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Development of Control Algorithm for Refrigerated Type Compressed Air Dryer Using Digital Scroll Compressor

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Abstract- **In this paper the refrigeration type compressed air dryer mostly used for drying compressed air in industries. All compressed air systems must be evaluated individually to develop a specification for compressed air treatment. The majority of compressed air users specify a 3°C dew point for plant air. This dew point provides dry compressed air at a very low energy cost. The digital scroll compress maintains the constant dew point at varying load condition compared to other refrigerant compressor. In this paper development of control algorithm and maintain the constant dew point temperature at varying load condition using digital scroll compressor .so in refrigeration system the refrigerator compressor replace the digital scroll compressor. This control algorithm will be loaded on PLC. Then PLC will be interfaced with refrigeration system and maintained the dew point at 3°C at varying load conditions**

Index term- **Refrigerator dryer, digital scroll compressor, dryer controller, dew point.**

I. INTRODUCTION

Compressed air is a fundamental source of energy for the majority of industrial production processes. However air from a compressor is often too contaminated, too hot and, moreover too humid to be used as an efficient energy source without prior treatment. Compressed air is the most powerful and useful, portable, easy to use economical source of energy. In manufacturing processes, almost at all stages the compressed air is required and 30% of electrical energy is used for conversion of pneumatic energy the compressed air. Air contaminates like solid, liquid, oil, which contaminates the compressed air. This untreated wet compressed air enters into the equipment causing failures and affects the production process. Thus, compressed air is to be treated to make it dry air, free from contaminants. The refrigerated air dryer is specifically designed and manufactured for drying and purifying compressed air generated by an air compressor. Refrigerated compressed air dryers have been used for many years as a cost effective and energy efficient solution for eliminating moisture from compressed air system. These 39°F (3°C) pressure dew point machines are well established and industry proven. The evaporator, compressor, expansion valve, and the condenser are the four main devices forming the refrigeration system; in refrigeration systems two section is there one is pneumatic section and refrigeration section.

In pneumatic section the moist compressed air (dirt, oil and water vapor) enters into the Air/Air Heat Exchanger where it is pre-cooled by the outgoing air and thereby conserving energy. The compressed air next passes through the evaporator. It is cooled up to +3°C by the Refrigerant. At this sub-cooled temperature, the moisture present in the air is condensed and removed by the Demister. The cool saturated air passes through the Air to Air Heat Exchanger where it pre-cools incoming air and it gets heated up. Thus this system provides clean dry air at the Outlet. Efficient Filter and Automatic Drain Valve carry out the removal of moisture at Demister. The Heat Exchangers are designed in such a way that they are self-cleaning to maintain the constant heat transfer rate.

In refrigeration section (Freon), The Evaporator removes heat from compressed air by means of cold and low pressure Freon. The heat removed from the system is dissipated to the atmosphere/water by the condenser. The high pressure refrigerant flows into the expansion valves where it changes into liquid phase at low pressure. The boiling of liquid refrigerant takes place in Evaporator and cold air leaves from the Evaporator. The low pressure, low temperature refrigerant passes into the compressor and the cycle repeats. The Refrigeration Dryer senses the Refrigerant suction pressure and accordingly varies the flow of Hot Gas Bypass inside the system and maintains constant Dew point at various heat loads.

The main aim of this project is development of control algorithm and maintain the constant dew point temperature at varying load condition using digital scroll compressor .so in refrigeration system the refrigerator compressor replace the digital scroll compressor. A digital compressor provides variable-capacity modulation by operating in two states, a loaded and unloaded state. it maintain constant dew point at varying load condition for adjusting loading and unloading conditions.

II.COMPRESSED AIR DRYER

How moisture is removed from the compressed air is given below,

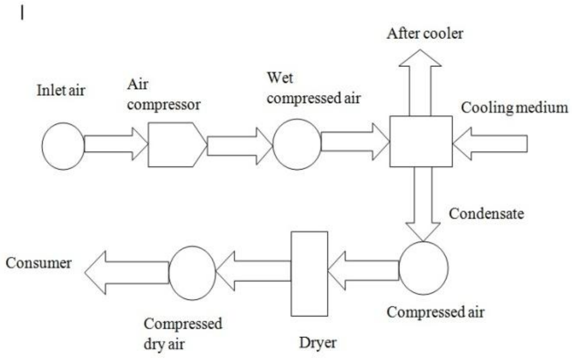

Fig.1 Compressed air dryer

Compressed air is the most powerful and useful, portable, easy to use economical source of energy. In manufacturing processes, almost at all stages the compressed air is required and 30% of electrical energy is used for conversion of pneumatic energy the compressed air. Air contaminates like solid, liquid, oil, which contaminates the compressed air. This untreated wet compressed air enters into the equipment causing failures and affects the production process. Thus, compressed air is to be treated to make it dry air, free from contaminants.

