TSK’S Technology

Sludge Dewatering & Drying System

December 10th, 2014

TSK TSUKISHIMA KIKAI CO., LTD.
Contents

1. Company Profile

2. Sewage Treatment Technology of TSK

3. Sludge Digestion Technologies

4. Sludge Dewatering Technologies

5. Sludge Drying Technologies

6. Sludge Incineration

7. Solid – to Fuel Technologies (Low temperature carbonization)
Profile Information

Corporate name: TSUKISHIMA KIKAI Co., Ltd.
Address: 3-5-1, Harumi, Chuo-ku, Tokyo, JAPAN
President & CEO: Kazuhiko Yamada
Established: August, 1905
Settlement Period: March 31 (once a year)
Capital: JPY 6,646 Mil
Employees: 720 (as of March, 2014)
2,191 (group)
Annual Sales: JPY 79,866 Mil (consolidated results)

Domestic Affiliates
- Tsukishima Techno Maintenance Service Co., Ltd.
- Tsukishima Machine Sales Co., Ltd.
- Tsukishima Business Support Co., Ltd.
- SUN ECO THERMAL Co., Ltd.
- Tsukishima Kankyo Engineering Ltd.
- Samukawa Water Service
## Ichikawa Factory

### Production Capacity

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifting Capacity</td>
<td>500 tons (in yard) 300 tons (in shop)</td>
</tr>
<tr>
<td>Max. Plate Forming Thickness</td>
<td>100mm</td>
</tr>
<tr>
<td>Max. Product Diameter</td>
<td>10m</td>
</tr>
<tr>
<td>Max. Product Length</td>
<td>60m</td>
</tr>
<tr>
<td>Heat Treatment Furnace</td>
<td>8m × 8m × 25m</td>
</tr>
<tr>
<td>X-Ray Inspection Facility</td>
<td>0.95 MeV Linear-Accelerator, etc.</td>
</tr>
<tr>
<td>Production Capacity</td>
<td>3,000 tons/month (sheet plate basis)</td>
</tr>
</tbody>
</table>

### Main Products

- Towers, Pressure Vessels and Drums
- Heat Exchangers
- Dryers, Kilns
- Crystallizers, Evaporators
- Filters (Drum and Belt Filter, Dewaxing Filter, DC Filter, Press Roll Filter)
- Centrifuges
- Large Storage Tanks, Gas Holders
TSK’S TECHNOLOGY

- Distillation
- Crystallization
- Gas absorption
- Extraction
- Filtration
- Separation
- Drying
- Incineration
- Water treatment
- Storage tank
- Measuring
- Packaging & FA
- Testing/Designing/Basic engineering/Detail engineering/Manufacturing/Procurement/Construction/Commissioning/Project Management & QA/QC

TSK’s Technology Overview
Main Equipment & Production Plant – Industrial Business

Production Plant
Major Products and Technologies

Steam Tube Dryer -STD-

BPA Production Plant

Biomass Ethanol Plant
(Source: Bio Ethanol Japan)

Environment Preservation Plant
Major Products and Technologies

Incineration

SWFGD

Photo: High Efficiency UASB
(Source: Bio Ethanol Japan)
Main Equipment & Production Plant – Environment Business

Plants and Individual Equipment
Major Products and Technologies

- Tornado press
- Filter press (Dewatering machine)
- Inclined Disk dryer
- Sludge Incinerator

Life Cycle Business
Major Products and Technologies

- An external and internal view (dewatering machine) of Samukawa Water Service (PFI business)
- Sludge fuel Production system
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Sewage Treatment Technology of TSK

- CSO Control
- Sludge collector
- Centrifuge
- Tornado Press
- UV

1. Sewage
2. First Sed. Tank
3. Aeration Tank
4. Final Sed. Tank
5. Advanced Water Treatment
6. Sanitation
7. Advanced Reclamation Water
8. Reclamation Water
9. Dewatered Sludge
10. Ash
11. Bio-Fuel

