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PULSED STIRRING CRYSTALLIZER FOR DEWAXING. RESULTS OF INDUSTRIAL INTRODUCTION IN THE KM-2 COMPLEX

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The results of long use of a pilot-industrial pulsed stirring crystallizer in production of KM-2 oils and waxes by Slavneft'-Yaroslavnefteorgsintez JSC in dewaxing distillate (420 – 490°C cut) and residual raffinates from mixed West Siberian crude oils demonstrated the significant advantages of this unit and the new technology for production of wax suspensions [1, 2].

After completion of the corresponding work, an industrial pulsed crystallizer with a feedstock output of up to 28 m^3/h began to be used at this plant. This unit, in contrast to the pilot-industrial unit calculated for output of 4 m^3/h (the real unit attained 10 m^3/h), is designed for processing the entire feedstock stream provided by the resources of the plant.

The process scheme (as in use of the pilot-industrial analog) provides for periodic processing of the types of feedstock mentioned above based on stockpiling after the preceding production stages and the necessity of producing base oil of the required quality.

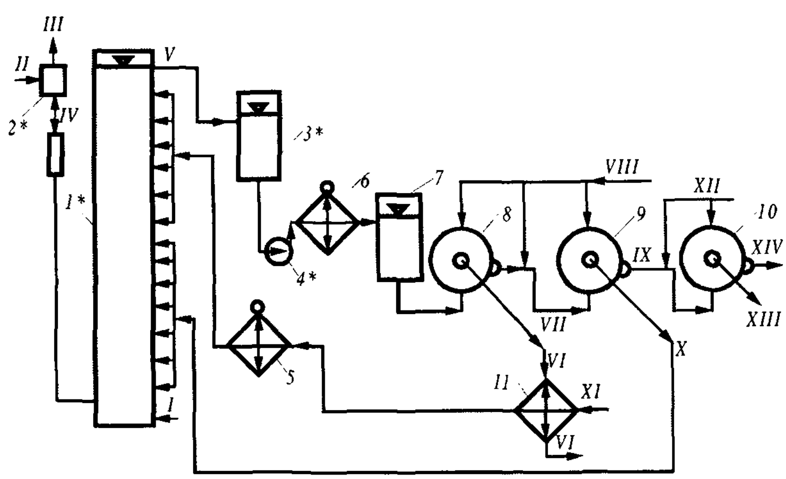

Fig. 1. Flow chart of dewaxing and deoiling using the pulsed stirring crystallizer: 1) crystallizer; 2) pulsator; 3, 7) containers; 4) pump; 5) cooler; 6) evaporative rake crystallizers; 8, 9) first and second dewaxing stage filters; 10) slack wax (petrolatum) deoiling filters; 11) heat exchanger; I) feedstock; II) compressed inert gas; III) discharge of inert gas into breathing line; IV) inert gas pulses; V) suspension; VI, X) first- and second-stage filtrate; VII, IX) sediment from first and second stages; VIII) cooled dry solvent; XI) dry solvent; XII) solvent for dilution and washing; XIII) deoiling filtrate; XIV) wax sediment (ceresine).

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The KM-2 production dewaxing section operates on a combined scheme; dewaxing of raffinate in two stages and deoiling of the slack wax obtained (petrolatum) in one stage. The main process scheme after inclusion of the industrial pulsed stirring crystallizer is shown in Fig. 1.

Feedstock **I** is fed into the first section of the pulsed stirring crystallizer by a pump. A coolant, filtrate **X** from the second dewaxing stage, enters the lower sections of this crystallizer. Dried solvent **XI** cooled by filtrate **VI** from the first dewaxing stage in a heat exchanger (regenerating rake crystallizers with the rake shaft drives switched off are being used in this capacity in the first stage of reconstruction) is delivered for aftercooling to a defined temperature to evaporative cooler 5 (a propane crystallizer with the rake shaft drive switched off is currently used for this purpose) and then to the following sections of the pulsed crystallizer. Mixtures of dry and wet solvents can be used as coolant **XI**.