III.REFRIGERATED AIR DRYER

The piping and instrumentation diagram of the refrigerated air is given below,

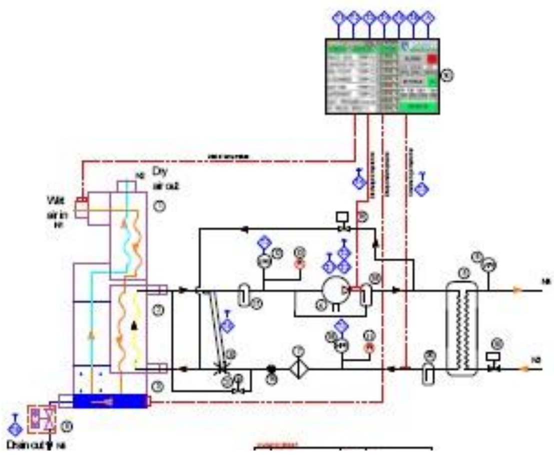

Fig.2 Piping and instrumentation diagram of Refrigeration dryer

Fig.2 Refrigeration dryer is functioning on basic refrigeration principle. As the incoming compressed air gets cooled to +2°C, it looses it ability to hold moisture. There by compressed air is dried out of moisture. Air from compressor is admitted to pre-cooler (1) (air to air heat exchanger) where it is pre-cooled to 31°C by outgoing dried and cold air. This pre-cooled air is then admitted to Evaporator (2) (air to refrigerant heat exchanger) where it is further cooled down to 2°C. It would be noteworthy that the outgoing 2°C air is deployed to cool the incoming 45°C air to 31°C. Thus refrigeration load is minimized in evaporator hence less power.

Refrigerant compressor (4) compresses refrigerant gas from 3.47 bar (g) to 16.55 bar (g). Due to this the temperature of the refrigerant gas increased from 10°C to 95°C. This high pressure, high temperature refrigerant gas is passed through water cooled condenser (6) where the refrigerant changes its phase from gas to liquid and its temperature is reduced to 45°C, pressure to 16.27 bar(g). This high pressure liquid refrigerant is further passed through filter dryer (8) where moisture, acids and solid particles is filtered out. This filtered liquid refrigerant is admitted to Expansion valve (9). Here its pressure is reduced from 16.27 bar (g) to 4.0778 bar (g) and hence the temperature to 0°C. This low temperature and low pressure liquid refrigerant is admitted to evaporator where the heat transfer from air to refrigerant takes place and air is cooled down to +2°C there by dried out of moisture. Here the refrigerant changes its phase from liquid to gas. This is the gas which was sent to compressor as in starting of this paragraph.

The above narrated operation of refrigeration air dryer is controlled regulated through the following instruments.

3.1 Pressure switch, Low Suction Pressure (14)

If there is any leakage in refrigerant pipe line, Suction Pressure of the refrigerant compressor goes below the set value (40 psi). Then this switch will trip the refrigerant compressor and an alarm will be activated.

3.2 Pressure switch, High Discharge Pressure (18)

This will trip the compressor if the discharge pressure of refrigerant compressor goes more than set value (350 psi) & an alarm will be activated. Following could be the reason for high discharge pressure

1. High inlet air temperature
2. High inlet flow rate
3. High inlet water temperature

3.3 Pressure switch, Low water Pressure(7)

If the water pressure goes down less than set value (0.5kgf/cm2), this will trip the refrigerant compressor & an alarm will be activated.

3.4 Refrigerant compressor over load protector (OLP)

refrigeration dryer is provided with refrigerant compressor with inbuilt OLP. This will trip the compressor if it is overloaded.

3.5 Capacity regulator (17)

This allows some portion of hot gas to be fed into evaporator when the load to the dryer is less than the rated load by sensing the suction gas pressure.