- Aeration panel
- Thickening
- Digestion
- Dewatering
- Methane Gas
- Drying
- Incineration
- Carbonization

- Belt thickener
- Gas Concentration
- IDD
- Fluidized Bad Incineration
- Carbonization
## Sewage sludge treatment in Japan

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Dewatering</td>
<td>Landfill</td>
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<td></td>
<td>Multi hearth Incinerator</td>
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<tr>
<td>Incineration</td>
<td>Land fill (as ash)</td>
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<td>1974</td>
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<td></td>
<td>Ash utilization</td>
<td>1963</td>
<td>1980</td>
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<td></td>
<td>Fluidized bad incinerator</td>
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<td></td>
<td>Pressurized fluidized bed incinerator</td>
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<tr>
<td>Melting</td>
<td>Slag utilization</td>
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<td>High temperature</td>
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<tr>
<td>Carbonization</td>
<td>Utilization (fertilizer)</td>
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<td>Fuel utilization</td>
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<td>Low temperature</td>
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</tbody>
</table>

Now in Japan there is few case of landfill by dewatered sludge.

After 2011, there is no new construction.
Merit of Drying and Incineration

100
(Moisture 98%)

water

Dewatering

13.3
(Moisture 85%)

Drying

3.3
(Moisture 40%)

Incineration

Volume reduction ▲93%

Volume reduction ▲75%

Thickened Sludge

Dewatered Sludge

Dried Sludge

Ash

Landfill

【Problem】
- Space Limitation
- Odor
- Non-sanitation
- Sludge spread during heavy rain (Heavy metal pollution)

Use as Fuel, Building Material

【Solution】
- Volume reduction
- Sanitary treatment
- Reuse as energy and material
# Market Share in Japan

## Plant & Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Tornado Press, Centrifuge, etc</th>
<th>IDD, etc</th>
<th>Pressurized FBI, FBI, Stoker, etc</th>
<th>Cokes bed, etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewatering machine</td>
<td>15%</td>
<td>28%</td>
<td>21% (Indirect 60%)</td>
<td>47%</td>
</tr>
<tr>
<td>Dryer</td>
<td></td>
<td></td>
<td>(Large 50%)</td>
<td></td>
</tr>
<tr>
<td>Incinerator</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Melter</td>
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<td></td>
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<tr>
<td>Carbonizer</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

## Life cycle business

<table>
<thead>
<tr>
<th>Business</th>
<th>Samukawa Water Service, Co., Ltd, etc (PFI)</th>
<th>PFI 7/12 plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purified &amp; Sewage water treatment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Operation & Maintenance

<table>
<thead>
<tr>
<th>Service</th>
<th>85 plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation &amp; Maintenance for Plant</td>
<td></td>
</tr>
<tr>
<td>Purified &amp; Sewage water treatment</td>
<td></td>
</tr>
</tbody>
</table>

※ TSK’s survey

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7. Solid – to Fuel Technologies (Low temperature carbonization)
Typical Digestion Process

**ESTIMATION**

40% Dewatered Cake Reduction!

21% Power Consumption Reduced!

**Dewatered Sludge Volume**

<table>
<thead>
<tr>
<th></th>
<th>Without Digestion</th>
<th>Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewatered Sludge (ton/d)</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

**Power Consumption**

<table>
<thead>
<tr>
<th></th>
<th>Without Digestion</th>
<th>Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Consumption (kWh/d)</td>
<td>43,000</td>
<td>13,700</td>
</tr>
<tr>
<td></td>
<td>30,000</td>
<td></td>
</tr>
</tbody>
</table>

Application of Digester

TO LANDFILL, ETC.
Effective Utilization of Sewage Sludge as Biomass Energy Source

→ Maximization of Methane Gas Production
→ Reduction of Required Space
→ Utilization of Methane Gas as Heat and Electricity
Block Flow of Digestion Gas Utilization

Influent → Primary Sedimentation tank → Aeration tank → Final Sedimentation tank → Effluent