TABLE 1

Indexes	Crystallization of raffinate	
	residual	distillate
Output of crystallizer in feedstock, m^3/h	17/16 – 17	28/20 – 21
Temperature, °C		
feedstock at inlet into crystallizer	75 – 78	68 – 72
wax suspension at outlet from crystallizer	3 – 5	4 – 6
filtrate from second dewaxing stage	1 – 2	1 – 2
cooled dry solvent (mixture of dry and wet solvents)	– (24 – 26)	– (23 – 24)
Average final feedstock dilution ratio (with consideration of dilution by second-stage filtrate and dry solvent) before first dewaxing stage, vol. fractions in feedstock	1:4.5/1:(4,5 –5.5)	1:3.2/1:(4,2 –4.6)
Consumption of solvent and filtrate from second stage for dilution of feedstock before first filtration stage, m^3/h	76.5/76.5 – 93.5	89.6/88.2 – 96.6

Note. In the numerator: after introduction of the industrial pulsed stirring crystallizer; in the denominator: before introduction.

TABLE 2

Indexes	Dewaxed oil	Slack wax (petrolatum)	Wax (ceresine)
In pulsed crystallizer			
Temperature, °C			
solid point	–(15 –17)/–(15 –17)	–	–
melting (dropping) point	–	–	(60–62)/(68–70)
Oil content, wt. %	–	(9.5–10.5)/(8.3–9.8)	(2.4–3)/(3.5–4.2)
Yield, wt. % in feedstock	81.8/81.5	–	–
In previously used technology			
Temperature, °C			
solid point	–(15 –17)/–(15 –17)	–	–
melting (dropping) point	–	–	(58–60)/(67–70)
Oil content, wt. %	–	(18.1–20.2)/(16.5–18)	(7.3–8.9)/(3.9–5)
Yield, wt. % in feedstock	78.8/78	–	–

Notes. 1. In the numerator: in processing raffinate from 420 – 490°C cut; in the denominator: residual raffinate.
2. Average values of the yield of dewaxed oil are reported.

The feedstock stream is mixed with the coolant streams in the pulsed crystallizer sections by inert gas pulses **IV** created by a pulsator. Wax suspension **V** obtained in the crystallizer enters intermediate container **3** by gravity and is pumped into the evaporative rake crystallizers where it is aftercooled to the required separation temperature. The suspension then enters the filters of the first dewaxing stage through container 7. After repulping with cooled dry solvent **VIII** (also delivered for washing of the sediments in the first- and second-stage filters), the sediment from these filters enters the filters of the second dewaxing stage. Sediment **IX** obtained in them is delivered to the deoiling filters after dilution with solvent **XII**.

The additional equipment installed is indicated by the asterisks in Fig. 1. Significant fitting out of the dewaxing unit and correction of the process scheme of the crystallization department are thus required for including the pulsed stirring crystallizer in production of suspension.

The basic process parameters for production of suspension in the pulsed crystallizer are reported in Table 1. Filtration was conducted in all stages in the routine conditions provided by the process regulations.

The results of analyses of the products of separation of the wax suspension and the yields of dewaxed oils obtained in using an industrial pulsed crystallizer and regenerating rake crystallizers are reported in Table 2.

TABLE 3

Indexes	Dewaxing of oil raffinates and deoiling of slack wax (petrolatum) using: regenerating rake crystallizers	pulsed stirring crystallizer
Number of rake crystallizers		
of regenerating type KRSN-340 (total heat transfer surface area of 1020 m^2),	3	3*
of evaporative type KPNK crystallizers for aftercooling of suspension to the filtration temperature (total heat transfer surface area of 540 m^2)	3	3*
Weight, tons		
regenerating rake crystallizers	230.2	–
pulsed stirring crystallizers	–	18
additionally installed shell-and-tube heat exchangers** for utilization of filtrate cold from first stage dewaxing and cooling of dry solvent to the required temperature	–	20
Number of rotary-drum vacuum filters (unit surface area of 75 m^2) for separation of wax suspension		
in first dewaxing stage	4 – 5	4 – 5
in second dewaxing stage	2 – 3	2 – 3
in slack wax (petrolatum) deoiling stage	2	2
Power, kW		
total for operating regenerating crystallizer drives	87	–
consumed for compression of inert gas for creating pulsation	–	48

Notes. * Currently used as heat exchangers when rake shaft drives are switched off.
** The regenerating and evaporative rake crystallizers used for these purposes have since been replaced.

