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INVESTIGATION AND DEVELOPMENT OF SORPTION TYPE SKIMMERS

INTRODUCTION

By accidents of the pipe-lines and other systems of river, sea and automobile transport of oil and liquid fuels often take place the leakage oil and products from a few to thousands tons which are lead to dangerous pollution of environment and irretrievable loss of the spill product [1,2]. The liquidation of spills is demand selection of various systems and technologies in dependent on kind of spill product and its debit.

On the department of petrochemistry and chemical technology USPTU in common with joint-stock company North-West Main Pipe-Lines are elaborated the complex of methods liquidation of products spills on the surface of water and soil on the base of sorption method [3]. That complex included:

- using sorbent in dispersion form for liquidation individual "pools" of spilled product on the surface of water and soil;
- using sorbent which be situated in the run through covers in form of mattresses or napkins (for liquidation continuous layer of spelled product with thickness to 1-2 cm and more in the relatively small aqueous space or the soil zone of spill with little gradients);
- using absorbent which be situated in the run through covers in form of cylindrical booms for to localize the spill product on the surface of water with simultaneous sorption of spelled product (for liquidation continuous layer of spelled product with thickness to 1-2 mm in the relatively small aqueous space);
- using absorbent which be situated in the run through covers in the constructions of mechanical skimmers where security in bounds of the compact structure the sorption of oil, press out it from the sorption napkin and take aside in the tank of utilize oil.

In that article we discussed the problems of investigation of skimmers.

INVESTIGATION OF SORBENTS

On the basis of formulate conception of the optimal absorbent [4] we are tested the sorption properties more 30 potential absorbents - from waste products of agriculture to special industrial absorbents [5 – 8] (Tab. 1). We are discovered a certain waste of cotton manufacture which possess with sufficiently high sorption ability for the numerous assortment of products (from gasoline to lubricants) on the level 5-20 g of product per 1 g of absorbent at its total hydrophobic (0.5 g of water per 1 g of absorbent). That absorbent is named as "SINTAPEX".

The collecting product is easily give back after press out from "SINTAPEX" in quantity of 70-80 % from initial what on the one hand allowed utilize part spilled product, on the another hand over and over again using the absorbent.

The absorbent "SINTAPEX" was patented [9].

Table 1.

Comparative characteristics of studied absorbents for oil sorption

Type of absorbent	Sorption of oil, g/g	Sorption of water, g/g	Regenerative ability of oil, %
Organic industrial origin absorbents			
Foamplastic polystyrene granules	9.26	4.45	0
Polypropylene granules	1.60	0.80	0
Rubber crumble	5.11	0.20	0
Carbamidoformaldehyde pitch			
- scrap form	23.30	0.10	0
- powder form	39.60	—	60
Phenolformaldehyde pitch	4.42	14.54	0
Tyres cut very small (crumble)	3.58	7.20	55
Porolone sheet thickness 2 mm	14.5	1.3	75
Porolone sheet thickness 18 mm	35.20	25.92	85
Porolone granules (5-8 mm)	36.89	30.71	—
Sintepone	46.31	42-52	94
Synthetic non-weave material (lavsan)			
- sample A	14.05	13.91	82
- sample B	7.27	7.08	66
- sample C	4.71	4.33	60
Coal crush	≈1	—	—
Bitum crush	≈1	—	—
Cotton linen	3.2	—	—
Sheet wadding	24-27	0.5	87
Non-organic industrial origin absorbents			
Fiberglass insertion	5.42	1.72	60
Vegetable wastes			
Wheat straw	4.10	4.30	36
Reed chap	8.20-2.66	4.68	18-30
Tree sawdust	1.72	4.31	10-20
Buckwheat corn husks	3.05-3.50	2.20	44
Waste products of cotton-wool manufacture	8.30	0.26	60
Dry moss intact	3.5	3.1	—
Dry moss cut very small	5.8	3.5	—
Peat	17.71	24.28	74
Special absorbents for oil collecting			
"Lessorb"(peat dust work up)	9.1	2.5	66
"Peat Sorb"(DFR, firm "Clon Inc.")	6.19	0.71	0
Working absorbent			
"SINTAPEX"	24.45	0.20	83

We think that using of absorbent in dispersing form in spite of high oil-capacity that rind absorbents insufficient technologic because demand great expenditures on the distribution of fresh absorbent and collection it after sorption from surface of soil and

in greater measure from surface of water. It is more convenient using "SINTAPEX" or another absorbent with analogous properties in the run through covers in the constructions of mechanical skimmers in spite of some absorbent condensation and reduction of it capacity on that case.

