The Case for Dairy effluent treatment using the Acidulation process with an FRC DAF

FRC is committed to the continual improvement of wastewater treatment methods and equipment. FRC has many dairy references across the US and strongly recommends using the acidulation-DAF process for dairy effluent treatment applications.

1. Introduction

Dairy plants process raw cow, goat, sheep, buffalo, horse and other milk, received from farmers, to extend its marketable life. Besides these traditional dairy sources, increasingly soya, almonds and rice are used as raw materials for milk and related products. Two main treatment processes are employed in the manufacturing process: heat treatment, to ensure the safety of milk for human consumption and to lengthen its shelf life and dehydrating products such as butter, hard cheese, ice cream and milk so they can be stored for longer periods of time.
2. **Dairy effluent**

Dairy processing wastewater is composed of three major types of pollutants;

1) Soluble inorganic matter; sanitary cleaning chemicals (CIP).
2) Insoluble organic solids; milk solids, butterfat, etc.
3) Soluble organic matter; lactose sugars, flavorings, & dissolved proteins (whey).

Each of these components presents a different treatment problem which requires the use of different treatment technologies.

3. **Problem statement**

CIP chemicals such as alkalis (NaOH), acids, chorine, H$_3$PO$_4$ etc., cause wide fluctuations in pH. Besides the fluctuations in pH there is a wide fluctuation in COD, TSS, FOG and BOD caused by the various CIP runs. The first rinse normally produces the highest COD, TSS and FOG because some raw product will be rinsed out of the CIP system. The following cycle will be of lower strength. The more frequent the product change over, the more effluent will be generated. The waste ratios vary from plant to plant but experience has shown ratios between 1 and 6 gallons/liters of effluent per gallon/liters of raw milk.

4. **Conventional wisdom**

Conventional wisdom calls for a large Equalization Tank (EQ) for homogenization of the hydraulics, pH, COD, BOD, FOG, and TSS, *(Mixers need to be installed for homogenization purposes)* followed by Dissolved Air Flotation (DAF) where metal salts such as Alum, FeCl$_3$, FeSO$_4$, MgCl$_2$, as well as organic coagulants, followed by an anionic flocculant, are used to treat the wastewater. The critical design criteria for this DAF system are as follows:
Table 4.1

<table>
<thead>
<tr>
<th>Design criteria</th>
<th>Nomenclature</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic surface loading rate</td>
<td>Gpm/sq.ft. [m³/m²/hr]</td>
<td>1-2 gpm/sq.ft.</td>
</tr>
<tr>
<td>Solids loading rate</td>
<td>Lb/sq.ft./hr [kg/m²/hr]</td>
<td>5 lb/sq.ft.</td>
</tr>
<tr>
<td>Air to Solids ratio</td>
<td>Liters of air/kg of solids</td>
<td>6 – 10 liters/kg</td>
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</tbody>
</table>

[1] Solids are defined as raw TSS and the portion of soluble/colloidal matter converted into solids after chemical dosing.

This conventional approach is satisfactory from an overall treatment perspective regarding COD, TSS and FOG removal, but there are also significant down-sides to this approach.

a. A large EQ tank is required for homogenizing the COD, FOG, pH and hydraulic loading. Dairy effluent is susceptible to natural fermentation which could lead to anaerobic conditions in the EQ and obnoxious odor generation.

b. The DAF float has a dry solids content of 4 to 12%, depending on chemistry used, and a neutral ph. The DAF float will rapidly ferment when stored for just a few hours, particularly in warmer climates. The DAF float therefore will have little value and could generate additional obnoxious odors under anaerobic conditions.

c. The DAF float most likely can’t be returned to the rendering plant due to high Free Fatty Acid (FFA) or returned to the food chain due to the presence of metal salts as well as organic polymers. In Canada even GRASS approved polymers are not approved for re-use of the DAF float (Food grade polymers are allowed in some instances)

d. If the DAF is not operated for a few hours at a time, the neutral DAF content will rapidly ferment generating solids in the DAF tank and reducing the pH, possibly below the discharge limit. *(Normally a pH between 6 and 9)* When the DAF is restarted, these solids will be discharged to the POTW resulting in possible
violations of the discharge permit and may cause clogging and fouling in the DAF system itself.

5. **FRC approach using acidulation**

The acidulation DAF process only requires a small equalization tank (EQ) for hydraulic homogenization. It is not necessary to have COD, BOD & TSS homogenization as precipitation of colloidal matter will occur as long as the pH is properly controlled at 3.9 throughout the system. We recommend the installation of an extended sump/small buffer tank in order to avoid natural fermentation and permit the removal of floating fats and oils from the EQ.

In the acidulation DAF process inorganic acids such as HNO₃ or more commonly H₂SO₄, are added to the plant effluent. The milk proteins coagulate when the pH is between 4.1 and 4.3, and the fat emulsions break down at a pH of approximately 3.9. The acid dosing can take place in a Plug Flow Reactor, an extended sump or a small EQ prior to the DAF. After acid dosing, an anionic polymer is required for flocculation of the coagulated material. Neutralization takes place after the DAF system. The DAF float and DAF contents are always maintained at a pH of 3.9 preventing rapid fermentation.

With the FRC acidulation DAF process it doesn’t matter what the manufacturing plant sends down to the effluent treatment process. The DAF system will perform consistently with little or no operator attention. The system can be completely automated versus the conventional approach where any change in process loading requires an adjustment of the coagulant dosage to maintain acceptable performance.

The features of the acidulation process are:

a. Automated process. *(Requires little or no operator attention)*
b. Reduced risk of rapid fermentation. *(Reduces the generation of obnoxious odors)*
c. Requires a much smaller EQ tank. *(Reduces footprint and capital cost)*
d. The DAF float contains no metal salts. *(Makes disposal simpler)*
e. 50% less sludge volume generated. *(Due to the elimination of metal salts and low pH, the solids concentration will be twice as high as conventional DAF float)*

The critical design criteria of the DAF system for acidulation are as follows:

**Table 5.1**

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<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic surface loading rate</td>
<td>Gpm/sq.ft. [m³/m²/hr]</td>
<td>&lt; 1 gpm/sq.ft. [&lt; 2 m³/m²/hr] [2]</td>
</tr>
<tr>
<td>Solids loading rate</td>
<td>Lb/sq.ft./hr [kg/m²/hr]</td>
<td>5–10 lb/sq.ft. [25 kg/m²/hr]</td>
</tr>
<tr>
<td>Air to Solids ratio</td>
<td>Liters of air /kg of solids [1]</td>
<td>6 – 10 liters/kg</td>
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</tbody>
</table>

[1] Solids are defined as raw TSS and the portion of soluble/colloidal matter converted into solids after chemical dosing.
[2] Due to the nature of the acidulation process we recommend reducing the hydraulic surface loading rate to < 1 gpm (< 2 m³/m²/hr). FRC recommends the lamella plate pack design DAF system for the dairy industry to ensure the low hydraulic surface loading rates.
6. **Conclusion**

With the acidulation process you receive the following benefits;

a. Reduced labor costs through full process automation.

b. Reduced treatment costs due to the elimination of metal salts.

c. Reduced sludge disposal costs due to sludge volume reduction. (<50%)

d. Reduced risk of fermentation and obnoxious odor generation.

e. Reduced discharge permit concerns due to a more stable DAF process.

Please call FRC or send an E-mail if you have any questions, require P&ID, P&ID input or wish to discuss the technology

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