- Addition of Other Biomass (Food Waste, Etc.)
- Gravity thickening
- Ultrasonic Disintegration System
- Mechanical thickening
- De-H2S tower
- Methane concentration (Hollow fiber contained liquid membrane)
- Low Pressure Gas Holder
- Intermediate pressure storage
- Digestion gas
- Digestion tank
- Dewatering machine
- Supply as fuel
- Dryer, Incineration
- Power generation (Micro gas turbine)
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Moisture in Sludge to be Removed by Dewatering and Drying Processes

Type of Moisture in sludge

Sludge dewatering process can remove part of gap water and capillary water.

Drying and incineration process can treat whole water in sludge by thermal treatment.
High Efficiency Centrifugal Dehydrator

TSK, with the cooperation of Andritz, developed the new High-Efficiency Centrifugal Dehydrator with an innovative structure and low energy consumption.

Features

- Energy savings by small radius discharge and the mitigation of rotating body weight
- Reduction of installation space and load by the simplification of equipment structure
- Easy operation and maintenance
Configuration of High Efficiency Centrifugal Dehydrator

- Main Motor
- Differentia Speed Motor
- Bowl
- Reducer
- Screw Conveyor
- Sludge
- Polymer
- Filtrate
- Dewatered Sludge
TSK Dewatering Systems

Full Line-up of Dewatering Systems To Meet Your Needs!
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Effects of Drying

Reduction

Sanitary Stabilization

Sludge temperature over 90°C
Sterilization by Heating

Moisture Content 80%

60% Reduction

Moisture content 50%

Water 80
Solid 20
Total volume 100

Drying 20

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IDD (Inclined Disc Dryer)

- IDD is indirect heat dryer and high transfer coefficient is materialized by TSK’s specially designed disc.

- The rotation of cut-off inclined discs enhances the agitation and oscillation, and prevents the sludge from sticking the surface and keeps high heat transfer efficiency.

- Odorous materials are suitably treated because of its small amount of flue gas.
Configuration of IDD

Sludge
Exhaust
Steam
Drain
Casing Jacket
Inclined Disc
Dried sludge

Steam is supplied
Disadvantages of existing disc dryer are:
① Stuck on the surface easily
② Low efficiency
③ Burned and stuck

Feature of Inclined Disc

IDD (Inclined Disc Dryer)

Inclined disc prevents sludge from sticking to the surface of disc.

Self-cleaning
Installation stage of IDD: $180m^2 \times 2$ sets
Feeding sludge is agitated and oscillated by the rotation of inclined discs and discharged at the target of moisture content.

Steam (0.5 - 0.8MPa) is introduced into shaft, discs and casing jacket as heat source.

Exhaust gas is introduced and treated (cooling and dust removal) in Scrubber, and 60-70% of it is re-circulated as Carrier gas.
**Construction Experience for IDD**

**Hokkaido Area**
1) Hakodate city (60m²)
2) Hakodate city (45m²)
3) Sapporo city (200m², 180m²)
4) Chitose city (80m², 100m²)
5) Tokachi province (60m²)

**Western Area**
1) Osaka pref. (92m², 80m², 150m², 180m²)
2) Osaka city (200m²)
3) Himeji city (100m²)
4) Kyoto pref. (200m²)
5) Kyoto city (180m²)
6) Hyogo pref. (250m²)
7) Kobe city (200m²)
8) Nara pref. (125m²)

**Kyushu Area**
1) Fukuoka pref. (200m²)
2) Fukuoka city (50m²)

**Eastern Area**
1) Yokohama city (100m²)
2) Tokyo pref. (125m², 180m²)
3) Kanagawa PREF. (80m²)
4) Yokosuka city (30m²)
5) Chiba city (65m²)
6) Saitama pref. (180m²)
7) Itako town (30m²)

**Site : 28 Sites  
Units : 155 Sets**

**China**
1) Wenzhou city 200m² * 2
2) Foshan city 200m² * 3
3) Shanghai city 200m² * 6
The Concept of All-in-one Drying Unit

