FIN & TUBES AQUEOUS DEGREASING PROCESS

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November 19, 2025

Rationale for TUR Project

- Initiated as a health and safety requirement to replace the trichloroethylene (TCE) degreasing system
  - Driven by the EPA’s regulation prohibiting the manufacture, processing, and distribution of TCE, and any material that contains TCE
- TUR strategy to be implemented: Replace the TCE degreasing system with an aqueous degreasing machine
  - After BOYD's engineering meetings, the RAMCO Aqueous Degreasing Machine was selected

Process Overview

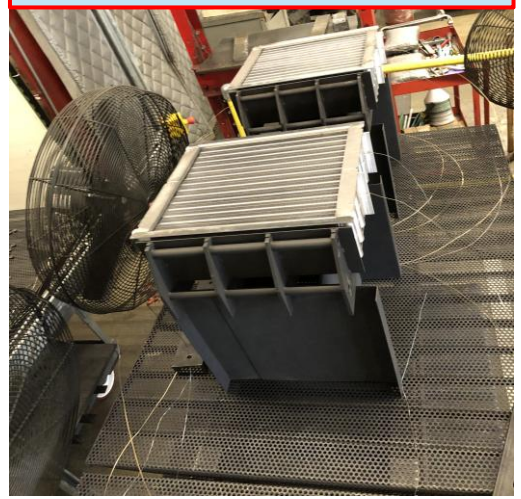
Boyd provides manufactured products to key industrial clients in several strategic fields such as Aerospace and Defense in NA and Europe. Our core business is cooling system design and manufacturing, primarily heat exchangers.

Vacuum brazing:
Consists of making heat exchanger from aluminum material and assembling it through a Vacuum Brazing process in vacuum furnaces. This method is known for its tight tolerances in both machining and brazing process.

Tube & Fin Heat exchangers:
Consists of manufacturing exchanger cores from tubes and fins made of aluminum, copper, and other materials, assembly is done by a Brazing process and by fastening components,

→ **Update cleaning process from TCE to RAMCO aqueous system**

VACUUM BRAZED CORE



TUBE & FIN CORE

Process Overview

Key Parameters for Cleaning Process

Cleanliness

To assess cleanliness, Boyd uses:

- ✓ Visual inspection / visual assessment
- ✓ Heating Inspection (baking/heating part)
- ✓ Low power microscope inspection
- ✓ Wiping inspection
- ✓ Water break tests
- ✓ Nonvolatile residue inspection
- ✓ Surface UV fluorescence detection
- ✓ Paint bond test

Other considerations include:

- ✓ Chemical cost
- ✓ Labor cost
- ✓ Operational cost

RAMCO Aqueous System Description

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The RAMCO degreasing machine is a modular based process equipped with conveyor system and PLC based control system.

Step One / Wash Tank:
A double wall insolated stainless steel covered tank (36”x36”x40”) equipped with reciprocating platform, agitation, heating element, **two sonic transducers**, bottom turbo jet, lateral turbo jet, forced skimming flow, filling pipe, drain port, fluid filter and level and temperature gauges.

Step Two / Rinse Tank:
A double wall insolated stainless steel covered tank (36”x36”x40”), equipped with reciprocating platform, agitation, heating element, bottom turbo jet, lateral turbo jet, gravity base skimmer, filling pipe, drain port, fluid filter and level and temperature gauges.

Step Three / Forced Air Dryer:
A double wall insolated stainless steel covered tank (36”x36”x40”), equipped with forced hot air, drain port, temperature gauge

RAMCO Aqueous System Description

Detergent concentration monitoring:
Fluid concentration is monitored by a dosing system to assure a fixed concentration of the added fluid; the wash tank concentration is daily monitored using a conductivity meter or by titration technique. It is highly recommended to measure the wash tank concentration at least once daily.

DOSING SYSTEM

CONDUCTIVITY TECHNIQUE

TITRATION TECHNIQUE

Aqueous Degreaser Initial Results

Phase One: Testing Machine

- Verified all machine functions
- Design and fabricate the basket
- Conduct first batch of tests and inspection for a series of parameters (temperature, concentration, cycle length, ultrasonic time, turbo jet mode)

Test Results: Cleaning failed inspection

- Fins show residual oil in some areas
- Tubing hairpin presented extensive amount of oil in the inside wall
- Powder residues were deposited on the fins and galvanized tubes plate
- Basket not adapted to conveyor design

Notes:

At this stage, I did not have a complete understanding of the aqueous solution specifications. I conducted more testing with a series of combinations of temperatures and concentrations.

No progress made and problems persisted.

Aqueous Degreaser Problem Solving

Phase Two: Modifying Detergent

Because nothing was working for me, I decided to try a different detergent, picking one recommended to us by the RAMCO team.

Problem Solving:

I did a series of tests with a series of temperatures and concentration using the same basket and theprogramming settings.