3.6 Pressure switch, Oil Pressure (5)

If oil pressure fails to build-up within the pre-set time period, the refrigerant compressor will trip and an alarm will be activated.

IV. PROPOSED DIGITAL SCROLL COMPRESSOR

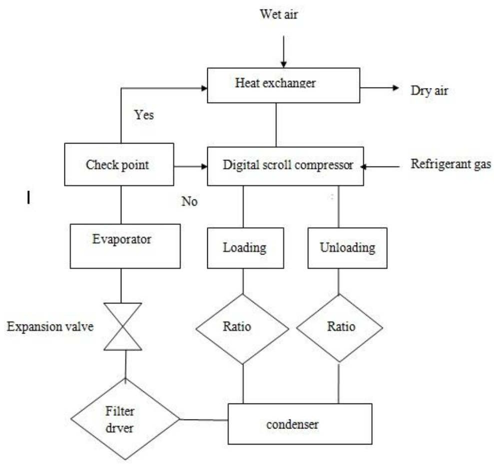

Fig.3 algorithm flow chart.

The dryer is operating at its full rated load, the power consumed by the dryer reflects the maximum value. As the load is reduced and the refrigeration compressor remains loaded, the refrigerant suction pressure and temperature begin to drop. This results in a lower air temperature exiting the evaporator. The temperature probe senses this and sends a signal to the solid-state control board. The control algorithm calculates the optimum amount of cooling and adjusts the loading and unloading of the compressor. The unloading is achieved by energizing the pilot solenoid valve on the compressor. If the suction pressure and exiting air temperature begin to rise, the controller determines the appropriate amount of compressor loading needed to maintain the desired air temperature. Testing has shown that the system is capable of maintaining the existing air temperature 3°C of the set point. This has been measured from a rated full load down to a no load condition. The use of hot gas bypass valve is completely eliminated by using digital scroll compressor.

V. RESULTS AND DISCUSSION

The dryer controller is fed with one analogue input(condensing temperatuer) and four input output (low suction pressure ,high discharge pressure and low water pressure, compresssor overload) whenever abnormal condition occurs as atated above an alarm will be activated and compressor will be tripped off.besides the above fuction this is built with timer for drain valve operation. On time and off time of drain valve can be changed with controller. Three additional digital indicators having analogue inputs from inlet,outlet and suction gas temperature and the same will be displayed .whenever the set points are exceeded indications will be activated for inlet and outlet temperature. Compressor load shall be controlled based on the cooling load to dryer by sensing suction gas temperature and operating a solenoid based on the temperature limits .this will reduce compressor power consumption. A separate dew point sensor with display is provided to monitor the outlet air quality and an alarm is activated upon exceeding limits of set values.

5.1 EXPERIMANTAL RESULTS

The experimental results of the refrigerated compressed air dryer is given below.

Fig.4 Dryer on

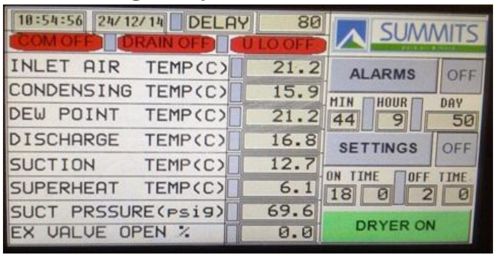

Fig.5 Delay start counting

Fig.6 Compressor on

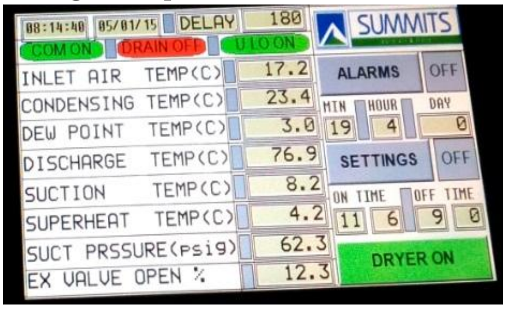

Fig.7 Constant dew point

VI.CONCLUSION

All compressed air systems must be evaluated individually to develop a specification for compressed air treatment. The majority of compressed air users specify a 3°C dew point for plant air. This dew point provides dry compressed air at a very low energy cost. We observe that the digital scroll compress maintains the constant dew point at varying load condition compared to other refrigerant compressor. in additionally digital scroll refrigerated dryer offers an innovative opportunity to efficiently and accurately provide non-cycling type dryer performance with true load matching energy savings.

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