Sludge Dryers

Environment Friendly
Engineering Solution Company

KERONE
Kerone Engineering Solutions Limited

In Association with SVCH-Technologii, Moscow (Russia)

ISO 9001-2008 | ISO 9001-2015 | EMS 14001 | OHSAS 18001

1. INTRODUCTION

The quantity of treated sewage as well as the level of their treatment results in the increasing amount of sewage sludge. On the other hand the requirements concerning the conditions of sludge neutralization and storage are growing. As a result of that new solutions regarding sludge treatment, management and utilization are in demand.

Years of neglecting of the sludge issue caused that nowadays sewage treatment factories have to cope with a huge amounts of sludge which has gathered over the years of reckless sludge management. Sludge condensation and dewatering processes are no longer enough to cope with the still growing amounts of sludge or to reach the required standards. The form of the product obtained after dewatering process is hardly acceptable by several potential clients, including among others agriculture, forestry as well as power industry. The product requires further transformation, more advanced treatment. This shall be the task of the sludge drying process, understood as the thermal drying process in which thermal energy is delivered to the sludge in order to evaporate water. Sludge drying process reduces mass and volume of the product, making its storage, transport, packaging and retail easier and also enables incineration or co-incineration of sludge.

2. IS DRYING A NECESSITY?

This is the question which is worth asking. It should be remembered that the process of sludge thermal drying is not a cheap solution mainly because of its high energy demand. At least as long as there is no source of "waste" energy that can be reused for drying (e.g. biogas, flue gases of a comparatively high enthalpy, low-parameter steam). On the other hand it is impossible to obtain a significant dry mass content in the sludge without an application of the drying process. It is connected with the types of water in sludge.

Water present in sludge may be of the following types:

- water between pores (unbound) that is subordinate to gravity force and can be easily removed from sludge by gravity settling (thickening);
- free capillary water, hold in sludge by adhesion and cohesion forces, that is readily removed from sludge by mechanical dewatering without using chemicals; e.g. in centrifuges where centrifugal force (inversely directed) opposes capillary force and helps to get rid of capillary water;
- physically half-bound water, that is bound inside flakes of sludge;
- bound water
    - biologically - in intracellular form, it is a part of the cells of living organisms present in sludge, bound by molecular forces to the constant phase of sludge;
    - chemically - in intercellular form, it is a part of the crystal lattice of molecules of the constant phase of sludge;
    - physically – in colloids, bound by the surface tension present on the border of phases;

1WFCFD Advanced-Techno Services Pvt. Ltd., Neptune Living Point, Behind Metro Mall, L.B.S. Road, Bhandup (W), Mumbai-400078, Maharashtra, India.
Tel.:+91 9930905388, E-mail: ganeshbhere15@gmail.com

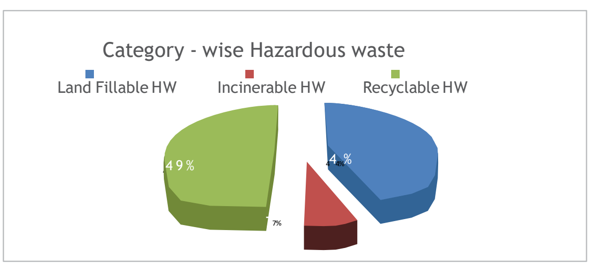
2 Advanced Drying Laboratory, Department of Chemical Engineering, Institute of Chemical Technology (formerly UDCT) Matunga (E), Mumbai-400019, Maharashtra, India. Tel.:+91 22 3361 1111/2222, E-mail:bn.thorat@ictmumbai.edu.in, thoratbn@gmail.com

Abstract: Thermal drying of sludge is gaining popularity to reduce the numerous problems associated with its handling and disposal. Despite being many types of dryers available for sludge drying, market demands innovative drying technol- ogies that can be cost-effective as well. With this in mind, a novel Screw Conveyor Dryer (SCD) has been designed for the drying of viscous industrial sludge with moisture content as high as 85 wt %. SCD consist of a jacketed cylinder which houses hollow shaft and piping arrangement to transport the drying medium from jacket and hollow shaft into the main dryer body. The dryer can utilize both modes of heat transfer, i.e. conductive and convective modes of heat transfer thus making design thermally more efficient. An arrangement of radial mixers and lifters on screw shaft at regular interval minimizes the agglomeration of sludge. This extremely important feature increases agitation and heat transfer to deal with stickiness of sludge. A procedure for the design of SCD is presented here with an example for drying of 100 kg/hr sludge using different heating media such as flue gas and condensing steam. Thermal drying of sludge is a very energy intensive process and hence it need to be justified economically. An attempt has been made to work out the economics of sludge drying for Indian scenario. It can be concluded from the results obtained through calculations that sludge drying using a novel SCD is technically as well as commercially feasible.

