**Refiner Trial Working Manual** Rev 3 updated July 26, 2012 by Nici Darychuk

**Steps for Preparing Refiner Loop and Running Trial**

**Before the trial**

1. **Minimum 2 hours before trial, switch on all electrical power supplies to the refiner loop equipment to let them warm up (do it first thing in the morning)**
   a. Turn on high voltage power box
   b. Turn on VFD electrical cabinet power and switch VFD to remote (switch speed ref. source to REM). Use CCW option for rotation direction.
   c. Turn on DAQ board power
   d. Turn on pump controller and switch to ref. mode using Jog button
   e. Turn on DAQ computer.
   f. Turn on Gap controller power

2. **Load tank**
   a. Always use tank A for repulping and mixing
   b. Close butterfly valve at bottom of tank
   c. Fill tank with 3000 L water before adding any pulp
   d. Add calculated amount of pulp and enough water to reach 3,800. Set lower mixer to 47 Hz, and overhead mixer at 20 Hz, on Reverse
   e. After the pulp suspension has mixed for long enough, measure consistency. To determine how much additional water needs to be added. Because the seal water from the mixer is continually diluting the pulp suspension, wait to add the last required amount of water until immediately before the trial begins.
   f. Shortly before trial, run overhead mixer in opposite direction (forward) for a few minutes to dislodge any pulp flakes. Then, return to reverse direction.

3. **Install plates at this time if necessary, to do so:**
   a. Remove top cover of refiner shaft
   b. Remove the gap motor connection shaft
   c. Very thoroughly, clean plate mounting surfaces and sealing area of door – all fibres must be removed for a proper fit
   d. Plate 1 goes on rotor, plate 2 goes on stator
   e. Align door plate with stamp at top. Align rotor plate with stamp aligned with notch on rotor.
   f. Be sure to use exact socket size to avoid stripping the bolts
   g. Each bolt type has its own torque requirement - use torque wrench and do not exceed requirement posted on VFD
   h. Close refiner door carefully, making sure pipe join above is clear. Close the join but not too tight, using pipe wrench. Some water dripping is ok, fibres will seal it when pulp starts to flow. Install horizontal pipe such that the pressure sensor sits on the bottom of the pipe. Thermocouple will be horizontal.
i. Plug in thermocouple and pressure sensor wires.

4. Perform consistency and conductivity tests, if necessary (for the current flow meter, conductivity test is not required)

5. Open LabVIEW (Aikawa Refiner icon on desktop)

6. Calibrate LabVIEW user interface (UI)
   a. Gap Calibration
      i. Open the drainage valve to the refiner
      ii. Remove refiner shaft cover
      iii. Remove the gap motor connection shaft, if not done during plate installation
      iv. Close gap manually until plates are touching
   b. Open LabVIEW user interface VI on DAQ computer desktop
   c. Zero offset adjustments
      i. In the LabVIEW, go to Window → Block Diagram, navigate to the offset adjustments
      ii. Set the offset adjustment values to zero for the following:
         1. Pressure out (psi)
         2. Pressure in (psi)
         3. Gap (mm)
         4. Power (kW)
   d. Run program for approximately 10 seconds
      i. Press run button in LabVIEW
      ii. Wait approximately 10 seconds and press the stop button on the UI
   e. Set offset adjustments
      i. Write down / copy the displayed values for each of the four readouts mentioned above
      ii. In the LabVIEW block diagram window navigate to the offset adjustments
      iii. Input the negative value of each of the above variables into its offset adjustment constant
      iv. Check your offsets by clicking the run button again, the values should be around zero, then click Stop
   f. In the LabVIEW UI input the plate BEL (km/rev) and the consistency (%)

7. Run LabVIEW UI and manually open gap to about 9.0 mm (read on the LabVIEW UI)

8. Stop LabVIEW UI

9. Install gap motor connection shaft

10. Install refiner shaft cover

11. Check all loop valve positions and verify that pulp will circulate as desired. Check with all team members that everyone and everything is ready.
   a. Verify valves are closed underneath pulp tanks
   b. Close the refiner drainage valve

12. Turn on seal water:
   a. Turn on blue tap on the wall behind pump controller
   b. Open the labeled valve below the tap, it is the left valve
c. Open the green handle of the seal water valve at the refiner

