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Structural instruments 2007-2013

Common strategy to prevent the Danube's pollution technological risks with oil and oil products – CLEANDANUBE

Operation: no.2(2i)-2.2-5, code MIS-ETC 653

STUDY 2

STUDY ON THE DESIGNATION OF TECHNOLOGICAL PARAMETERS AND CONSTRUCTIVE TO BE ATTAINED.

Working team:

Lead partner: National Research & Development Institute for Gas Turbines COMOTI Bucharest, Romania

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Summary

STUDY ON THE DESIGNATION OF TECHNOLOGICAL PARAMETERS AND CONSTRUCTIVE TO BE ATTAINED.

Waste oil discharged into the Danube (accidentally or otherwise) can eliminate / reduce the processing in a special facility, separate them into single-phase components, components that can be easily re-integrated into natural cycles.
Following this operation, it separates two fluid phases, one consisting of oil, another of water, and solid phase (semi), composed of mud and other materials from oil drilled solids from the water.
Water with solid phase (sludge, decanted and cleaned) are discharged into the Danube, and oil can be stored and eventually re-used in different processes.

1. Centrifugal separation of oil waste

The presence of oil waste is a major problem in terms of environmental factors as well as economic, these wastes are hazardous fauna and flora in the development and further investment is needed greening affected areas.

Waste oil composition is diverse, depending on the types of waste and stock of origin and the nature of oil spilled.

Waste oil has a composition consisting basically of three types of phases of compounds:

¬ The first part consists of a phase oil and contains various species of heavy hydrocarbon compounds and resins or asphalt category.
¬ The second phase consists of water in various minerals that are dissolved.
¬ The third phase consists of mineral compounds are in solid phase.

Separation of the three phases is a difficult technical problem and high costs.
The project proposes the separation of waste oil by centrifugation.
The following is the general scheme of the greening process of petroleum products.

