DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Patrick Pellerin · James Gesse · Jeffrey Meagher · Xinglun Yang

Department of Mechanical Engineering

# Compressed Air System Optimization

## Introduction

CKF is a pulp fiber mill located in Hantsport, Nova Scotia that has been fabricating disposable tableware and food packaging products since 1933. In accordance with their sustainable development plan, the Dalhousie capstone team was tasked with making recommendations to improve efficiency on the generation, distribution, and consumption points of the compressed air network.

## Design Process

1. Explore compressed air system for areas for improvement
2. Evaluate each design concept and select the most feasible and economical. The concepts chosen were:
   - **I. Compressor Cooling Water Recovery System:** reuse warm cooling water to supplement cold mill water in areas of the plant that require hot water.
   - **II. Compressor Air Intake Optimization:** convert compressor air intakes from indoor air to outdoor air to improve efficiency.
3. Engineering Justification and Energy Savings Analysis
4. Cost Analysis

## Conclusion + Recommendations

- Based on the team's cost analysis, it is concluded that the proposed additions to the compressed air system will save CKF on electricity and gas consumption.
- The total annual cost savings from the team's proposed designs is $70,775 per year.
- Some further recommendations;
  - Install cooling tower for remaining compressors.
  - Hook up isolated compressor #8 to the outdoor air intake.

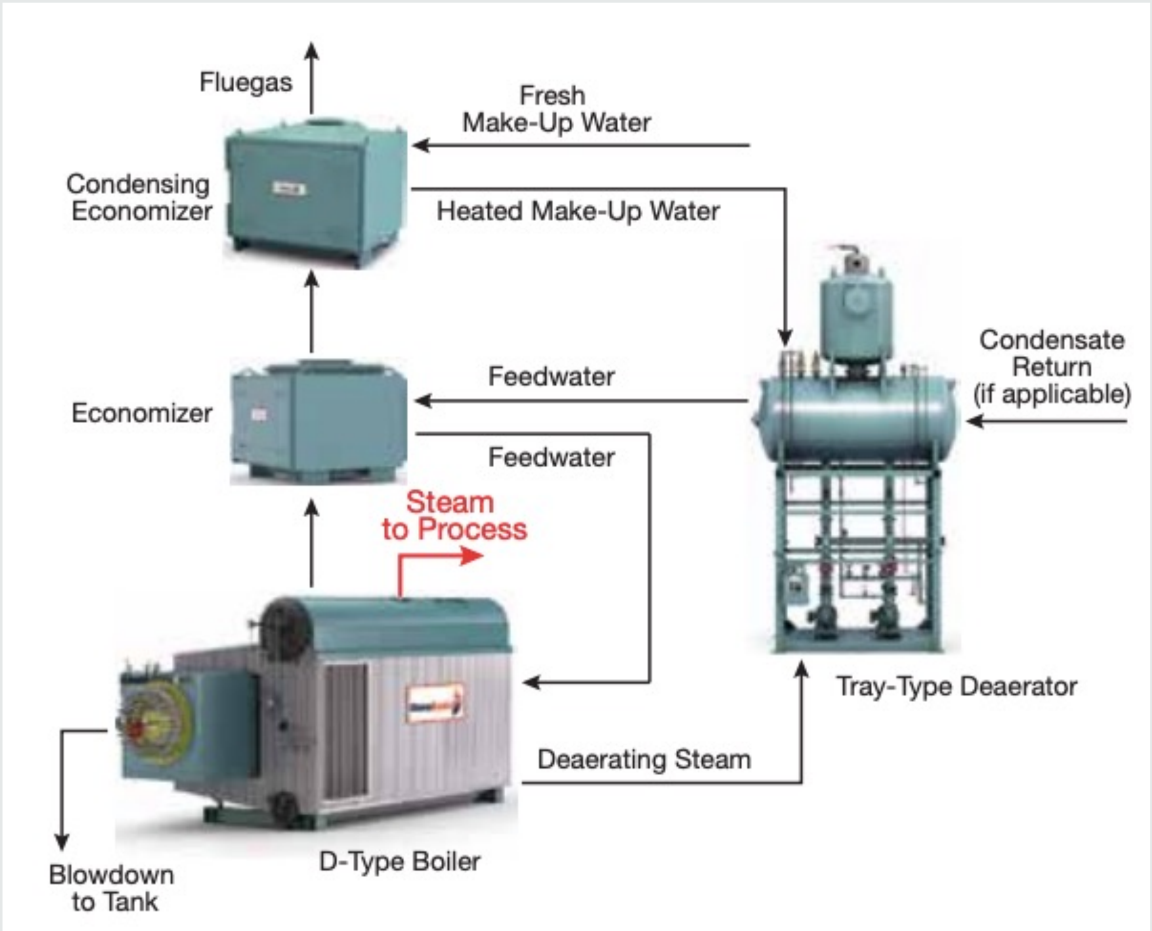
## References


- CKF Inc. (2020). *Boiler Water and Steam Data.* Hansport.
- Skilles, D. (2014, October). *Improve the Performance of Your Boiler System.* Retrieved March 15, 2022, from AIChE: https://www.aiche.org/sites/default/files/cep/20141031.pdf


