

A further oil recovery cycles are resulting in a lower recovery values but they may be considerably improved if the used powder is exposed to a annealing of short duration (up to 1 hour) at 200-300℃ temperature (Table 1).

The advantage of fourth composition consists in the fact that in condition of small amounts of used power(0.1 kg per 1 kg of oil) the oil recovery is maximum as compared with other composition (table 1). The increase of power amount to oil recover isn't suitable because the recovery percentage is decreased in result of this power losses related with its higher bulk density.

So, the synthesized powder is applicable for many times reuse and hence its reserves on the vessel-gatherer's board may be substantially limited.

Table 1. Properties of magnetic adsorbent.

Test stages	Compositions			
	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Bulk density, ρ g/㎤				
Initial value	0.797	0.845	0.912	0.976
Magnetic permeability η, in case of multiple recovery cycles and after powder properties reclaiming				
1	30	20	14	19.5
2	29	19.2	13.1	18.5
3	26.5	17	11	16.5
4	17	13	9	16
Annealing at 200 ℃	20	12	7	16
Oil recovery Mt., % of the adsorbent amount m, kg per 1 kg of oil				
Adsorbent amount, kg, 0.1	51.8	90.9	90.9	97.9
0.5	90.0	93.3	96.6	96.5
0.7	87.6	94.1	97.0	94.1

4. Method of Oil Spillage Recovery From the Water Reservoir Surfaces

Based on the properties of the synthesized magnetic adsorbent the method of electromagnetic recovery of oil spillage spots by concentration and controlled movement of the letters in result of controlled exposure of the water surface within a pollution region to the electromagnetic field is elaborated. The plant of oil spillage recovery should consist of a device to spray power, facilities to remove oil from the water surface, pump, collector-reservoir to recover mixture (oil+adsorbent), separator to separate liquid and solid fractions, collector-reservoir to collect refined oil and low temperature (up to 300℃) heating chambers.

The magnetic powder is spreaded by spreading devices. The application of the adsorbent on the oil spillage surfaces results in that the mixture of

oil + adsorbent on the water surface acquires magnetic properties ensuring control of the magnetized oil spillage sports are moved by a specially designed magnetic system on the water surface and pumped in the ship-borne tank or in the refining plant.(Fig. 1)

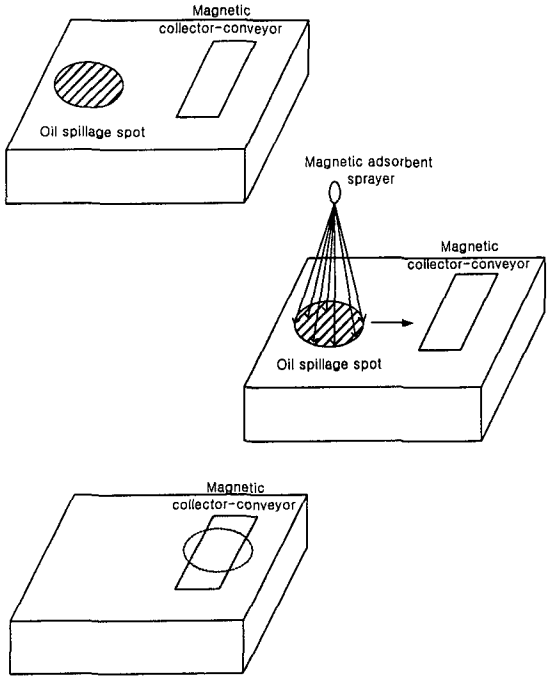

Fig. 1. Scheme for better understanding of oil spillage recovery method.

For experimental check of this method and investigate optimum operation modes of the mixture pumping and electromagnetic field intensity the laboratory plant was designed and implemented as an operating scale model of electromagnetic trawl. The results of its tests showed efficiency of this proposed method of water purification from the oil spillages.

The efficiency of this method is determined as well by that once such pulp intake recovered, it is separated in the liquid and solid constituent fractions. The adsorbent may be exposed to reclaiming and be reused, as well as it may be processed and used in production of some building construction materials. Such method enables to solve in absolutely new manner the problems of water cleaning from any oil products ensuring high efficiency and quality of the oil spillage recovery. Also, the recovered oil spillages aren't disintegrated but they are reused conforming to any suitable purpose. So that, the adsorbent may be use for its many times designed purpose and has multiple operation functions.

5. Conclusions

This elaborated method based on the new magnetic absorbent use ensures a considerably higher efficiency and quality of the oil spillage recovery as compared with other known mechanical methods.

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