Appearance of All-in-one Unit
Structure of All-in-one unit Drying system

- Sludge Feeder
- Dryer
- Scrubber
- Exhaust Pipe
- Exhaust Fan
- Mist Separator
- Circulating Pump
- Dried Sludge Conveyor
- Control Panel
Connection Points of All-in-one Drying system
Balance sheet of Drying unit

<Throughput> 10ton/day ~ 15ton/day (12.5ton/day)

Dewatered sludge
12.5 ton/day = 521 kg/hr

Steam
10.85 ton/day = 452 kg/hr

Exhaust gas
97 Nm³/hr (Tem. 40°C)

Treated water
6.25 m³/hr (150 m³/day)

Exhaust gas
485 Nm³/hr

Dried sludge (50%-DS)
5 ton/day = 208 kg/hr

Drain (Tem. 50°C)
6.56 m³/hr, 157.5 m³/day (Tem. 50°C)

Steam drain (Tem. 170°C)
452 L/hr, 10.85 m³/day
STD (Steam Tube Dryer)

**TSK ADVANCED STEAM TUBE DRYER**

TSK have supplied almost 500 of Steam Tube Dryers all over the world.
Introduction of TSK Steam Tube Dryer

STEAM TUBE DRYER

Features
- Capability of processing a large quantity materials
- Continuous, stable, safe and easy operation
- High thermal efficiency
- Shut off the atmosphere
- Small amount of exhaust gas

Delivery record:
More than 500 since 1950s
Introduction of TSK Steam Tube Dryer

Applications

For Plastic Resin drying…
-Telephthalic Acid (TPA) powder
  Material for polyester fiber and PET (bottles and films)
-Polyacetal (POM) powder
  for electronics, office machinery and automobile parts
-Polycarbonate (PC) powder
  for optical disks and electronic equipment parts
-High-density polyethylene (HDPE) powder
  Films, containers and packing materials

For the other materials drying…
-Conditioning of coke-oven charge coal in iron works
-Sludge
-Corn by-products in isomerized sugar plant
-Brewer’s grains and whiskey lees
Since 2000, TSK supplies about 120 Steam Tube Dryers all over the world.
1. Rotation and raising movement
2. Flip-flopping by gradual collapse of layer (Some particles remained in gaps of the tubes and lifted up)
3. Avalanche phenomenon
4. Throwing movement
5. Lifting by the tubes
6. Collapse of snow eave
7. Free fall of particles
8. Slipping movement
Installation at site
Huge Size Dryer – Fabrication at Site-

Example of Coal Dryer for iron works
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7. Solid – to Fuel Technologies (Low temperature carbonization)
1) Pressurized fluidized bed furnace system consist of combination of fluidized bed furnace, which is the most suitable furnace for sewage sludge incineration, and turbo charger.

2) Sewage sludge is combusted under plus pressure (130 to 150kPaG) and pressurized flue gas compressed air for furnace by using turbo charger. Then no fluidized air fan is necessary.

3) Because flue gas is pressurized, no induced draft fan is necessary.
Overview of PFBI facility
Overview of Turbo charger

- Flue gas inlet
- Turbo charger
- Air inlet
- Pressurized air outlet
- Flue gas exhaust
Feature of PFBI

Feature 1
Because sludge is combusted under plus pressure, furnace, duct air heater and bag filter are compacted.

Feature 2
Equipments and duct are compacted, then heat loss is reduced. Fuel consumption is also reduced.

Feature 3
Fluidized bed air fan and Induced draft fan are not necessary → Power saving

Feature 4
Under pressurized combustion, there forms high temperature zone in the furnace
→ Emission $\text{N}_2\text{O}$ is reduced
Feature.1 Compact facility

Flue gas volume comes to be 40% reduced compared to conventional fluidized bed furnace and flue gas duct size is reduced. because flue gas pressure is +150kPaG.