13. Ensure that the air is on and that there is 40 psi of pressure on the gauge below the green valve.

Running the trial

1. Press the run button in LabVIEW
2. Check that the set RPM and frequency for the refiner and pump are low in the LabVIEW UI
3. In LabVIEW ensure valve is fully open (at 0%)
4. Press the drive start button on the VFD electrical cabinet
5. Set the pump to ref mode using the jog function and press the run button
6. In LabVIEW turn on refiner at low RPM (~600 RPM)
7. In LabVIEW turn on the pump to desired Hz (23 Hz is good), pump starts slowly before increasing to desired frequency on its own
8. Open valves underneath appropriate pulp tank(s)
9. Slowly increment refiner speed to desired RPM
10. Slowly change valve position, and, if necessary, pump frequency and refiner RPM to get desired inlet pressure and flow rate. Inlet pressure should be around 14 PSI (as little as 10 PSI can be OK if there is no evidence of cavitation in refiner). See valve control guidelines in operating notes below
11. Immediately before readings begin, take a sample to measure consistency of later, and use this consistency value in subsequent calculations
12. See gap control guidelines in operating notes below
13. No-load power is read at gap = 2.5 mm, enter this value into appropriate field
14. At this point we need an extra person to sit by the VFD and record the RPM off the display at each sample point, as the displayed RPM is slightly different from that read by LabVIEW.
15. Sampling sequence:
   a. Change file name to next sample
   b. Click “Log Data” to start logging, prompt RPM reader to record RPM displayed on VFD
   c. Count ~5 s (One one thousand, two one thousand... five one thousand)
   d. Click “Log Data” to stop logging, prompt sample taker to collect sample from valve
15. At end of trial, look at no-load power at gap = 2.5 mm to see if it is similar to initial no-load power.
16. Open gap back up to ~9 mm
17. Turn off pump first, then slowly increment refiner to 0 RPM.

After the trial

1. Allow an hour for flushing of pipes and clean-up
2. Turn on mixer for tank to be emptied to aid in moving the pulp
3. During tank unloading sometimes valves and corners in the pipes get plugged – running the pump back and forth a few times at 29 Hz can dislodge the blockage.
4. After filling tank A with some clean water, flush system 2x into tank B. When system is pumping clean water, actuate green valve to flush fibres from the ball valve. Play around with all other valves to clean them as well.

5. When discharging water from the tanks down the drain, first check the whole length of drain in HHR to make sure there aren’t any blockages that could cause flooding.

6. Data logged is saved in data_test folder on desktop. Retrieve your files and empty the folder for the next person.

**Operating Notes**

1. Our pulp tanks are not ideal repulpers – pulp chunks can get stuck in crevices and pipes, especially at valves and corners.

2. Refining result depends on pH. Tap water is slightly acidic. It can be useful to check pH of pulp suspension, especially if you are repeating experiments, so it can be controlled by adding small amounts of acid or base if necessary.

3. After starting a mixer or the pump, look at the water pressure gauge beside the control boxes – it should show pressure. Look at individual seal water requirement gauges – make sure dials are to required levels.

4. Treat pressure sensor and thermocouple wires with care!

5. During a trial, be very careful when entering values into LabVIEW to avoid any accidental large changes to refiner RPM, valve position etc. that could damage the equipment.

6. Ground loop interference in HHR makes readings jump around, but taking readings over ~5 seconds averages them out to a trustworthy value.

7. Gap control is achieved by the following inputs to move the gap control motor:
   
   i. Fast movement = 10 V (for gaps > 2.5 mm)
   ii. Medium movement = 5 V (for gaps between 2.5 and 1 mm)
   iii. Slow movement = 3 V (for gaps < 1 mm)
   iv. Very slow movement = 2V (for gaps very close to zero)

8. **Valve Control** guidelines for the OLD valve, new valve to be determined (should be similar?)

   - Never go above 70%
   - 0% = open
   - 100% = closed
   - Valve position adjustments:
     
     o 0-20% = No limit
     o 20-40% = increment by 5%
     o 40-70% = increment by 1 or 2%

9. **VFD** has overdrive protection: turns off if RPM is changed too abruptly. Push drive fault button to reset.

10. The refiner generates a delta P of about 30 PSI
11. If LabView has been running for a while, its internal array size buffer of 72,000 could be reached. When this happens, the program will stop, and an error message will pop up saying the array size buffer has been reached. Click “Continue” and immediately execute program again.

12. Tank A mixers need to be turned down as the tank empties to avoid messy splashing. First turn off overhead mixer, then lower the RPM of lower mixer ~10 RPM at a time as needed

13. Plugging of plate grooves with pulp is a concern, because it alters your refining numbers. Procedures to identify plate plugging:
   i. At end of trial, in LabVIEW, set values to no-load condition. If power is >1 kW lower than during initial no-load condition, there could be plugging. Example: Initial no-load conditions were 27 kW, gap 2.5 mm, 1200 RPM, 400 L/min. Return to these conditions and power decreases to 24 kW – there could be plugging.
   ii. Or, during trial if flow rate drops suddenly, it could be due to plugging (fewer grooves through which pulp can move). Keep in mind, however, that the amount of pulp in tank A decreases during the trial, decreasing pressure on the pulp, so this can gradually decrease flow rate as the trial proceeds.
   iii. Take a good look at the plates after opening up the refiner to identify plugged grooves.
### In-Depth Refining Notes

#### Planning your experiment

Every refining experiment should begin with adequate planning. Be clear on what it is that you want to find out with your trial. Goals of experiments in refining:

- Target intensities
- Target specific refining energy (SRE)

Some experimental designs:

- Deplete one tank into the other
- Single chest recycle
- Tank to tank, and then refine again back to original tank

Useful resources:

- The PPC has available a sample spreadsheet useful for planning a refining trial which calculates flow rates etc.

