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CASE STUDY

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AN INNOVATIVE UPGRADE ON AMMONIA REFRIGERATING SYSTEM FOR ICE CREAM MAKING FACILITY

This is a case study on trouble shooting and operation of an ammonia refrigeration system, for an overseas ice cream making facility located in the Middle East Region. The production capacity of this facility was designed for 15 Metric Ton. Our team was called upon due to serious discrepancies observed in its refrigerating system, because of which original production capacity was not met, also the quality of ice cream was far below standard (too watery and soft).

To rectify the problem we formed a trouble shooting and operation team, and decided to walk thru the plant where we may come across problems that causes refrigerating plant operate inefficiently. We understood that walking around the plant ensures that an investment becomes a profit center. By utilizing time honed expertise and advance technology solutions we aim to create an efficient system, allowing this plan to maximize profitability through fully integrated operations . In walking between the control room , the main refrigerating equipment plant room and the chilling/ freezing rooms, lots of complications were noted between the pipe connections and its controls. Also the evaporator coils of the air cooling units and its fan surfaces including fin surfaces, drain pan etc had attracted contaminants & debris thus decreasing the system's refrigeration effect while increasing compressor discharge head pressures. Often without proper maintenance the adverse effects lead to increased energy usage. These are seen to signal heat gains from the environment which decreases the efficiency of this closed loop industrial refrigerating system. The anhydrous (dry) ammonia refrigerant gas was used in this plant because of its high environmental marks with ODP & GWP being zero and in the event of leaks it breaks down to its natural components of nitrogen & hydrogen in relatively short time.

This evaporative condenser cooled refrigerating plant operates thru natural (gravity) flooded feed. It's low rpm v-belt drive reciprocating (piston) compressor packages (3W + 1R) widely used in 2-stages (booster and high stages) accommodating 8:1 compression ratios, operated as the heart of this system.
The team's objective was: to try keep the ROI within less than a year while achieving minimum 25% in energy savings and increase the production capacity of the ice cream thru green design aiming to achieve improved efficiency plan through real-time energy monitoring.

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NOTED PREVAILING PROBLEMS :

As part of our sustainability action plan we took the primary step in preparing a Hazop report by investigating the existing plant on day to day basis whereupon following shortcomings were observed:

1-The cooling & freezer rooms failed to achieve desired room temperatures inspite of long running hours of booster and the high stage compressors.

2-All unit compressors including the swing unit had to continuously operate full load in order to achieve the required cooling capacity.

3-The compressor suction pressure and plant evaporating temperatures did not correlate whereby the former was observed to be much lower.

4-The air cooler units for chilling & freezing rooms operated inefficiently and would often have frosted coils with lots of oil accumulation, hence prevented proper heat transfer .

5-Although the freezer room temperatures was designed to be maintained at -28C , however the best temp achieved would be -14C.

6- The level control system was bypassed and operators would throttle valves manually.

7-The full plant including defrosting of coils were manually operated.

8- With entrapped airborne contaminants near the air cooling units , accuracy of measuring devices were non-existent.

9- The air cooling unit of freezer rooms were often observed starved for liquid supply.

10-The plant operators were kept heavily occupied by operating various valves, checking different temperatures & liquid level.

11-The freezer and chiller rooms were widely located around the plant, and many a time the operator would be trapped in the control or other rooms, thus preventing him to freely communicate with his colleagues.

12-Due to leakages thru flanged joints and some welded connections, strong ammonia odor was felt in the main plant room.

Above discrepancies and lack of availability on skilled technicians at jobsite, led to high system temperatures and energy consumption and reduction in the ice cream production.

NOTE: Due to minimum allocation in the budget set by the owner, energy efficient updated devices such as the VFDs , PLC & SCADA Panels could not be furnished.

ENERGY EFFICIENT CORRECTION MEASURES:

To offer an easy-to-operate trouble free updated plant, we decided to correct the above by submitting the following automatic system with the intent that operation of the plant be handled by owner’s certified professional operator.

1-Calibrated, repaired and re-connected compressor safety cut outs and its integrated controls.

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2-For each compressor installed an automatic monitoring display panel.
3-Installed fully automatic air purger for connection on condenser & liquid receiver circuits.
4-Installed an ASME-approved dual safety (relief) valves on all pressure vessels.
5-Installed & connected automatic hot gas defrosting circuit by taking vapor from top of liquid receiver (where the heat available is the latent heat), complete with suitable valves, measuring devices, controls and a timer for each freezer air cooler circuit.
6-Furnished and installed a stop check valve on the main discharge line , in order to reduce motor starting torque when compressor is unloaded for starting.
7-Installed sub-panels outside each room which displayed digital controls & devices.
8- Serviced the automatic level control system and put it back to use.
9-Installed reflex type level gage (in place of glass tube one).
10-Installed central ammonia leak detection system with sensors and controllers at suitable locations in the refrigerating plant room and the hallway.
11- As far as possible replaced the flanged joints with 40 bar welded in-line back-seating valves.
12-A built-in battery back-up alarm system for the chilling & freezing room doors were provided to prevent any trapped person.

While successfully implementing above repairs within approx. 15 days, we managed to provide Low Life Cycle Analysis (LLCA) with a system emitting low carbon where the refrigerating system gets greener and the energy savings added to the bottom line footprints.

NOVEL SOLUTIONS :
The above solutions were implemented thru valuable assistance of a plant technician, operator and a welder without any down time on plant operation, performed within prevailing industry standards and achieving the following win-win results :
1-The compressor discharge pressure was reduced significantly from 220 Psi to 160 Psi.
2- Automatic compressor operation removed operator interference and resulted in automatic & smooth loading/unloading of each compressor thus reducing energy consumption.
3-The automatic ammonia leak detection system increased plant safety, meeting OSHA's PSM (Process Safety Management) requirements.
4- Replaced the manual defrost system with an automatic hot gas defrosting system designed on a pre-set defrosting period.
5- During defrost period the temperature increase in the freezer rooms decreased from 10C to plus/minus 2C .
6- Successfully maintained the freezer room temp at -28C.
7- Number of operating compressors were reduced and the swing compressor operated only when called upon. Also compressor running hours were substantially reduced .

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8- The automatic level control ensured that the chiller/freezer room operated flooded, thus preventing liquid surge to the compressor.
9- Oil accumulation & frosting of air cooling unit coils were eliminated.
10- With installation of welded valves & joints the leakage and plant room ammonia odor were eliminated.
11- Extended durability and flexibility throughout the main refrigeration equipment and system.

LOOKING AHEAD:
Thus overall durability on main equipment and plant performance were improved by;

1- Reduction in plant operating period hence reduction in depreciation and energy consumption, providing throughout safety and visual communication management.
2- Achieving relevant room temperatures as per original design requirements.
3- Operating at optimum suction & discharge pressures.
4- The automation of the compressors, defrost system, liquid level control and plant monitoring system gave us a peace of mind and allowed operators address other maintenance issues.

After observing a trouble-free automatic operation on the refrigerating plant for a period of 3 months, it was estimated to achieve approx.20 to 25% energy savings anticipating a payback period of less than 6 months. Additionally the implementation of above works highly improved the ice cream quality and brought its original production capacity to 15 Metric Ton, thus creating substantial profit for the owner.

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