Introduction:

Hazardous Waste Generation in INDIA:

- 36,165 no of Hazardous waste generating industries
- 62,32,507 MT of hazardous waste generated every year



Need of Sludge Drying:

- It is mandatory to dispose off sludge in HWM sites approved by Government agencies
- The companies are paying Rs.16-17 per kg of sludge towards the disposal cost
- The sludge usually contains 80% to 85% moisture content. This means companies are paying Rs. 13-14 per kg of sludge just for disposing water which other wise can be removed by drying
- More cost effective to handle relatively dry sludge either through incineration or any other means of disposal, keeping in mind the minimum impact on environment

Advantages of Sludge Drying:

- Sludge weight will reduce approximately by 60%
- Volume of sludge will reduce by 4-5 times
- Because of weight and volume reduction, the transportation cost of sludge will reduce significantly. Also environmental problems associated with sludge will reduce substantially
- Because of reduction in moisture content, calorific value of sludge increases. This will result in efficient incineration without any additional fuel
- High drying temperature will sterilize and deodorize the sludge.

Sludge Drying Operation requirement:

- Drying is an energy intensive operation because of its high energy demand and inherently inefficient operation thus demanding economic justification
- Market demands innovative drying technologies with higher thermal efficiencies, lower emissions, less manpower requirement and affordable capital cost

Available Dryers:

- Direct drying system: less energy efficient, need expensive equipment for air handling
- Indirect dryer system: expensive in terms of capital cost
- Combined system

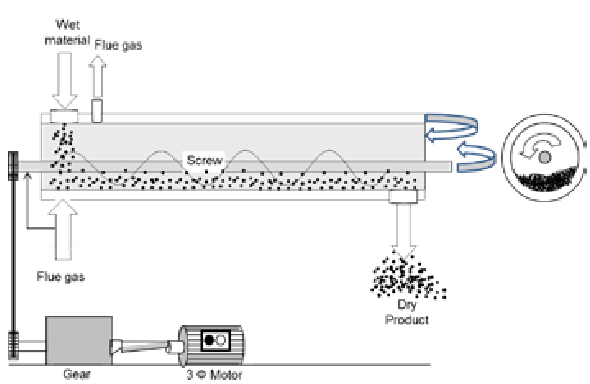
Objectives of the work:

- To give Design procedure for Screw Conveyor Dryer (SCD) with an example
- Techno-commercial feasibility of proposed SCD for Indian scenario

Features of SCD

- Designed to use both conductive and convective modes of heat transfer
- Screw shaft and flights are kept hollow to provide greater heat transfer area within the constrained space
- The heating medium will have two different paths
- First the steam will pass through the jacket and hollow shaft providing conductive heat transfer. Then the preheated hot air will provide convective drying action over the surface of sludge material. Alternatively we can use hot flue gases for both conduction as well as convection
- Twin screws can be installed for better mixing, to increase the heat transfer rate and to avoid fouling
- Innovative component: Radial mixers will be welded to screw shaft at fixed intervals along the length to minimize agglomeration of sludge on the way of transport. This will increase the agitation in dryer and will result in improved performance

Schematic of SCD



Design Procedure

Compartment model approach:

- SCD is divided into 'n' compartments of equal length

'lmix' termed as 'mixing length' such that

$$n = \frac{\text{Length of SCD}}{\text{Mixing Length}} = \frac{L}{L_{mix}}$$

'lmix' is termed as the length required for sludge to get perfectly mixed during its transport through SCD