Results:

- ✓ I noticed improvements in the powder residues problem if concentration is low (from 4% to 5% @ 150°F)
- ▪ No progress made in degreasing, oil residues still consistent

Aqueous Degreaser Problem Solving

Phase Three: Modifying Oil

I consulted a specialist in oil and detergent in similar processes. Based on their feedback I studied the oils we use in our manufacturing process. The goal was to determine if they are compatible with the aqueous degreasing process.

Problem Solving:

I checked the emulsification and solubility properties of all oils used in our manufacturing process in both hot water and hot cleaning mix @ 150°F.

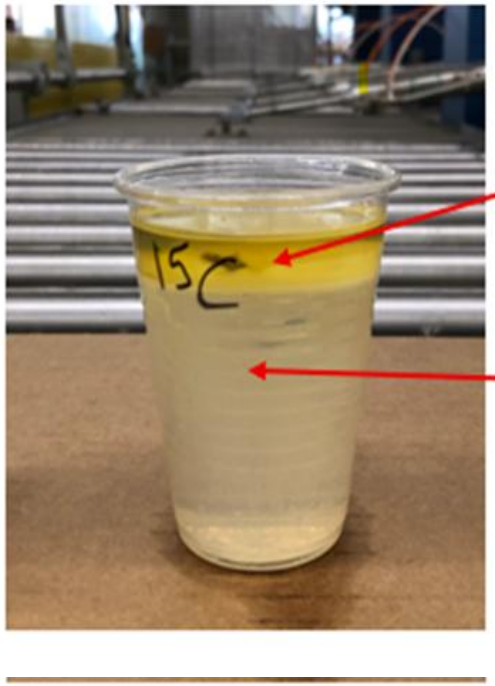
Test Results:

- ✓ I generated a spec sheet for our oils with basic information based on a very simple set of tests. Specifications for compatibility with aqueous cleaning:
  - ✓ Not soluble
  - ✓ Floats
  - ✓ Oils are emulsifiable

- ✓ I eliminated incompatible oils from our manufacturing process and replaced them with oils that are compatible with aqueous cleaning.

Illustration of Compatible vs. Incompatible Oil

Compatible



Unreacted oil drops float on the top.

An emulsion of water and emulsifying agent at 7.5%

Soluble and sinking oil = incompatible with aqueous cleaning

Aqueous Degreaser Problem Solving

Phase Four: Modifying Basket

After eliminating all incompatible oils, I was dealing with one last problem – successfully degreasing the inside wall of the tube.

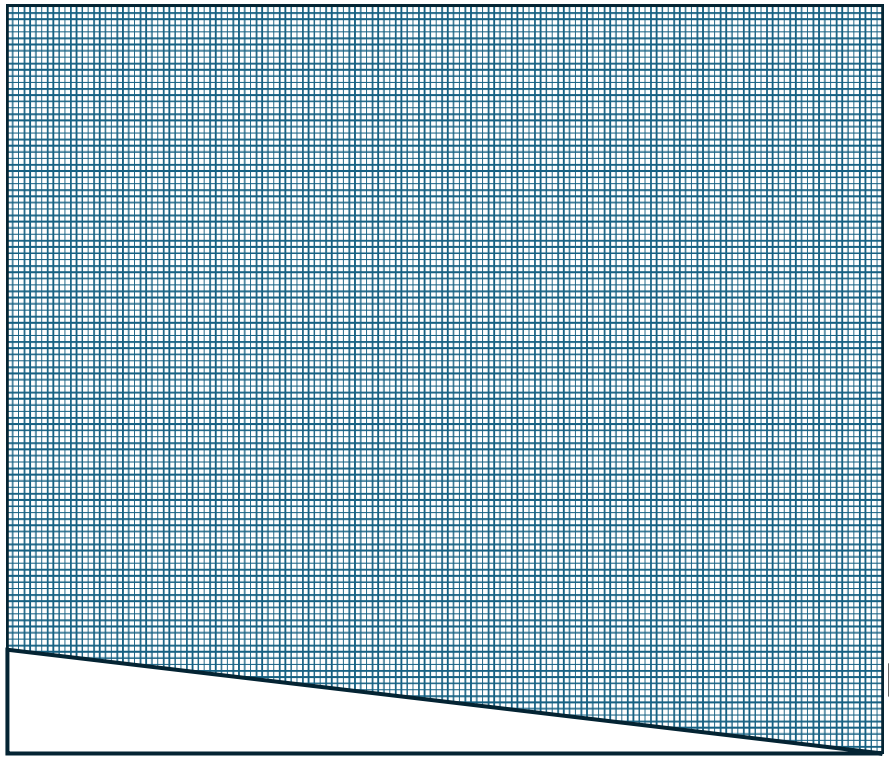
Problems solving :

I designed a tilting basket that allow parts to tilt accordingly to a fill-drain process while it is being degreased.

Test Results:

The results were positive and inside tubes inspection showed very good results that comply with our standards.

