Modular Protection System For Ammonia Refrigeration System

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Abstract *- In this paper we are designing a modular monitoring and protection system for ammonia refrigeration system. The race for finding safer and efficient engineering system is always on in modern digital world but some time we have to mitigate the hazards for reaping the benefits of efficient and cost effective system. Ammonia refrigeration system are employed across the industries for wide range of applications like thermal storage systems, HVAC chillers, process cooling, air conditioning, winter sports, district cooling systems, heat pump systems, supermarkets, convenience stores and increasing output efficiencies for power generation facilities etc. Our main aim is to operate these systems in more safer and effective way by using faster monitoring and protection modular system, Which will be flexible to implement on single stage or multistage system as per end user requirement .We developed a prototype with the help of ATMEGA processor and ESP8266.Along with Ammonia gas sensor MQ137 we monitor and control all NH3 refrigeration parameter and trigger ESD in case of emergency.*

Keywords—*ESD-Emergencyshutdown,PHE-plateheatexchanger,microcontroller,sensors,modular protection system-MPS*

I. INTRODUCTION

Ammonia, NH3, is a chemical compound composed of one nitrogen atom and three hydrogen atoms. Ammonia is a colourless gas that is lighter than air, and can easily liquefy. Refrigeration is the process of cooling a space, substance, or system to lower and/or maintain its temperature below the ambient temperature (while the absorbed heat will be dissipated at higher temperature). Ammonia refrigeration is one of the older types of refrigeration that is still used today. While the average person doesn't realize it, just about all food and drinks that are purchased have been kept chilled using ammonia refrigeration at performing routine tasks. The ammonia gas is compressed which causes it to heat up as it is pressurized.[1] Ammonia refrigeration system which is well utilized for wide range of application led to the need for a safe engineered systems is on top priority. Please refer the fig2 for ammonia accidents

Case study of British Columbia.

II. PROPOSED SYSTEM

The key trigger for the accidents is pressure leading to mechanical failure. The purpose of our system is to have a fool proof multilayer protection in all stages with adaptability and scalability for variety of ammonia refrigeration systems. In our system two microcontroller model one for the parameters monitoring, alarm, startup, shut down, ESD triggering, alert emergency response team and dedicated second controller specific for ammonia leak detection. We considered ATMEGA2560 as Arduino started launching industrial controllers and secondary controller we considered ESP8266 with which we can expand and connect multiple ESP8266 through wireless mesh network for monitoring Ammonia PPM at various points.[3]

Once powered up MPS checks initial parameters and once satisfied MPS will enter ready to start condition. Start command is given by the operator and MPS handles the system startup and enter high speed loop to monitor all parameters. The high speed loop can be interrupted by the ESP8266 in case of ammonia leak and alert emergency response team. MPS is powered by redundant dual power supply (backup battery) for high reliability.

All the sequence starts with initial check by reading a set of parameters which are looped every 60 seconds continuously to ensure the system is in safe condition to start any time. In initial check, liquid Separator level is checked ensure enough vapour and to avoid liquid ammonia entering compressors, and secondary refrigeration temperature is checked; Once the MPS is satisfied it will give clearance for startup.

Operator can give start command only if the MPS clears the initial check parameters or alarm is triggered based on condition. When the operator provides start command the MPS handle proper sequential startup ensuring smooth startup and enters high speed monitoring loop monitoring motor voltage, current, temperature and vibration are monitored for motor. Coming to compressor High pressure, low pressure, differential pressure are monitored and vibration level of compressors is also monitored [2] to predict problems and plan for proactive maintenance avoiding incidents.

