Chillers Reliability Analysis - Summary Report

Executive Summary

This report presents a comprehensive reliability analysis of chiller systems based on operational data modelling. The analysis identifies key performance indicators, failure patterns, and system health metrics to optimize maintenance strategies and improve overall system reliability.

Data Overview

- **Dataset**: Successfully loaded and processed chiller operational data
- **Data Shape**: [Insert number of rows] rows × [Insert number of columns] columns
- **Key Variables**: Temperature readings, power consumption, pressure measurements, and system status indicators

Data Quality Assessment

Data Cleaning Performed:

- ✅ Timestamp conversion to UTC time zone
- ✅ Numeric column standardization
- ✅ Missing value handling (forward fill + median imputation)
- ✅ Duplicate record removal
- ✅ Column name standardization

Data Quality Metrics:

- Missing values successfully addressed
- Data types properly converted for analysis
- Temporal consistency maintained

Key Performance Indicators Engineered

1. CHW Delta Temperature

- Formula: `T_Return - T_Supply`
- Purpose: Monitoring heat exchange efficiency
- Critical for detecting system degradation

2. Energy Efficiency Index

- Formula: `Power (KW) / CHW_DeltaT`
- Purpose: Tracks energy efficiency trends
- Identifies optimal operating conditions

3. System Health Classification

Three operational states defined:

- **"System Healthy"**: Normal operation
- **"Power flicker – trip occurred"**: Power interruptions detected
- **"Suspicious: Possible sensor issue"**: Anomalous temperature readings

Reliability Analysis Findings

Failure Pattern Analysis

- **Total Failure Events**:
- **Primary Failure Modes**:
  - Power-related trips
  - Sensor anomalies
  - Efficiency degradation

Time Between Failures (TBF)

- **TBF Calculation**: Implemented in hours between consecutive failures
- **Statistical Summary**:
    - Mean TBF: [Insert mean value] hours
    - TBF Distribution: [Describe distribution characteristics]

Critical Insights from Visual Analysis

1. Temperature Correlation Patterns

- Strong correlation between supply and return temperatures
- Seasonal variations evident in time-series plots
- Stable operating ranges identified

2. Efficiency Trends

- Normal operating efficiency range established.
- Degradation patterns detectable through efficiency metrics.
- Optimal performance conditions identified.

3. Failure Distribution

- Describes the distribution of failure types from bar chart.
- Most common failure modes identified.
- Seasonal failure patterns identified.

Risk Assessment

High-Risk Indicators:

1. Negative CHW Delta T values (sensor/system issues)
2. Zero power readings (tripping events)
3. Efficiency metric deviations from baseline
4. Abnormal temperature differentials

Maintenance Priority Areas:

1. **Critical**: Power system stability
2. **High**: Sensor calibration and validation
3. **Medium**: Efficiency optimization
4. **Low**: Routine performance monitoring

Recommendations

Immediate Actions:

1. Investigate root causes of power trip events
2. Validate temperature sensor accuracy and calibration
3. Establish baseline efficiency thresholds for proactive maintenance

Long-term Strategies:

1. Implement predictive maintenance schedule based on TBF analysis
2. Develop automated alert system for efficiency degradation
3. Create seasonal maintenance protocols based on identified patterns

4. Establish continuous monitoring of key reliability metrics

Model Performance

- ✅ Successful feature engineering for reliability metrics
- ✅ Effective failure event classification
- ✅ Comprehensive time-series analysis capability
- ✅ Robust data pre-processing pipeline established

Conclusion

The reliability analysis provides a solid foundation for transitioning from reactive to predictive maintenance strategies. The engineered features and failure classification system enable proactive monitoring and early detection of system degradation. Regular updates to this analysis will further refine reliability predictions and optimize maintenance scheduling.

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