- Sludge enters at 1^{st} compartment and leaves at n^{th} compartment
- Total residence time of sludge in SCD is τ and the residence time in a single compartment is given by

$$t = \frac{\tau}{n}$$

- Sludge enters the SCD at i^{th} compartment in perfectly mixed form. During its residence time 't', sludge is assumed to be stationary in the given compartment. As per Page model, drying kinetics is applied for static sludge which is treated as horizontal slab drying heated from bottom. During this process, the moisture is lost from the sludge
- At the end of time period 't', sludge is instantaneously well mixed again and transferred to $(i+1)^{th}$ compartment
- Neglecting the sensible heat changes, Page model is applied for sludge drying and the same procedure is repeated till n^{th} compartment
- Moisture contents are calculated whenever sludge is transformed to the next compartment and this new moisture content is used for calculating drying kinetics through Page model for the next compartment
- To ensure that the required heat is supplied for drying as predicted by Page model, heat transfer calculations are carried out. The highest possible heat transfer should be always higher than that required for drying

Calculation steps

Determination of energy required for drying

$Q_{in} = Q_{sen} + Q_{lat} + Q_{loss}$ .... (1)
Since $Q_{sen} = 0$, $Q_{in} = Q_{lat} + Q_{loss}$ .... (2)
The drying rate at the bed surface is given by assuming Page model as follows: $MR = \exp(-k X t^n)$ .... (3)
Where MR is the moisture ratio. Values of constants k and n should be found out experimentally
In this case, $t = t_R$ and $t_R = N_{mix} . T_{mix}$ .... (4)
$t_{mix} = 1/N$ .... (5)
Moisture content at the outlet of first fictitious period t_R is given by, $X_{D1} = MR . X_{Di}$ .... (6)
$m_{m1} = m_{DS} . X_{D1}$ .... (7) $m_v = m_{DS} (X_{D,i} – X_{D,1})$ .... (8)
$Q_{lat} = m_v . \lambda$ .... (9)
$Q_{in} = Q_{lat} / \eta$ .... (10) $Q_{loss} = Q_{lat}/\eta - Q_{lat}$ .... (11)

Determination of energy transfer possible in the SCD

$Q_{poss} = U.A.\Delta T$ .... (12)
$1/U = 1/h_h + 1/h_w + 1/h_c + 1/h_b$ .... (13)

$h_b = 2 \sqrt{\frac{(\rho c_p k)_b}{\pi t_R}}$ $_{A}$ $_{cp}$ (............ $_{A}$) $\frac{2k_G \; d}{\sqrt{2}+ 2l+2\delta}$ .... (14)

$h_c = \; . h \; + \; 1 - \; . \; / \; (\;) / d + h_{rad}$ ...(15)

3. Check if $Q_{poss} \geq Q_{in}$
$Q_{poss} \geq Q_{in}$ .... (16)

Conclusion:

SCD with improved mixing and heat transfer is proposed for sludge drying. The design procedure for SCD based on Compartment model approach is proposed with detailed equations which take into account drying, mixing, heat transfer and flow from inlet to outlet of SCD under certain assumptions. Simple design procedure allows calculating moisture ratio, heat transfer and steam requirement at certain intervals of length. Based on proposed design procedure, a SCD of 100 kg/hr sludge inlet capacity is illustrated along with economic returns as an example. SCD for sludge drying, when sludge disposal is mandatory, seems to be a good option giving payback within a year

Results

Summary of results

Compartments	Sludge inlet flow rate Kg/hr	Moisture content Dry basis	Moisture evaporated Kg/hr	Steam required Kg/hr
1	100	5.667	5.240	9.628
2	94.8	5.317	4.917	9.030
3	89.8	4.990	4.614	8.469
4	85.23	4.628	4.329	7.943
5	80.9	4.393	4.062	7.450
6	76.8	4.123	3.812	6.987
7	73.0	3.868	3.577	6.553
8	69.4	3.630	3.357	6.146
9	66.1	3.406	3.150	5.765
10	62.9	3.196	2.955	5.407
11	60.0	2.999	2.773	5.071
12	57.2	2.814	2.602	4.756