Air Dried (AD) pulp sheets usually come 95-97% dry. Determine moisture content using a sample from the middle of the bale. Weigh it, dry it in the oven and weigh again to determine moisture content. Determine how much pulp in how much water is needed to get the desired volume of pulp at the desired consistency.

#### Background on PPC refiner loop

Created in 2010, the LC refining facility consists of a pulp pump loop and a single-disc 14" Aikawa refiner overhung to 16". The loop includes:

- 112kW (150 HP) motor and variable speed drive (VFD) to power the refiner and provide variable speed refining up to 1750 rpm.
- Flow meter and transmitter for accurate measurement of the pulp suspension.
- Measurement sensors for refiner power, rpm, inlet and outlet pressure (EPX 100 psi), inlet and outlet temperature, and plate position (gap size).
- Computer and A/D system for control and data acquisition.
- Control valves to measure and control the feed to and the backpressure to the refiner.

#### Loop maintenance

- Install updates to computer when needed. Do not leave it to the next person, as they can add up to a long wait.
- Perform maintenance as laid out on sheet posted on VFD above refiner and in refiner retail manual.
Refiner is connected to motor via a special coupling, requires a special oil listed in retail manual and on sheet posted on VFD. To add oil, open orange case.

**Refiner loop equipment limitations**

- Our refiner is limited to a maximum net input of power: maximum Pnet = 50 kW
- Minimum tank level to run a trial (filling pipes, etc.) is 1000 L. Maximum is ~4000 L
- When refiner is running, flow rate should be minimum 200 L/min, maximum 1,500 L/min
- 4.5% is the maximum consistency (consistency in industry is typically 4%)
- Tank A bottom mixer should not exceed ~47 RPM
- For Tank A overhead mixer, 20 Hz is a good value for a full tank (George). Should be set to Reverse, so that it pushes pulp down. Only use it for >2500 L in the tank.
- Good frequency for tank B mixer is ~30-40 Hz
- Pump maximum is 38 Hz (because it was damaged once by running without seal water)
- If plates are not installed correctly they can be out of tram, this shows up as wear patterns on the plate surfaces
- New plates have to be “broken in” by refining pulp with sand added, to wear down sharp edges that cause excessive fibre cutting

**Pulp types**

Pulp type determines plate type. Longer fibred softwoods require coarser plates than short fibred hardwoods. 3 types of pulp we deal with:

1. Chemical SW
2. Chemical HW
3. TMP/CTMP

**Chemical SW**

Cannot repulp to >4.5% consistency. For 4000 L at 4% consistency: mix for 4 hours after the tank is loaded before refining. It can handle a lot of beating and freeness does not change over this time period.

**Chemical HW**

Fibres are more delicate. For 4000 L at 4% consistency: mix for 1-1.5 hours after the tank is loaded before refining. Longer beating destroys the fibres and causes a freeness change.

**TMP**

Ideally, TMP is heated to ~80-90°C while disintegrating. TMP fibres still contain lignin inside and outside the cell wall. Heating softens the lignin, improving flexibility of the fibres. We use the building hot water
supply to get to 60°C. Use the black hose in the loading bay, prop tank lid open with a 2x4 and stick hose in tank. Put a sack over hole in lid. The tanks are insulated – a 60°C tank, after 24 hours, only loses 5°C in temperature.

For all pulp types, mix lower consistencies for shorter periods of time.

**Calibration of sensors**

Voltage vs. Value curves need to be redone from time to time (e.g. gap, power, inlet pressure, inlet temperature, outlet pressure, outlet temperature). We have a digital pressure indicator used for making calibration curves for the pressure sensors. Read the pressure in PSI from the digital pressure indicator, and read the voltage in LabVIEW. Plot Pressure vs. voltage in Excel. The slope and y-intercept are collected and entered into the LabVIEW block diagram:

```
slope-----------------y-intercept-----------------offset
```

For temperature sensor calibration, we use a beaker, a hot plate and a thermometer to make the curves.

**Thoughts for future improvement of the refiner loop**

- A heat exchanger would be ideal to heat the tank during repulping of TMP
- We could remove the gap hand wheel and use torque wrench to zero gap, once we agree on a torque value
- Recalibrate LabVIEW refiner RPM readings to match that seen on VFD
- At this facility we tend to use 2.5 mm as a no-load gap. A true no-load condition, however, could be determined empirically for each pulp and plate combination by finding the gap at which freeness starts to change.