INVESTIGATION OF SKIMMERS SORPTION TYPE ON THE PHYSICAL MODELS

It is nice perspectives of mechanical skimmers which worked in laboratory "SINTAP". These skimmers are using principle mechanical press out of collected oil from absorbent. There are patented three type of basis construction of sorbing skimmers [10 –12] (Fig. 1) and five their modifications [13 –17].

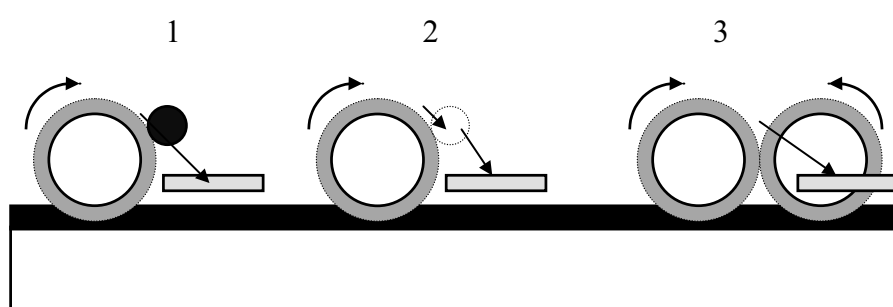


Fig.1. There are patented skimmers with different way of oil press out it from the sorption napkin: with unbroken shaft (1), with perforated shaft (2) and compression of skimmer's drums (3) .

For verify of capacity for work of skimmers construction was elaborated, designed and making run models of skimmers in scale 1:4 following modification:

- one-drum fasten model number 1 with rubber unbroken shaft;
- one-drum fasten model number 2 with aluminium perforated shaft;
- two-drum fasten model number 3 with compression of skimmer's drums;
- four-drum swimming model number 4 which was combined from two models number 3.

In all models the skimmer's drums have diameter 106 mm and width 60 mm. On the outward cylinder side of drums with area 200 cm² was placed oil-sorption napkins with absorbent. As absorbent was using substances having high value of oil-sorption – wadding, porolone and sintepone (Tab. 1).

Testing of models at different number rotation of drum showing (Fig. 2) that at small number rotation (7 rot/min) supplementary effort in 2 kg is lead to increasing of productivity of model near 1.5 time both at collection of pure oil and at collection of oil layers with thickness 1 and 0.5 cm from water surface. At greater number rotation (18 and 24 rot/min) supplementary effort of press out is not lead to increasing of productivity of model and dependence of skimmer's productivity from effort of press out have extreme character with run up to maximum at effort of press out 50-60 kg on 1 m of press out line. At decrease effort of press out on 15-30 kg more quantity of collection oil (to 30-50 %) is remain in sorbing napkin and recycling in system. At increase effort of press out on 15-30 kg is beginning slip of opposite drum relatively

leading drum what lead to decrease productivity of model. Similar situation is observed and at increase of number rotation of drum. Maximum of productivity on the level 1.7 L/min (102 L/hr) arrived at number rotation of drum 18 rot/min.