Original Basket Design

- 
bo jet
- The inclination (tilt) works in one way only, will not clean inside tubes
- Frame material size and shape is not adapted to conveyor design

Modified Basket Design

- Larger mesh size
- Improved tilting feature to move both ways
- Stainless steel and fit to conveyer design

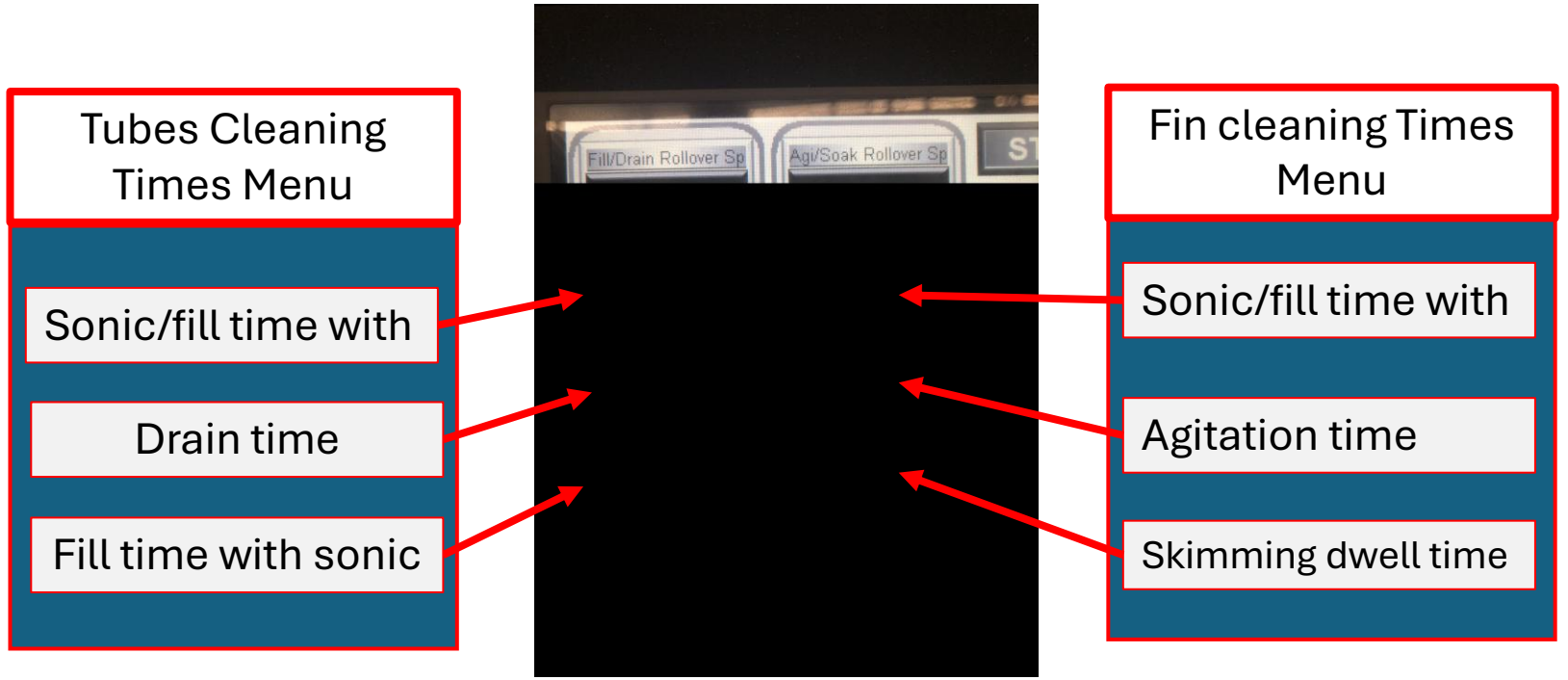
Aqueous Degreaser Problem Solving

Phase Five: Modifying Program for Basket Tilt

The new basket design required a change to the logic control program according to the tilting feature. The idea is simple; we must create new parameters that control the dwell time for every basket's state and designate a programable timer to control its length.

The goal is to fill and drain the tubing for a designated number of cycles, in both the wash and rinse tanks.

The filling and draining process requires a dwell time that must be programmable as an input for every recipe, based on the size of the tubes.



Peer Advice

- Project engineer must **be involved** in the design of all features that are adapted to their process and parts geometries.
- **Vital components** to ensure proper cleaning:
  - Ultrasonics in the wash tank, which substantially enhances the degreasing process
  - Turbo jet, as turbulences mechanically removes oil from parts
  - Heating, which catalyzes the degreasing process
- **Detergent selection is critical** for a successful process
- Oils and greases used in your process must be **studied before the cleaning machine acquisition**, for emulsification and solubility properties. Create a reliable procedure to analyze all oil that must be removed (degreased) and identify substitutes for oils that are incompatible with the aqueous degreasing system.
  - Any used oil must have the quality of separating from the mix and floating to the top of the wash tank to be skimmed out.
- Using **two rinse tanks** is better. Size of tanks must be well calculated to allow basket design improvement
- A **secondary drying conveyor** is a good idea to recover residual water trapped in hidden areas
- If machine is equipped with dryer, make sure to **provide an even flow pattern** across the load to efficiently remove moisture

BOYD

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