Summary of results

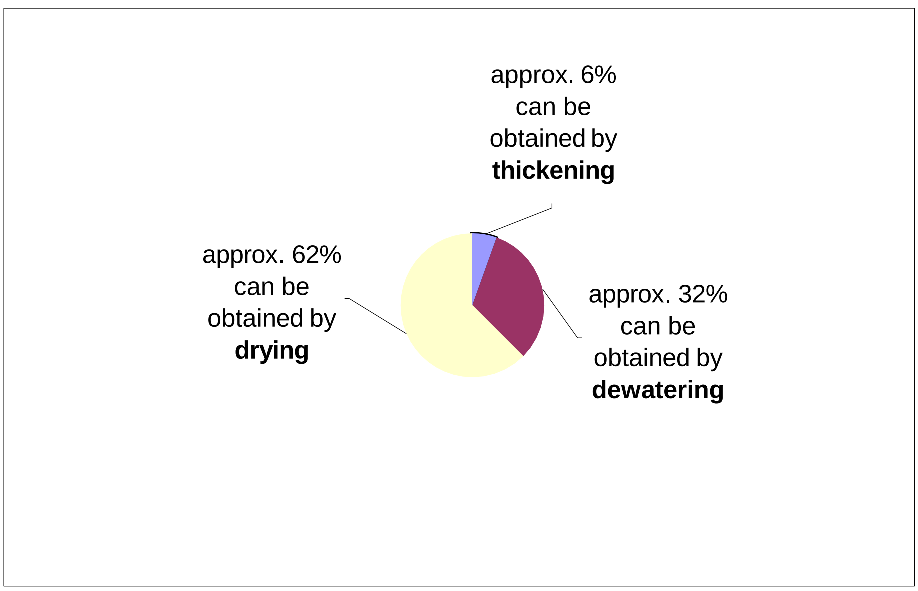
Particulars	Quantity	Unit
Sludge flowrate @ inlet	100	Kg/hr
Moisture evaporated	45.4	Kg/hr
Sludge flowrate @ outlet	54.6	Kg/hr
Sludge disposal cost	16.5	Kg/Kg
Sludge disposal cost w/o drying	1650	Kg/hr
Disposal cost for outlet sludge	901	Kg/hr
Steam required	83.2	Kg/hr
Steam cost	124.8	Rs/hr
Sludge disposal cost after drying	1025.9	Rs/hr
Savings	**624.1**	**Rs/hr**
	44,93,526	**Rs/year**

The bound water, in intercellular form and in colloids, is partially removable by mechanical dewatering but requires the addition of polymers. The intercellular water is retained in the sludge by chemical bonding, which may be broken by the addition of polyelectrolytes which cause a change in the surface tension. The same situation is with water physically bound and half-bound. The intracellular bound water is only possible to remove if the sludge particle walls will be broken either by heating, freezing or by electro induced forces. That means, that without e.g. thermal drying it will be impossible to remove biologically bound water from sludge.

Assuming that:

- ✓ the initial percentage of dry solids (dry solids - DS) concentration is 2%, which means that there is 2% of dry mass in sludge,
- ✓ the final percentage of DS in sludge is 90%,
- ✓ the total possible concentration of DS in the processed sludge (from 2% of DS to 90% of DS) makes 100%,
- ✓ after thickening 7% of DS can be achieved and after dewatering 35% of DS can be achieved,

it can be estimated that approximately only 6% of the total possible DS concentration can be obtained by thickening, further 32% of the total possible DS concentration can be obtained by dewatering and the rest 62% of the total possible DS concentration has to be obtained by thermal drying if 90% of DS in sludge is to be achieved



The conclusion is that if water content in sludge has to be diminished to minimum (approximately 90% of DS) or if there is a need to get moisture removal higher than it is guaranteed by mechanical dewatering, thermal drying is necessary. Thermal drying of sludge removes water from sludge to significantly higher degree than the best dewatering processes. When taking into consideration a wide range of sludge thermal utilization methods (e.g. incineration), sludge drying should be treated not only as a necessary but also as an integral process; only ways of diminishing amount of conventional fuel used to produce energy for drying should be looked for.

3. THE RESULTS OF SLUDGE DRYING PROCESS

The main goals of thermal drying of sludge are:

- to eliminate water from sludge and diminish volume of sludge (approx. 4-5 times) in order to make the transportation cost lower and the sludge storage easier;
- to increase sludge calorific value, so that sludge could be easily incinerated without any additional fuel;
- to make sludge hygienic (without pathogenic organisms);
- to stabilize sludge (what is achieved by drying sludge to the sludge dry mass above 90% of DS);
- to improve sludge structure before spreading by the agricultural equipment;
- to make sludge a fertilizer or a soil conditioner of high market value.