## COOLING WATER RECOVERY SYSTEM

### Details of Design

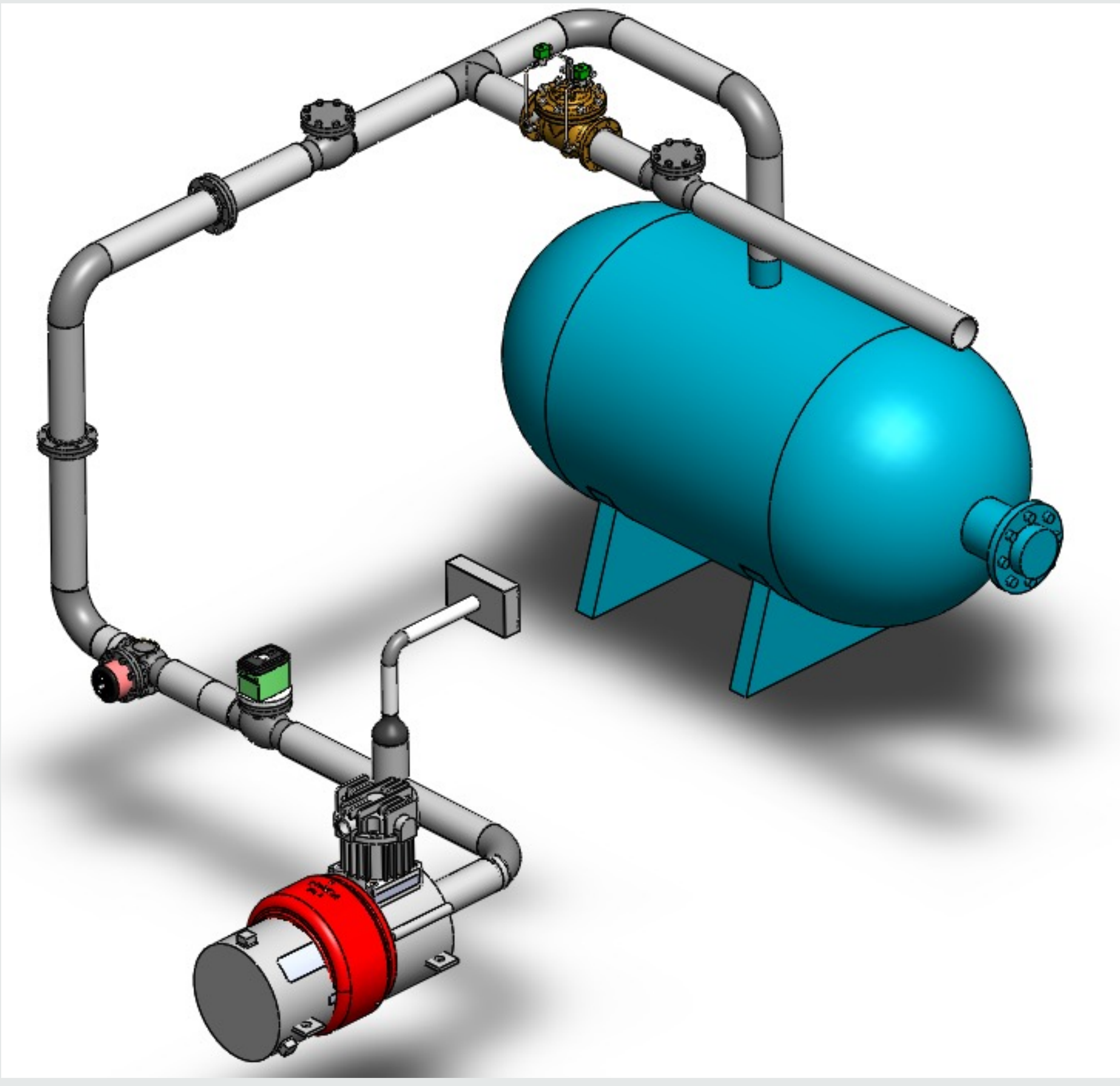
- CKF has two 400 HP, natural gas boilers that generate process steam for the plant. They use an annual average of 4 million gal. of make-up water supplied from the mill (~3 °C).