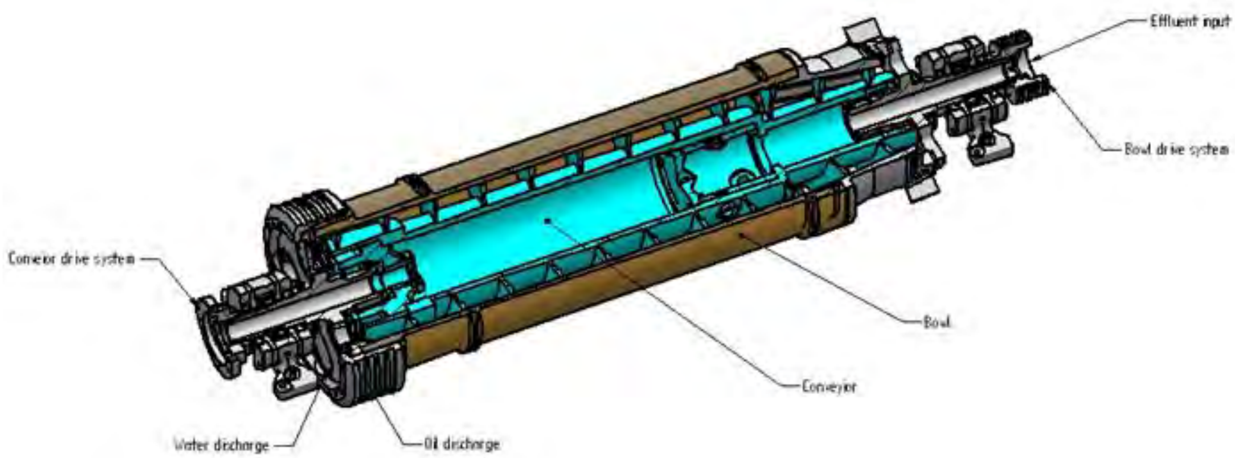

Fig. 1 General configuration of a centrifugal separator

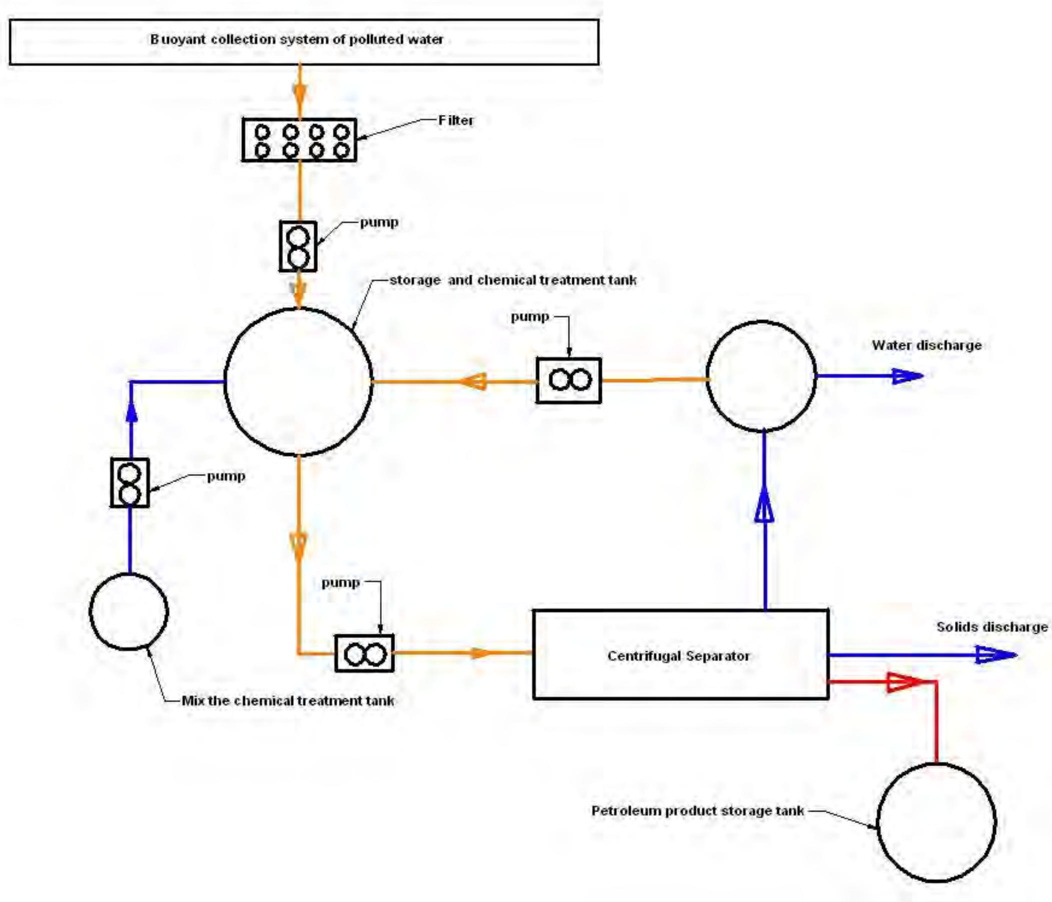

Fig. 2 The general proposal scheme for centrifugal separation plant

Contaminated water is collected, filtered and then pumped into a tank that is chemically treated and diluted with recycled water.
The mixture is processed in centrifugal separation plant and resulting components are disposed differently: it is mostly recycled water, petroleum products collected and stored, cleaned solids are discharged into the Danube.
Centrifugal separation is the division of the constituents of a heterogeneous mixture, different based on their specific weight, using centrifugal force created during rotation. Decanter centrifuge separated by specific gravity liquids, spilling the top, centre, easy fluid, and one hard on the periphery. Can be employed in the same manner and to the separation of a liquid which has solid particles in suspension. Speed centrifuges can reach up to 60,000 revolutions per minute (ultracentrifuge). Separation is facilitated by dividing the conical liquid layer by means of conical plates.

2. The general principle of operation

Components with different densities separator works in principle only by sedimentation, a process that produces the separation of liquids and solids in suspension due to the difference in density. If the density difference is large, then gravity can provide enough force for separation to occur within a reasonable time - as is the case with large tanks or separators with blades or angled plates. If the density difference is small, then it would take too much gravitational separation, and separation force must be increased by adding the centrifugal forces several times higher than that of gravity.
Centrifugal force can be created either by the flow of the mixture as a hydro cyclone or mechanically driven rotation, as in sedimentation centrifuges.
The main beneficial features of the separator in this range of sedimentation equipment is its ability to remove solids separation zone separated from the continuous system. Centrifugal separator can be used for most types of liquid / solid, given its ability to handle a variety of different mixtures and concentrations.
The separator can be used for three phase separation in which liquid is composed of water and oil. It can be operated so as to give a high degree of separation.