Sludge dried in modern drying facilities consists in 5-10% of water, is in the form of granules (1-4 mm), and there is no more than 1% of dust in it.

Presuming that 1/3 (33,3 %) of sludge dry mass is mineral (does not undergo incineration process), the high calorific value of dried sludge is approximately 14 MJ/kg of DS. In case of 50% of mineral fraction in sludge dry solids the high calorific value of dried sludge is about 11 MJ/kg of DS. The high calorific value of digested and dried sludge is usually lower then of raw sludge by about 2 MJ/kg of DS.

After Kowalik the high calorific value of digested and completely dried sewage sludge is similar to the slimed peat, about 12-14 MJ/kg of DS.

According to Grabowski and Oleszkiewicz the high calorific value of raw sludge ranges from 16 to 20 MJ/kg of DS and for digested sludge between 10-15 MJ/kg of DS. The raw sludge consists of organics (combustible fraction) in 75-85% of DS; after stabilization (digestion) of sludge this value lowers to 45-60% of DS.

Dried sludge can be also a natural fertilizer which interacts with the environment less (if at all) in comparison to artificial fertilizers. The tests show that organic soil conditioners which came into being during thermal drying processes have following advantages:

- provide a slow release of nitrogen;
- supply plants with basic nutrients;
- increase sandy soils ability to hold water;
- increase aeration and drainage of loamy and clayey soil;
- increase ability of soil to hold nutrients;
- don't cause a threat to ground water, as it happens in case of artificial fertilizers;

However, it should be remembered that sludge may pose a sanitary threat to human health and life or to the environment. Stabilized sludge is inhabited by microfauna and microflora, forming a specific biocenose. In its composition can de distinguished: bacteria, viruses, parasitic worms, fungi, protozoa and many other microorganisms. Some of them are dangerous (pathogenic) and some are neutral (saprophytic) from a sanitary point of view.

During thermal drying process sludge undergoes pasteurization (approx. 30 minutes in the temperature min. 85oC). After drying in contact dryers, where sludge is wormed up to 100 - 140oC, sludge is even partially sterilized. [5] Accordingly, thermally dried sludge is considered as sanitary safe.

4. THE PROCESS OF DRYING

1. The exchange of mass and heat.

The exchange of mass and heat between dried sludge and air (material and factor) is of essential significance for the drying process. The heat exchange is achieved through radiation, convection and conduction. Moisture mass goes from the area of higher concentration to the area of smaller concentration as a result of diffusion.

While being in contact with the heated factor moisture from the surface of sludge evaporates to the air. The rate of moisture evaporation differs for materials depending on their properties. It is highest in the first phase of drying when water content in sludge is greatest. Then it diminishes. The rate of moisture evaporation depends also on the contact surface of a drying medium and a dried material. The more extended the contact surface is the higher rate of moisture evaporation can be obtained.

In case of sludge the extension of the contact surface can be achieved through granulation. Granulation extends the contact surface of the drying medium and the dried material which keeps the drying rate at a high level what is the basic condition for making the drying process economically rational.

2. Three phases of drying

The first phase of sludge drying process is preliminary drying. During this very short phase the temperature of sludge is increasing up to a certain, constant value. After preliminary drying the next phase called essential drying begins. It is the longest phase of drying during which moisture evaporates from the surface of the sludge particles with a constant speed, not dependent on the type of sludge. The whole surface of sludge particle is covered with water which constantly evaporates and is replaced by the water from inside of the particle. The temperature of sludge during basic drying phase is constant and is the same as the temperature of surrounding water (50-85oC). The time of basic drying depends on the difference between the moistness on the surface of the sludge particle and the amount of not bonded water inside the sludge particle. The last phase of sludge drying is final drying. It begins when the moistness of sludge reaches the critical value, for which the temperature of sludge is beginning to increase. Water from the surface of sludge evaporates quicker than it is replaced from the inside of the particle. The speed of drying in the last phase is decreasing until balanced hydration (dependent on the drying temperature and air humidity) is achieved.