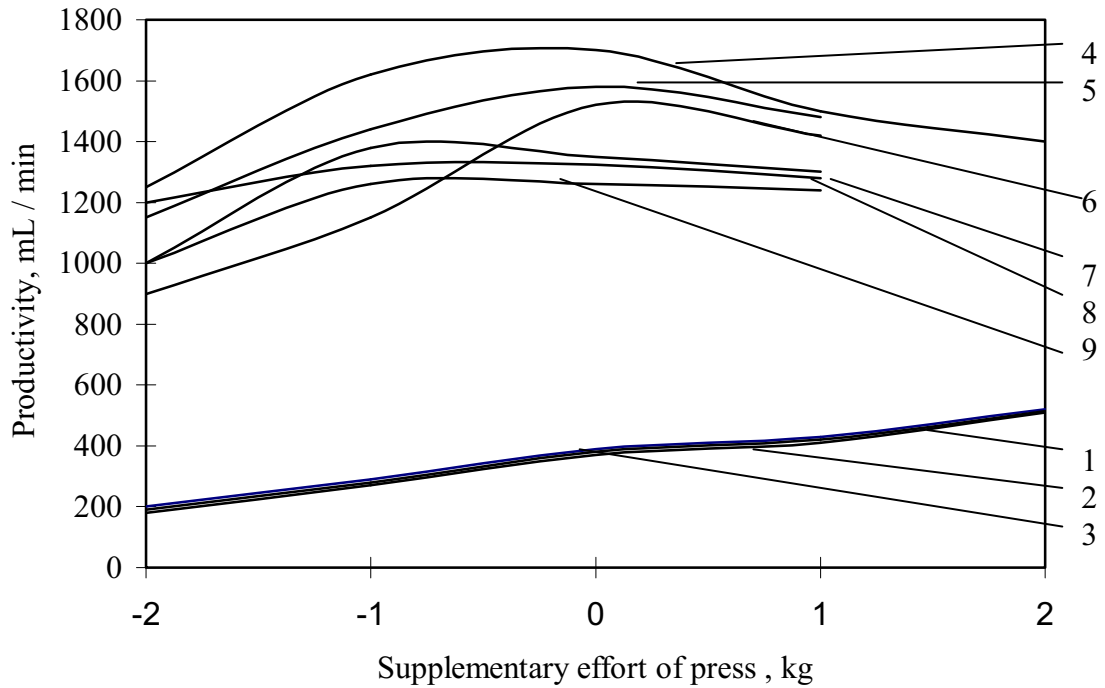


Fig.2. Influence of supplementary effort of press on productivity of skimmer model at number rotation of drum 7 (1,2,3), 18 (4,5,6) and 24 (7,8,9) by working on pure oil (1,5,9) and oil layers with thickness 1 (3,4,8) and 0.5 cm (2,6,7) from water surface

Analysis of work models and pilot skimmers is show (Tab.2) that variety constructions with different characteristic of apparatuses (number rotation of drum, geometry of oil sorbed napkins and other) which be distinguished by oil collection in 25 time have specific parameter – invariant of similarity equally 0.05-0.1.

Table 2.

Characteristics of studied skimmers.

Type of skimmer	Number rotation of drum, rot/min.	Quantity of drums	Parameters of oil sorbed napkin, m			Oil sorption, L/hr	Invariant of similarity
			length	diameter	thickness		
Model 1 (scale 1:4)	2400	1	0.07	0.11	0.05	24	0.083
Model 3 (scale 1:4)	5800	1	0.07	0.11	0.05	41	0.055
Model 4 (scale 1:4)	840	4	0.07	0.11	0.005	39	0.097
Pilot skimmer immovable (scale 1:1)	300	1	0.35	0.46	0.010	150	0.095
Pilot skimmer swimming (scale 1:1)	960	4	0.34	0.31	0.010	600	0.048

INVESTIGATION OF SKIMMERS SORPTION TYPE ON THE PHYSICAL MODELS

The process of oil-collection from water surface with skimmer sorption type is complicated polyfactor process. Because of absence in technical literature mathematical model of sorption oil-collection process we work out stochastic mathematical model in form system of 10 regression equations on the base method of planning of experiments (composition orthogonal plan of second degree) by four parameters: number rotation of drum, viscosity of oil product, thickness of oil layer on the water surface, thickness (mass) of oil-collecting napkin. Initial experiment was conducted on the one-drum model of skimmer (model 1). On the Fig. 3 is show any results of mathematical modelling [18].