3. Theoretical aspects of the phenomenon of centrifugal separation

In the second co-acting centrifugal force fields: gravitational forces and centrifugal forces.
Centrifugal force
Centrifugal acceleration developed inside the cylinder radius r and angular rotational speed "ω" is:

$$a = r\omega^2$$

Centrifugal force is:

$$G = \frac{r\omega^2}{g} = \frac{r}{g}\left(\frac{2\pi n}{60}\right)^2$$

$$G = \frac{n^2 \emptyset}{1800}$$

Where: r = bowl inner radius [m]
ω = angular speed [rad/sec^2]
g = gravitational acceleration = 9.81 [m/sec^2]
n = bowl speed [rpm]

360 ° = 6.287 radian
Slippage force is (**S**)

$$S = \sin\alpha \; G$$

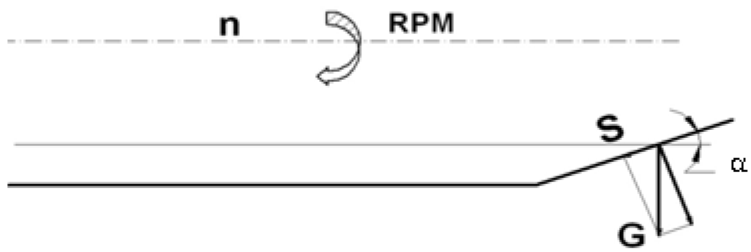

Fig. 3

Equivalent surface (sigma value)

$$\Sigma = \frac{1}{160} n^2 L_{cil} r^2$$

Where;
Σ = sigma value[m^2]
n = Bowl speed [rpm]
L_{cyl} = barrel length[m]

r = maximum radius of cylinder (half diameter) [m]

Sigma value is the equivalent surface in sq. m of a static flotation tank to produce the same solid/liquid separation results.

Dewatering surface
Dewatering surface [sq.m] is the surface of the cylinder section (the cylindrical portion)
$A_{c,n} = \pi D L_{cil}$ or $A_{c,n} = \frac{\Sigma}{G}$

Where;
$A_{c,n}$ =Decanter surface settling [sq.m]

Σ = sigma value [sq.m]
G = centrifugal force
D = internal diameter in meters

L_{cyl}= length of the longitudinal section in meters.

The dewatering volume
Centrifugal separator dewatering volume is obtained assuming the total volume of liquid in the cylinder of the bowl .
This volume is a function of diameter flats.

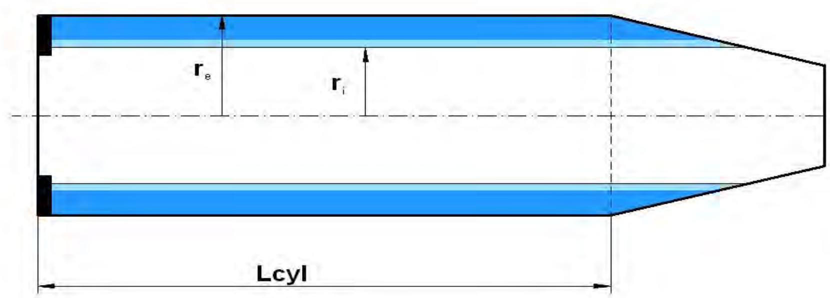

Fig. 4

To calculate the dewatering volume cylindrical part take into a consideration the cylindrical length L_{cyl} [only, the bowl inner radius $r_{e(in\ m)}$and the $r_{i(in\ m)}$ where r_i approx = 60% $r_{e.}$
Dewatering volume is: **$Dv=(r^2_e-r_i^2)\pi x\ L_{cyl}$ (cu.m)**

Retention time

$$R_t = \frac{3600\ V_{td}}{Q\ intrare},$$

Where,
R_t = retention time
V_{td} = bowl total dewatering volume
Q input =Slurry feed rate [l/h]
The retention time is the time liquid remains in the bowl before being discharged. Retention time depends on characteristics of the feed slurry like this:

- specific weight of solid;
- viscosity of liquid phase
- amount of substance treatment

Longer retention time will result in more efficient solid/liquid separation.