TABLE 4

Indexes	Crystallization of oil raffinates	
	before introduction of new technology	after introduction of new technology
Output in feedstock, tons/year	71542/45617	95150.9/45617
Additional feedstock processing volume due to increase in output, tons/year	–	27846/–
Additional yield of dewaxed oils, tons/year		
due to increase in yields from feedstock	–	2146.3/1596.6
due to increase in output of the unit for the yields attained from the feedstock	–	19507.1/–
total	–	21653.4/1596.6
Output volume, tons/year		
slack wax with >7 wt. % oil content	13020.6/–	–
brand Ns wax, tons/year	–	17317.3/–
Increase in profits, millions of rubles (millions of US$)/year		
as a result of additional total output of dewaxed oils	–	27.445(1.044)
as a result of output of brand Ns wax	–	18.14(0.7)

Note. In the numerator: in processing distillate raffinate; in the denominator: in processing residual raffinate.

The generalized indexes of dewaxing of the indicated raffinates and deoiling of slack wax (petrolatum) before and after introduction of the pulsed stirring crystallizer are compared in Table 3.

Using the industrial crystallizer in dewaxing and deoiling in production of KM-2 thus has the following advantages:

- production of a suspension with large wax crystals of homogeneous size and thus an increase in extraction of residual and distillate dewaxed oils by 3.5 and 3 wt. % on average in production of brand Ns wax instead of slack wax with an oil content of >7 wt. %;
- increasing the output of the filtering equipment due to significant improvement of the filtration properties of the suspensions obtained and consequently loading of the unit in processing of distillate raffinate from 21 to 28 m^3/h, i.e., by 33%;
- increasing the reliability of the crystallization equipment as a result of simplifying the design of the equipment and the wax suspension production process;
- decreasing the metal content of the crystallization equipment by six times as a result of replacing all regenerating rake crystallizers with one pulsed crystallizer (with consideration of the weight of the additionally installed heat exchangers);
- decreasing the operating costs for servicing and repairs of the rake crystallizers as a result of reducing the number – only evaporative rake crystallizers for cooling the suspension to the filtration temperature are still in operation;
- reducing losses of selective solvents due to better hermetic sealing of the pulsed crystallizer in comparison to regenerating rake crystallizers (no packing for rake mechanism shafts), i.e., increasing the environmental safety of the plant.

The results obtained totally correspond to the high indexes obtained in using the pilot-industrial pulsed stirring crystallizer, which indicates the successful modeling of production of wax suspensions using this equipment.

The fundamental indexes of the suspension separation conditions in all stages (ratio of washing sediments on filters, repulping sediments after the corresponding separation steps, filtration temperature, etc.) were almost unchanged.

The fundamental technical and economic indexes in introduction of the new crystallization technology in processing distillate (420 – 490°C cut) and residual raffinates from mixed West Siberian crudes are reported in Table 4. The increase in profits will be 45,585,000 rubles or US $1.733 million (for an exchange rate of 26.3 rubles per dollar) a year.

The real technical and economic efficiency of this technology will be increased if the 700,000 ruble (or US$26,620) reduction per year in operating expenses for repairs and servicing the crystallization equipment and the possibility of increasing the output of the unit for residual raffinate after completion of work to optimize crystallization of this feedstock are taken into consideration. No increase in operating expenses related to an increase in the amount of solvent circulating in the system (including the increase in power consumed for its regeneration) is anticipated (see Table 1).

REFERENCES

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