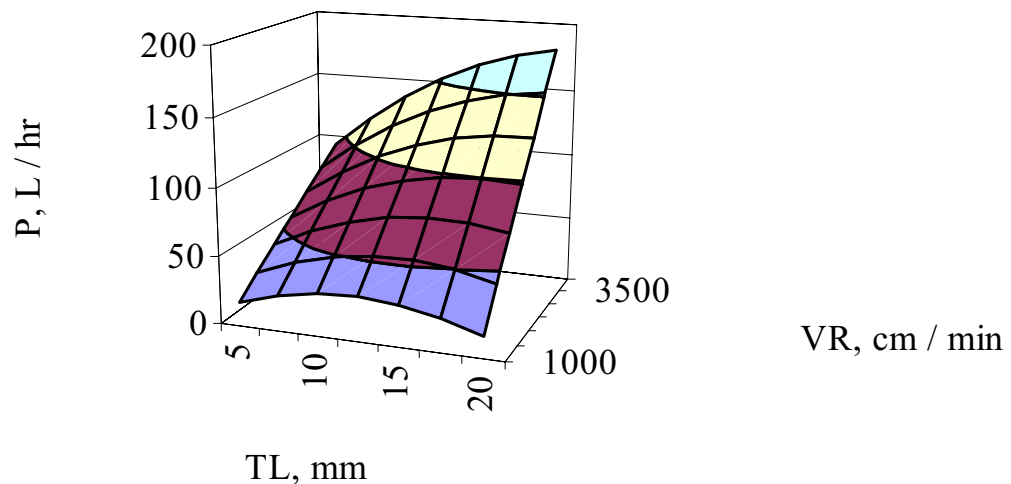
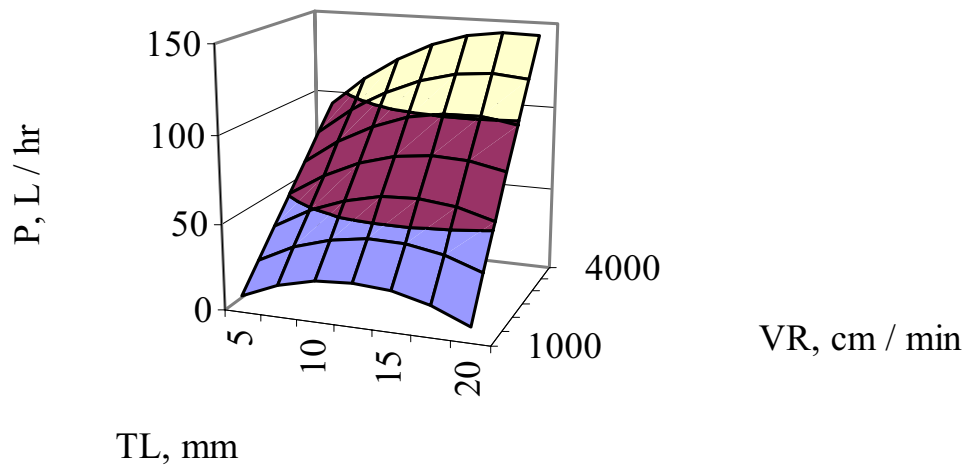


Fig. 3. Dependence of productivity model skimmer (P) from velocity rotation of drum (VR) at different thickness of oil layer on the water surface (TL) for viscosity of oil product $10 \text{ mm}^2/\text{c}$ (a) and $100 \text{ mm}^2/\text{c}$ (b); mass of oil-collecting napkin – 10 g.

DEVELOPMENT OF INDUSTRIAL SORPTION TYPE SKIMMER

At the basis of installation experiments on the models mechanize drum's skimmers and immovable pilot one-drum skimmer of industrial size in scale 1:1 with length and diameter of drum 0.35 and 0.46 m (Fig.4) was elaborated the construction of experience-industrial swimming four-drum skimmer.