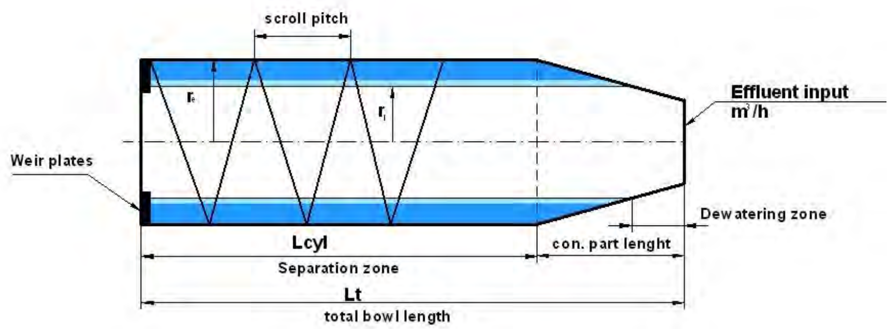

Fig . 5

Δn's influence on retention time (fig. 5)
Depending on water quality by introducing a speed differences between roller and separator conveyor within walking distance increases and hence the quality of the separation process.

Efficiency of separation is achieved by changing Δn, where Δn = differential between the cylinder and conveyor speed.

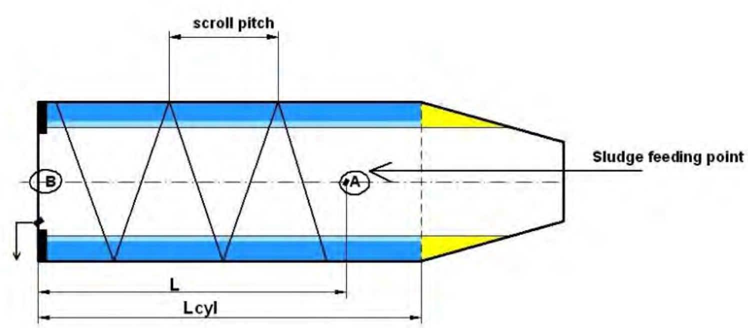

Fig. 6

Intensity ratio of the two fields (centrifugal and gravitational), is called the effectiveness factor:

$$z=\frac{C}{G}=\frac{\frac{mv^2}{R}}{mg}=\frac{v^2}{gR}=\frac{\varpi^2 R}{g}=\frac{4\pi^2}{g}n^2R\sim n^2R$$

Frequently for centrifuges used, the effectiveness factor z has values:
- The low efficiency centrifuges 30
- Centrifuging the crystals 100-150
- The sugar centrifugation 450-650
- The super centrifuge> 3000
- The ultracentrifuge 10^5-10^8

The power required to drive the centrifuge

- For training centrifuges power consumption involved the following:
  - N_a power required to bring the masses in motion, from sleep mode to speed;
  - N_b required to bring the liquid to the centrifuge at the speed of system;
  - N_c power to overcome friction in the spinning shaft bearings;
  - N_d power to overcome friction between the centrifugal and ambient air;
  - N_e power for other resistance to overcome, eg scrapers which remove sediment friction (in centrifuges with continuous operation), the friction in the flow of fluid through the centrifuge, etc.

The starting power is: $N_p= N_a+N_b+N_c+N_d+N_e$

Nominal power:

For discontinuous centrifuges is: $N_{r,c}=N_c+N_d$

For continuous centrifuges is: $N_{r,c}=N_b+N_c+N_d+N_e$

Nominal power system is therefore lower than the starting power. The starting power is even greater as the starting time (up to the speed of the system) is smaller.

Calculation of power N_a.