The speed of drying is dependent on:

- the temperature of drying and air humidity;
- the speed and the direction of a heat carrier flow;
- the size of uncovered surface of sludge (contact surface);
- mixing of sludge;
- the time of sludge retention in a drying facility;
- the way of organizing the contact of sludge with the heating factor.

3. Types of driers

There is quite a big variety of technical solutions of dryers. The classification of dryers is based on the method of supplying heat to the sludge particle. According to that dryers can be divided into:

- convective dryers (represented by drum dryers) in which sludge has a direct contact with the drying factor (e.g. hot air);
- contact (tray and layer) dryers in which sludge has contact only with a hot surface, that is heated from the other side by the heating factor;
- mixed convective-contact dryers;
- infrared dryers with the use of infrared radiation or high frequency currents.

According to Urbaniak and Hillebrand drum and fluidized dryers are particularly useful for the drying and stabilization in the form of granulate.

Direct drying facilities (with a direct contact of sludge with heating factor) which are applicable to sludge drying are :

- pneumatic dryers (flash dryers);
- rotary or drum dryers;
- fluidized bed dryers.

That type of dryers is usually working with the heating factor of a high temperature therefore often has problems with sludge dust and dust explosions. While using convective dryers expensive (up to 30-35% of all the cost of the drying facility) equipment for air protection and deodorization is necessary. Among the main disadvantages of direct dryers should be put also: a significantly high pollution (by dust and volatile compounds) of the gases coming out of the dryer and a necessity of dried sludge recirculation (dependent on a degree of sludge dewatering).

Indirect dryers which are applicable to sludge drying are :

- paddle dryers;
- hollow flight dryers;
- disc dryers;
- multi-shelf dryers

Among the advantages of indirect dryers should be put: reduced odour and dust risk; reduced air pollution; also the fact that dried sludge recirculation is no longer a necessity. The main disadvantage of that type of dryers is the fact that they are less economically efficient than the direct dryers. Indirect dryers have also limited efficiency of drying and usually long time of sludge retention.

Paddle Dryers

Paddle Dryers are used for drying of wet cakes, pastes and thick slurries like sludge. The heating media like steam or hot oil flows through the hollow paddles as well as the jacket thus heating the paddles and the container walls. The wet material gets dried after coming in contact with the paddles and container walls. The design of the paddles is such that it is self-cleaning and does not allow the product to stick. The product moves from one end to the other end and during this travel the moisture is removed. Heating medium is usually steam or thermal fluid.

Construction:

Two hollow shafts with its special wedge shaped heating transferring blades are rotated to convey the wet product from the feed end to the discharge end. The paddles have high heat transferring efficiency and provide a self- cleaning function. The trough for these paddles are duly jacketed and heat is injected into the casing of the trough. The material for the Paddle Blades and the Trough can be Carbon Steel or the applicable grades of Stainless Steel as required.

The Paddle Blades are rotated with the help of a heavy duty gearbox and a suitable motor to ensure trouble free operation. The drive is of robust design, designed for high torque and low operating speed. Shafts, bearings and drive components are designed for long trouble free operations under adverse conditions.

Features of Paddle Dryer:

- Efficient drying of sludge and paste through direct contact.
- Capacities up to 5 tons per hour.
- Complete product discharge.
- Low running and maintenance cost
- Compact construction - less floor area.
- Minimum exhaust air quantity – no elaborate air cleaning equipment needed.
- Special paddle form - ploughing and self-cleaning action.

5. ENERGY CONSUMPTION AND COSTS OF DRYING

The comparison of the total costs of different sludge utilization options often indicates sludge drying as the best option. The final decision should take into consideration not only economical factors but also others like: reliability of the solution, easy service, ease of storage and transportation or whether the considered solution is environmentally friendly.

Energy consumption of the sludge drying process to a great extent depends on water content in sludge directed to a drying facility. Using highly-effective belt press or chamber press for sludge drying is advised. Depending on the method of sludge stabilization 20-35% of DS in dewatered sludge can be achieved. Korczak-Niedzielska and Gromiec suggest sludge dewatering to minimum 18-20% of DS before it is directed to the drying facility.

Energy consumption of the sludge drying process also strongly depends on technical solutions of drying facilities like:

- type of a dryer;
- method of heat recovery;
- detailed technical solution of gases, steam or other heating factors delivery;
- characteristic of sludge.