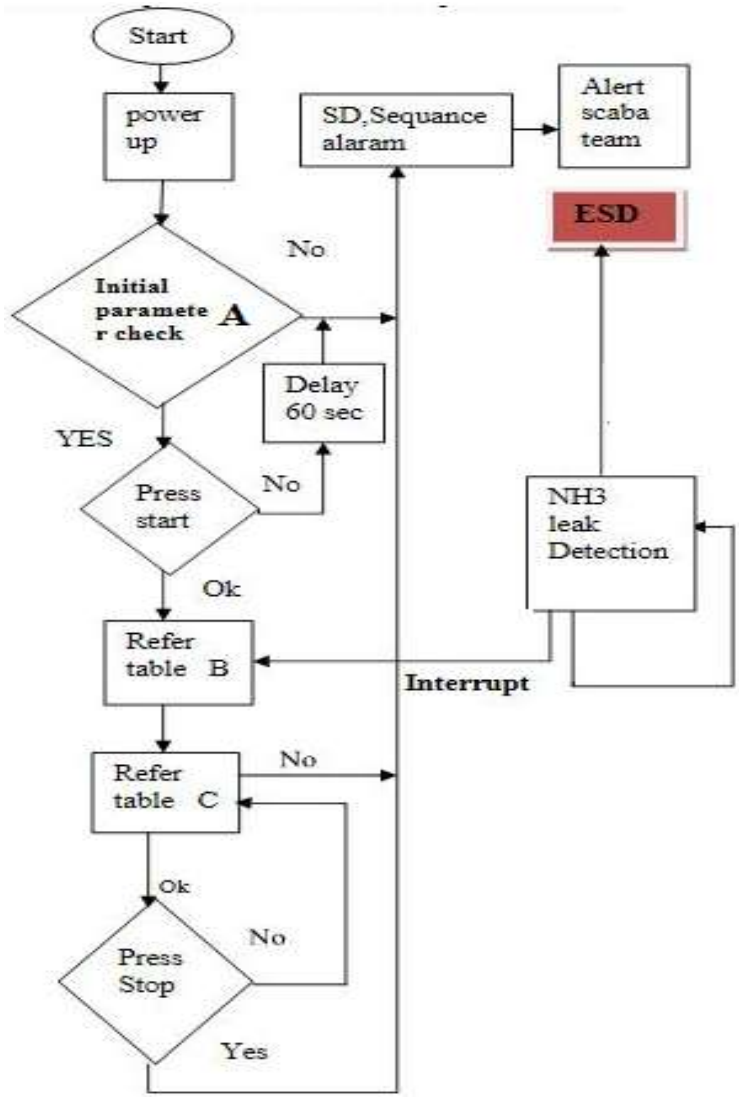

Fig -1 MPS Flow Chart

Evapco water delta temperature is monitored to ensure proper condensation and trip the system if the temp range slips from set range. Collector pressure is under check for safe operation. In case of any deviation from set points the MPS triggers a safe shut down procedure and cannot be restarted until condition is cleared if the plant enters any unsafe condition MPS passes a message to medics and emergency response scba team.[7]

Plant ammonia leaks will be monitored by dedicated microcontrollers at different point for safe operation .Incase of leak master ESP8266 will trigger the main microcontroller interrupt break the 'B' loop to initiate emergency shutdown sequence.

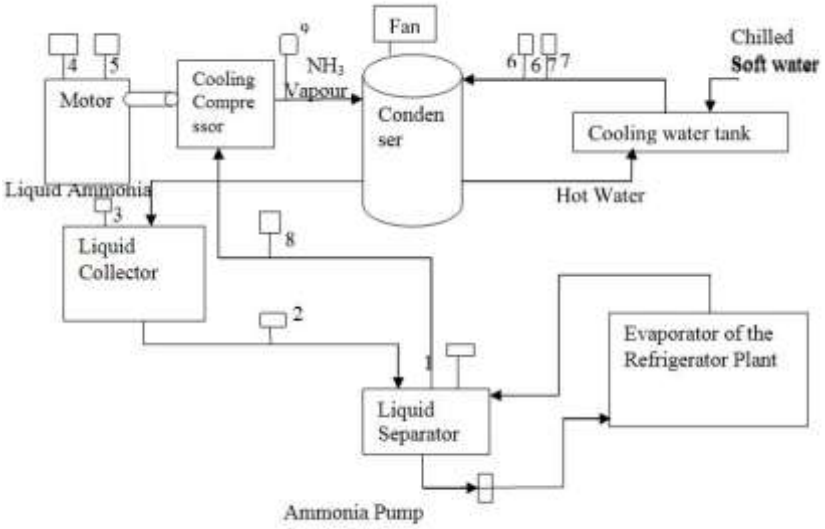

Fig3: Block diagram of Ammonia Refrigeration process.with

In the fig (3) 1.Level monitor, 2. Expansion valve, 3. HP monitor, 4. Temperature Monitor, 5.Vibration monitor, 6. Evapco Temperature7.flow switch8.LP switch9.HP switch