### CleaverBrooks Boiler System

- Fluegas (waste heat) is used to pre-heat the make-up water and feedwater.
- Deaerator removes gases from the make-up water.
- The higher the make-up water temperature once it exits the economizer, the less steam is required in the deaerator.
- Less deaerating steam means less fuel required.

- Our team is proposing a design for a "Cooling Water Recovery System" that would use the compressor cooling water (32°C) from one of the compressors to supplement the mill water. This would result in a higher make-up water temperature.
- Primary benefits of this design:
  - **Reduction in boiler fuel costs**
  - **Reduction in water consumption (164 $m^3$ per day)**



### Piping System

- Discharged cooling water is transported to boiler room via the piping system pictured to the left.
- No pump required, as cooling water pressure (60 PSI) is enough to overcome head.
- Oil detection system required to prevent oil from entering boiler, which can cause failure. If oil is detected, water supply to boiler will shut off immediately.
- Pressure relief valve set to 80 PSI.
- Flow control valve to be installed on mill water line to meet make-up demand if cooling water is not sufficient.

**Annual Fuel Cost Savings:** $25,360 per year

**Estimated Cost of Project:** $40,000

**Payback Period:** 1.6 years

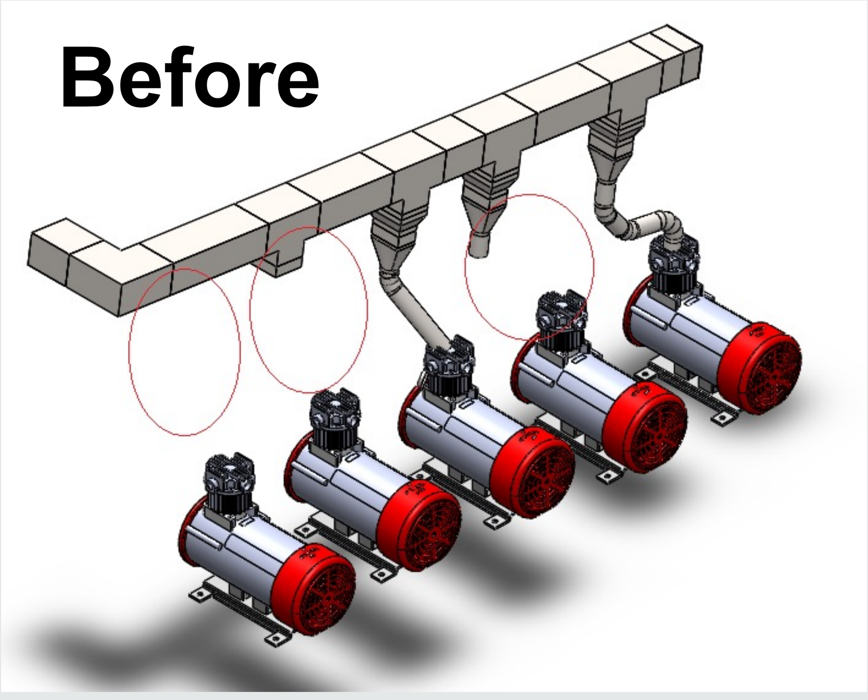
## COMPRESSOR AIR INTAKE OPTIMIZATION

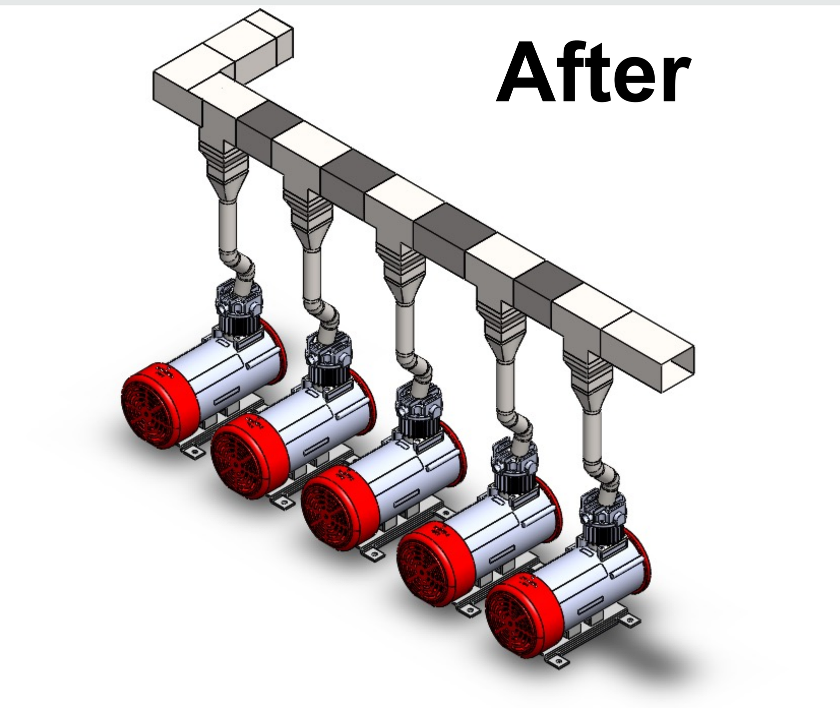