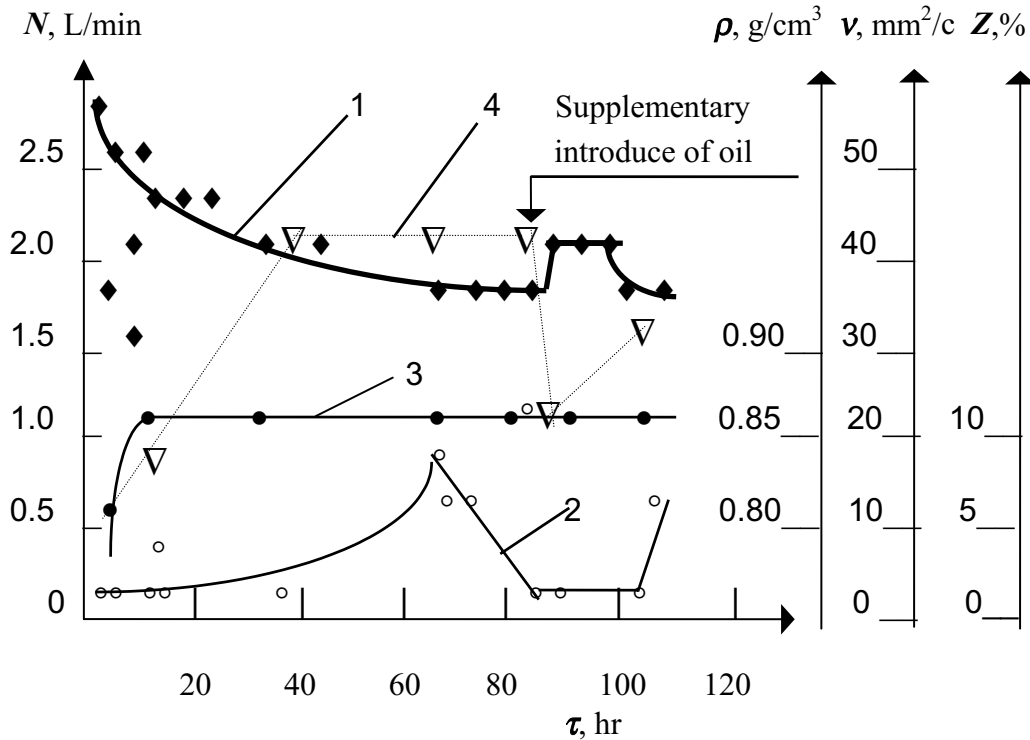


Fig. 4. Dependence of specific productivity by collecting oil (N), maintenance in oil water (Z), density (ρ) and viscosity (ν) of oil from time of apparatus working (τ) at long examination pilot one-drum skimmer.

$$1 - N = f(\tau), \quad 2 - Z = f(\tau), \quad 3 - \rho = f(\tau), \quad 4 - \nu = f(\tau).$$

The industrial apparatus have boundary size 2.6 · 1.75 · 0.75 m, mass 130 kg and total mass 200 kg if take into account the mass of take off the electromotor and gear rotary pump. It is being provided the drive to the every drum by chain transmission. The total capacity of motor and pump for drainage of collected and press-out oil is 2.95 kW. The quantity of drum's rotations are 16 rot / min.

The experience-industrial swimming four-drum mechanize skimmer was making in company North-West Main Pipe-Lines [19] and passed several stages of tests: long dry examination, starting tests, long tests of the oil collection and examination on the stability to waves and swimming. At the time of long tests of oil collection the skimmer works 240 hr without some observation to construction. Productivity of the skimmer was stable equally 400-600 L / hr and depended on a thickness of layer collecting oil. At decrease of the thickness of layer to size less 1 mm the process of oil-collecting is limited by velocity of spread of oil in thin films at water surface and their approaching

to works elements of skimmer but not characters of itself apparatus and sorption qualities of oil-collecting napkins. It is most worth while using of elaborated skimmers at thickness of oil 0.5-5 cm.



Fig.5. The series example of industrial swimming four-drum mechanize skimmer.

The good exploitation qualities of elaborated skimmer are permit producing in the company North-West Main Pipe-Lines the experimental batch of the skimmers (Fig.5) for solution on the that firm in spite of continuation of research works which make for increasing of the skimmer's productivity. The tentative price of skimmer with container for it convey is 5000 \$. At liquidation of accident product spill our apparatus be worth while at 40-50 hours of work [20].

CONCLUSION

On the basis of formulate conception of the optimal absorbent are tested the sorption properties more 30 potential absorbents. There are given properties of the waste of cotton manufacture, named as "SINTAPEX", which possess with sufficiently high sorption ability for the numerous assortment of products. There are patented three type of basis construction of sorbing skimmers and five their modifications. It is examined and studied some variations of skimmer sorption type and work out stochastic mathematical model in form system of 10 regression equations on the base method of planning of experiments by four main parameters which described process oil-collection. There are permit producing in the company North-West Main Pipe-Lines the experimental batch of the skimmers.

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