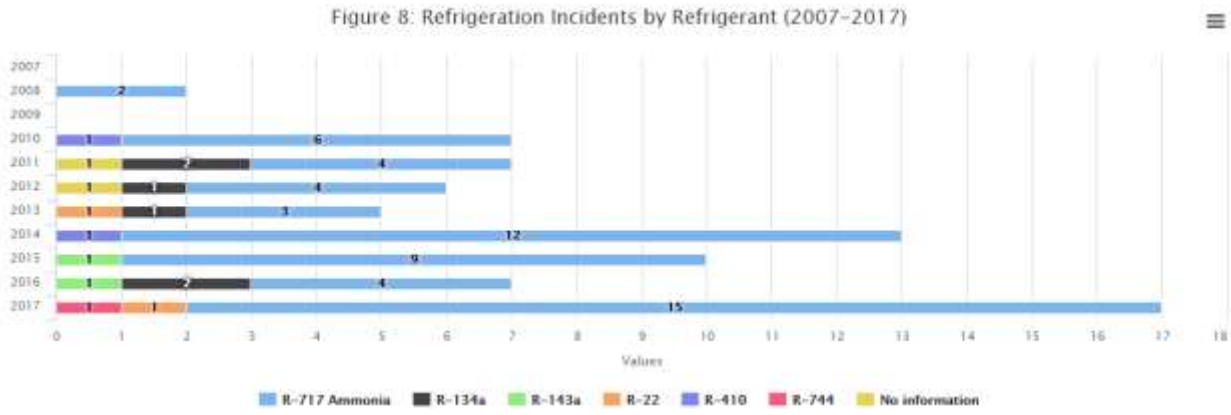

Fig -2 Case study in British Columbia

S.No	Initial Check Represents
1	Compressor hp
2	Compressor lp
3	Motor temp
4	Evapco/condenser water reservoir temp check
5	Collector Pressure check
6	Liquid Separator level check
7	Expansion valve check
8	Secondary Refrigeration temperature check

Table1:Intial check Parameters

S.No	B Refers to
1	Valves open
2	Evapco water pump start
3	Evapco fan start
4	Expansion valve set
5	Expansion valve set

Table2:Parameters Refers to B

S.No	C Refers to
1	Motor Voltage Check
2	Motor Current Check
3	Motor Temperature Check
4	Motor Vibration Check
5	Compressor Vibration Check
6	Compressor High Pressure check
7	Compressor Low Pressure Check
8	Evapco/ Condenser water flow switch check
9	Evapco/ Condenser water Δ Temperature check
10	NH_3 collector check
11	Liquid separator level pressure check
12	Expansion valve control check
13	PHE NH_3 Δ Temperature check