### Details of Design

- CKF utilizes an air system that contains 8, 150 HP air compressors that supply air at 90 psi to the entire plant. Of these air compressors, only 2 of them intake their air from outside, while the rest of the compressors intake their air from inside the plant.
- Air compressors will operate more efficiently when colder air is supplied at the intake.

### Design Requirements

- No restriction to the airflow entering the system.
- The air must stay clean and dry.
- Consideration of climatic conditions such as rain, snow, and humidity.
- Does not affect the plant operation in the event of failure.

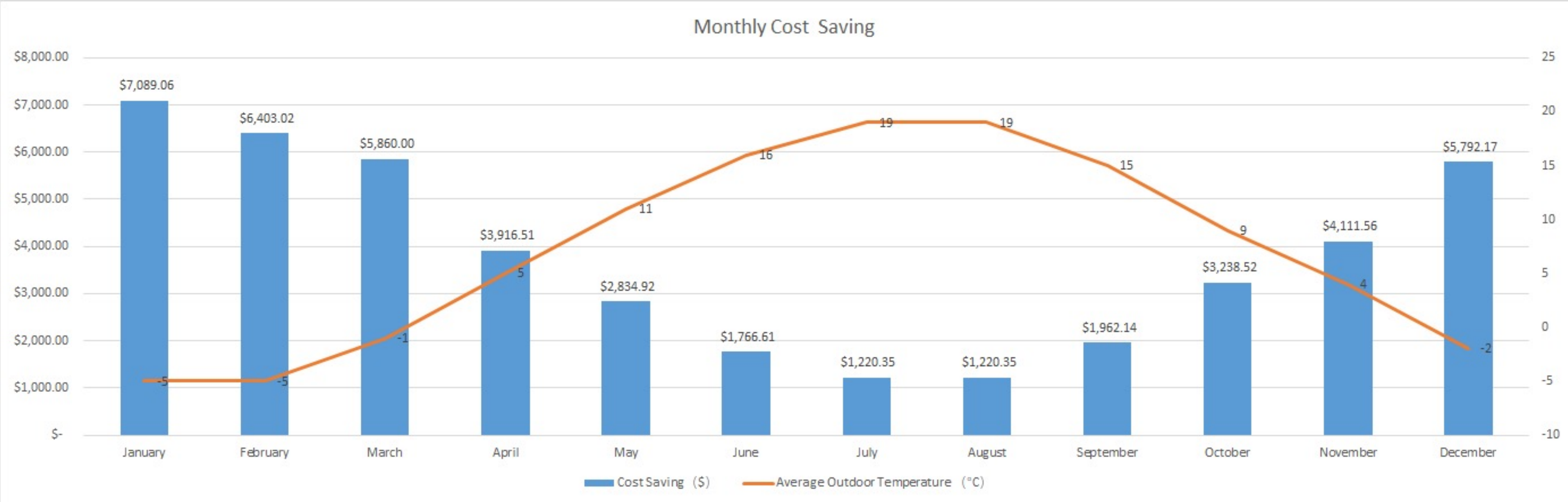



### Design Solution

- As seen in the *Before Figure*, some compressors are not connected to the cold air supply ductwork located above the compressors. To correct this anomaly as shown in the *After Figure*, a sheet metal shop was contacted to connect the unconnected compressor to the ductwork. Since colder air is denser, replacing the air intake supply from inside air to outside will increase the efficiency of the compressors. This will result in a reduced electrical cost to produce compressed air.

### Cost Analysis




**Compressor operation hours :** 8713 hrs./year

**Base Energy Rate:** $ 0.06/kWh

**Annual Electricity Cost Savings:** $45,415 per year

**Upgrade Cost:** $13,540

**Payback Period:** 0.34 years or ~4 months