The work (dL) for the basic motion of a stationary mass (dm) is:

$$dL=\frac{v^2}{2}(dm)=\frac{\omega^2 R^2}{2}(dm)=\frac{\omega^2}{2}(dI)$$

where dI = R (dm) is the moment of inertia, equal to the product of mass and square of the distance.
The work should be calculated for all moving masses of the centrifuge. For simplicity will consider only the cylindrical rotor, for which the moment of inertia is:

$$I_a=Mp\,R_2^{\,2}=2\pi hs\rho R_2^{\,2}$$

Mp is the mass of the cylindrical wall of the rotor.
The work to bring the rotor speed mode (with that simplification) is:

$L_a = \frac{\omega^2}{2} I_a = \pi h s \rho \omega^2 R_2{}^2$

If the starting time is τ, the necessary power to achieve nominal speed is:

$$N_a = \frac{L_a}{\tau} = \frac{\pi h s \rho \omega^2 R_2{}^2}{\tau}$$

Calculation of power N_b.

It is considered that the speed is high enough that the liquid layer to form a cylindrical inner radius R_1 and outer radius R_2.

The mass of a thin cylinder, the thickness (dR), radius R and height h, in the liquid centrifuged is:

$$dm_b = 2\pi R h \rho_1 (dR)$$

and moment of inertia:

$$dI_b = 2\pi h \rho_1 R^3$$

For the entire layer of liquid, moment of inertia is:

$$I_b = \int_{R_1}^{R_2} 2\pi h \rho_l R^3 (dR) = \frac{1}{2}\pi h \rho_l \left(R_2^4 - R_1^4\right)$$

and the work needed to bring the liquid layer to speed the system is ;
:

$$L_b = \frac{\omega^2}{2} I_b = \frac{1}{4}\pi h \rho_l \omega^2 \left(R_2^4 - R_1^4\right)$$

If reach the speed centrifuge system during τ, the power is:

:

$$N_b = \frac{I_b}{2} = \frac{1}{4}\pi h \rho_l \frac{\omega^2 \left(R_2^4 - R_1^4\right)}{\tau}$$

Calculation of power N_c.
Is used formula:

$$N_c = f \frac{M_c \omega^2 r}{\tau}$$

Where:
f is the coefficient of friction of the shaft spinning in the bearing, with the value 0,07 – 0,1;

M_c – mass of all moving parts of the centrifuge;

r- shaft radius in bearing zone.

Calculation of power N_d.

The recommended formula:

$$N_d = 0{,}736 \cdot 10^{-6} \zeta D_2^2 v^3 \gamma_a$$

Where:
N_d-is the consumption of power by friction with the air rotor, in Kw;

ζ – resistance coefficient, equal on average 2,2;

D_2 – Rotor outer diameter, in m;

v – peripheral speed of the rotor, în m/s;

γ_a – specific weight of air, in kgf/m^3.

4. Conclusions

The strategy proposed by this project have in this context a new method of intervention, prompt and reliable removal of pollution with oil products, the method devised by specialists involved project partners, based on outstanding professional experience.

It proposes the use of the most effective and used multiphase mixtures separation method based on the difference between the different specific weight of the components. In most cases the system is non-invasive (does not require chemical treatment than in cases of catastrophic spills).

Target groups are centres for tracking and monitoring of the Danube water pollution through the development and awareness of the entire population on the banks of the Danube

Promote a highly effective common strategy based on developing new scientific ideas, leads not only near the Romanian and Bulgarian economies but also to achieve sustainable development in the area of common interest, and we hope to develop new collaborative projects based on experience and closer link between research conducted by universities and further developing new scientific ideas, leads not only near the Romanian and Bulgarian economies but also to achieve sustainable development in the area of Community interest, and we hope to develop new collaborative projects based on experience and closer link between research conducted by universities and further.

Protecting the environment through advanced processing efficiency, to complete environmental components (water and solids) and re-oil industrial circuit (without further special treatment) leading to the sustainability of the intrinsic value of natural resources in the region, which identifies the specific objective no. 3 Programme.

The project has two main objectives:

- Through a coordinated joint management system, develop a strategy for dealing with technological risks of pollution of the Danube with oil and oil products, thus ensuring an efficient protection, and natural values of the area, which perfectly overlaps Objective no.1, Priority Axis no.2.
- To protect the natural environment primarily in the area, which clearly extends protection to a population of firms that work in this area and whose operating results and keep the environmental quality of existing local infrastructure by creating a rapid response service and especially effective for the prevention and timely elimination of possible disastrous consequences of crises caused by human or technological accidents, which identify practical Objective no.3, Priority Axis no.2.