Table 3: Parameters Refers to B

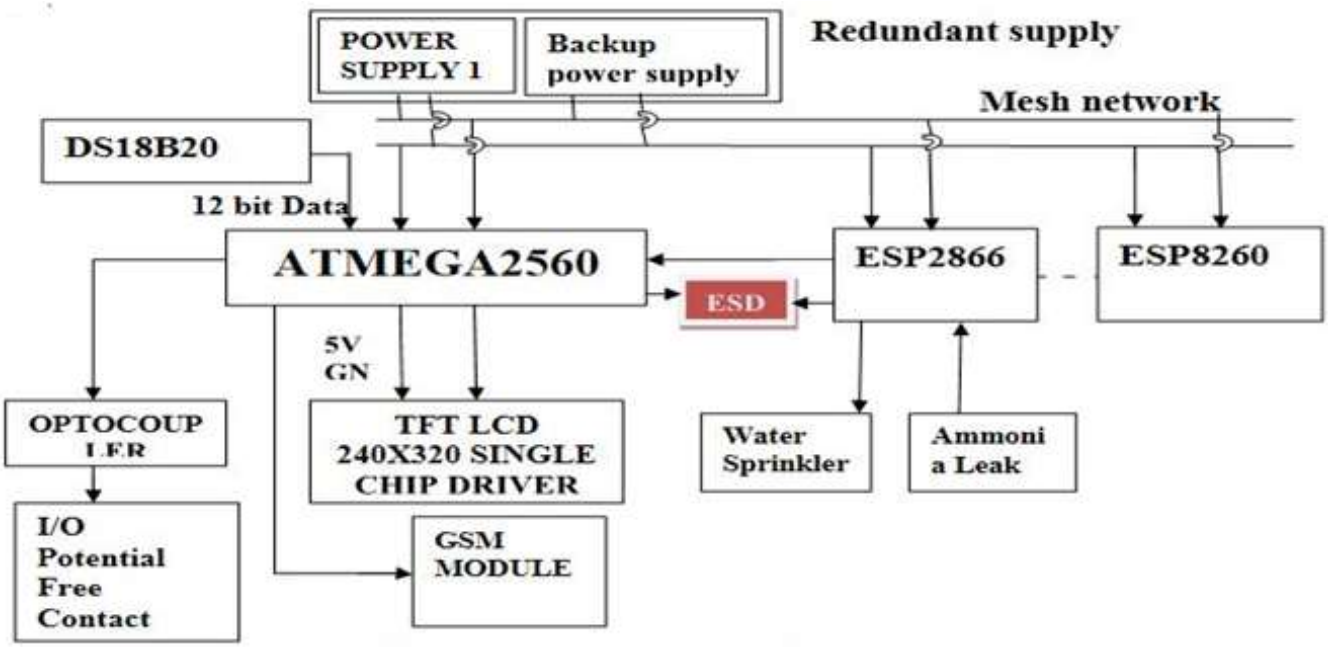

Fig4:Architecture of NH_3 Refrigeration Modular protection system

III. SENSORS For Control

A. MQ-137 Gas sensor:

MQ-137 Gas sensor can detect or measure gases like ammonia (NH3) and carbon mono- oxide (CO). You can either use the digital pin or the analogue pin to accomplish this. Simply power the module with 5v and you should notice the power LED on module to glow and when no gas it detected the output LED will remain turned OFF meaning the digital output pin will be 0v Remember that these sensors have to be kept on for pre-heating time before you can actually work with it. Now introduce the sensor to the gas you want to detect and you should see the output LED to go high along with the digital pin, if not use the potentiometer until the output gets high. Now every time your sensor gets introduce to this gas at this particular concentration the digital pin will go high.[5]

B. DS18B20 Temperature Sensor:

The core functionality of the DS18B20 is its direct-to-digital temperature sensor.

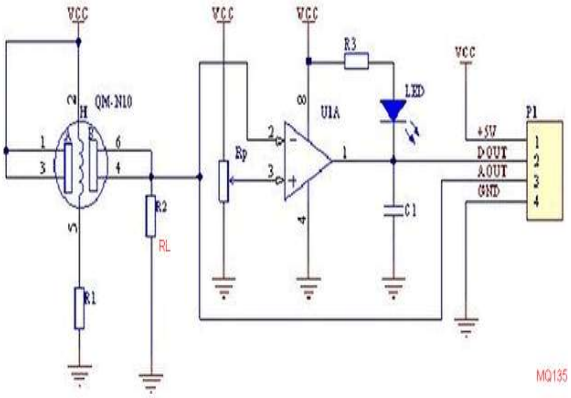

Fig:5 Schematic diagram of gas sesnsor

The resolution of the temperature sensor is user –configurable to 9, 10, 11(or) 12 bits, corresponding to increments of 0.5 c, 0.25 c, 0.125 c, and 0.625 c, respectively.