Sludge and oxygen reaction comes to very active then furnace inner diameter is 40% reduced compared to conventional fluidized bed furnace, because flue gas pressure is +150kPaG. and oxygen partial pressure is higher.

Air heater and bag filter size are also reduced compared to that of conventional fluidized bed furnace, because flue gas pressure is +150kPaG.
Feature.2 Saving Fuel consumption

Because furnace size, air heater size, bag filter size and flue gas duct are compacted. Then heat loss from these equipments surface is reduced and fuel consumption is reduced around 10% from conventional fluidized bed furnace.

Conventional fluidized bed
100t/d

PFBI
100t/d
Feature.3 Saving electrical power

As turbo charger is running by using flue gas pressure, air is compressed and supplied to furnace. According to flue gas pressure, flue gas is emitted by it’s pressure.

Then no fluidized air blower and no induced draft fan are necessary. So 40% of electrical power is saved.
Feature.4 Reduce N₂O emission

Because under pressurized combustion oxygen partial pressure is higher, oxidation reaction is very active and combustion speed is very quick.

Then in the furnace, high temperature combustion zone is formed.

According to combustion temperature raising, N₂O is decomposed.

N₂O emission is reduced to around 50%.

The figure shows that according to pressure raising, combustion completion height becomes lower.
Construction record of TSK’s PFBI

Kofu city
60t/d 1 train
2013 New Order!

Osaka pref.
100 t/d 1 train
2016 Operation will start.

Kanagawa pref.
100t/d 1 train
2014 Operation will start.

Tokyo metro.(Kasai)
300t/d 1 train
2014 Operation will start.

Tokyo metro. (Miyagi)
300t/d 1 train
2013 New Order!
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The Feature of the technology

Methods of sludge fuel conversion

100°C  250°C  350°C  500°C  600°C  800°C

Drying

Low Temperature Carbonization  250~350°C
Middle Temperature Carbonization  400~500°C
High Temperature Carbonization  600~800°C

Evaluated property for converting sludge into a fuel

High heat value
Low odor
Low Spontaneous combustibility

High heat value
Low odor
Low Spontaneous combustibility

High heat value
Low odor
Low Spontaneous combustibility

High heat value
Schematic Flow of Carbonization system ～process①～

**Process flow**

- Dewatered sludge
- Hot blast furnace
- Dryer
- Granulator
- Carbonization furnace
- After burner
- Heat exchanger
- Scrubber
- Stack

**Fuel product**
Φ3~5mm×5~15mmL

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Schematic Flow of Sludge Fuel Conversion ~process②~

Process flow

1. **Dryer (IDD)**
   - Sludge
   - Carrier air
   - Dried sludge
   - **Pelletizer**

2. **Combustion chamber**
   - Flue gas
   - **Package boiler**
   - **Waste heat boiler**
   - **Steam header**
   - Steam for dryer

3. **Condenser**
   - Carrier air
   - Vapor

4. **Carbonizer**
   - **Waste heat boiler**
   - **Scrubber**
   - **Steam header**

5. **Emission**
   - **Auxiliary fuel**

※IDD: Inclined Disk Dryer
Schematic Flow of Multi Stage Sludge Fuel Converter ~process③

※MSC: MULTI STAGE SLUDGE FUEL CONVERTER
General view of the facility

- Fuel sludge storage hopper
- Dewatered sludge storage hopper
- Carbonization furnace
- Heat exchanger
- Dryer
Installation Carbonization System

Hiroshima City  process①
50ton / day × 2 units
In operation

Kumamoto City  process①
50ton / day × 1 unit
In operation

Kyoto Pref.  50ton / day × 1 unit
2013 New Order!
Operation from 2017

Yokohama City  process②
150ton / day × 1 unit
Under construction
Operation from 2016

Osaka City  process①
150ton / day × 1 unit
Under construction
Operation from 2014.

Osaka City  process③
33ton-ds / day × 5 units
In operation
Growing Solution
Toward the next 100 year

THANK YOU