As thermal drying of sludge inquires significant amount of energy it is advised to use biogas, energy from sludge or waste incineration or other "waste" energy for diminishing the amounts of fossil fuels needed for producing energy for sludge drying.

6. SLUDGE DRYER LOCALIZATION

Localization of a sludge drying facility is a very important issue, especially from the economical point of view, therefore should be well considered. There are three options which can be taken into consideration:

- a sludge drying installation localized on the territory of every sewage treatment plant where sludge pre-treatment is taking place and drying would be an extension of the sludge treatment line;
- a central sludge drying facility, common for several sewage treatment plants, where the quantity of sludge undergoing the process of drying could be significant in comparison to the quantity which can be obtained within one sewage treatment plant;
- a transportable station for sludge drying.

While localizing sludge dryer on the territory of every sewage treatment plant there is no need for equipment for the transportation of wet sludge from the treatment plant to drying facility and for packaging or storage of the large quantities of sludge. What is also important in that solution the vapours from the sludge drying facility can be sent directly to the sewage treatment line what enables recovery and reuse of the energy from the condensate. A serious disadvantage of this option of the sludge drier localizing are comparatively high to a central drying station investment and operating costs.

7. STICKY PHASE

While sludge drying one ought to pay attention to the fact that sludge is changing its consistence from a liquid phase to a paste form. It is then comparable to sticky rubber. The phase is called the sticky phase of sludge. While being in this phase sludge tends to cling to the inside of a dryer decreasing the efficiency of the dryer. The sticky phase phenomenon can also be a cause of the dryer's break down. For average municipal sludge the sticky phase occurs between 45-65% of DS in sludge. To avoid it, mixing previously dried sludge (90-95% of DS) with dewatered sludge (20- 35% of DS) is suggested. As a result of this at the entrance to the dryer sludge of 65-75% of DS is obtained.
An application of sludge mixing improves also the structure (granulation) of sludge what is particularly important with reference to sludge further usage, utilization.

Sludge drying to dry solids content ranging from 48-80% is not applied regarding the unfavorable physical properties of municipal sludge. Partial drying (up to 30-48% of DS) and total drying (80-97% of DS) is suggested as the most convenient for the drying process and the drying facility exploitation

8. VAPOURS REMOVAL

Moist air, called vapours, collected from the dryer should undergo certain processes before it is released to the atmosphere. In the first step it should be separated from particles of the dried material. It is done in the dedusting cyclone-type devices or in bag filters. In the next step vapours should be cooled and the obtained condensate should be taken away to the sewage treatment plant. The vapour condensation system can be direct (in spray devices) and indirect (with the help of membrane heat exchangers). Cooling can be carried out by means of air, treated sewage or water in a closed circle. Heat recovered from hot vapour can be reused. The air without vapour should be deodorized in biological filters or in flame (by the fire method) before it is released to the atmosphere.

9. SLUDGE STORAGE

There is a need of sludge storage - dewatered sludge for drying as well as the dried one. In case of the drying facility failure there should be a possibility to store the dewatered sludge. The storage of dewatered sludge is also convenient for equalization of the quality of sludge.

There should be also an opportunity to store already dried sludge for some time in case of the product (dried sludge) user market falling (shaking) e. g. a breakdown of incineration facility if it is the way of the dried sludge utilization.

The dried sludge should be stored under conditions that prevent it from renewed absorbing the moist from the environment (getting dump). Usually it is stored in silos under the cover of gaseous nitrogen that prevents it from self-ignition.

Kerone Engineering Solutions Limited

UNIT I

A/4,Marudhar Industrial Estate,
Goddev Fatak road,
Bhayander(E), Mumbai-401105

UNIT II

Plot No. B-47, Addl. MIDC
Anandnagar, Ambernath
(East), Dist. Thane-
421506

UNIT III

Plot NO. W-104, Addl.
MIDC Anandnagar,
Ambernath East, Thane-
421506. (India)

EMAIL
info@kerone.com
sales@kerone.com
marketing@kerone.com

WEBSITE
www.kerone.com
www.kerone.net
www.keroneindia.com

Phone
+91-22-28150612/14
+91-251-
2620542/43/45/46