The default resolution at power –up is 12-bit the DS18B20 Powers up in a low power idle state. To initiate a temperature measurement and A-to-D conversion, the master must issue a Convert T (44h) command.

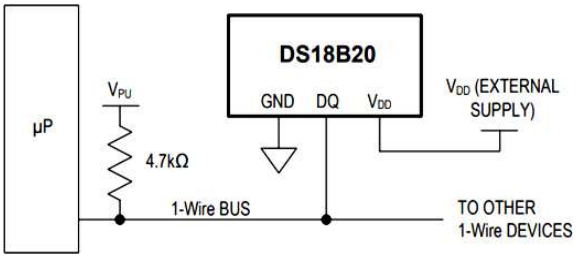

Fig 6: Schematic diagram of DS18B20 temperature sensor

Fig 7:Motor Temperature sensor

C. SW-420 Vibrating sensor:

The vibrating module based on the vibration sensor SW-420 and comparator LM393 to detect if there is any vibration that beyond the threshold.

The threshold can be adjusted by the on-board potentiometer.

When there is no vibration. This module output logic LOW the signal indicates LED light and vice versa.

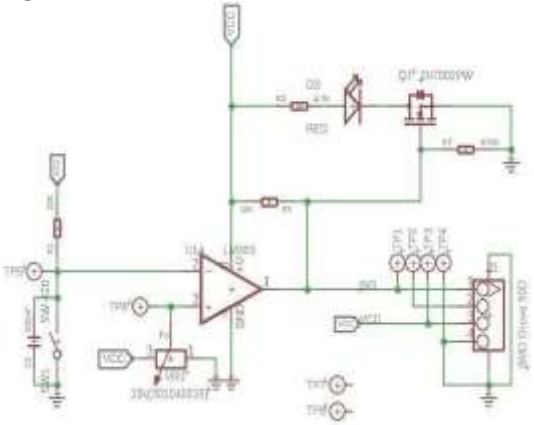

Fig8:Schematic diagram of SW-420 vibrating sensor

Fig9:Motor Vibration Sensor

***D. ATMEGA 2560*:**

Fig 10:ATMEGA 2560 in Modular Protection System

- In the MPS ,it is the main controller Low power consumption with fast start-up
- Easier to use, with 8-bit microcontroller being less complex than 32/64 bit versions[6]
- QTouch Suite allows for ease of exploring, developing and debugging own touch applications

Patented Adjace

- . less complex than 32/64 bit versions

Hence we have chosen this atmega2560 as a main controller in MPS.

IV. RESULTS AND DISCUSSION

A. WORKING:

a) Ammonia refrigeration in normal condition:

- The refrigerant enters the compressor as a low pressure gas and is compressed into high pressure gas, heating the refrigerant.
- The heated high pressure refrigerant gas enters the condenser, removing heat and condensing the refrigerant to a high pressure liquid.
- Rapid expansion of the liquid refrigerant through the expansion valve rapidly cools the refrigerant resulting in alow-pressure liquid/gas mixture.[4]
- Heat from the ambient air is absorbed by the cooled refrigerant, resulting in a low pressure gas cooling the refrigerated space. The cycle repeats.

This chilled ammonia is send to PHE. Here the liquid ammonia is converted into low pressure liquid as it and this is send to liquid separator.

b) Ammonia refrigeration in abnormal condition:

- Any abnormal conditions like vibration due to poor maintenance or failure of bearing will be predicted by vibration sensor for planning proactive maintenance.
- Pressure and temperatures develop due to abnormal operation of plant when load , water temperatures, pressure, due malfunction of systems components will be monitored by the system and will trigger a safe shutdown and alert the operator by alarm.

V. CONCLUSION &FUTURE SCOPE

The proposed system architecture will ensures the safe operation and save most valuable human lives by avoiding catastrophic accidents, saving assets and reputation and environment. The system has minimum sophistication ensuring adaptability, scalability and reliability. We can expand ammonia sensor microcontrollers (ESP8266) using mesh network

Fig11:Emergency Shutdown Condition In MPS due to Ammonia Leak in Ammonia Refrigeration System

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