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Design and Analysis of Dehumidifier to Improve Air Quality

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ABSTRACT- Compressed air is used for obtaining brake application in which brake pipe and feed pipe run throughout the length of the coach. Brake pipe and feed pipe on consecutive coaches in the train are coupled to one another by means of respective hose couplings to form a continuous air passage from the locomotive to the rear end of the train. Compressed air is supplied to brake pipe and feed pipe from locomotive also the magnitude of braking force increases in steps with the corresponding reduction in brake pipe pressure. So due to brake binding and brake failures due to pressure drop and high moisture rate so there was need of dehumidifier because of less moisturized air. When passed to braking system it will help the braking system and there will be less brake binding and pressure failure in braking system so with the help of dehumidifier, we can reduce moisture content and pass dry air to the braking system and increase good braking effect and decrease maintenance. As per the result of dehumidifier we have decreased moisture content up to 81.08% and decreased maintenance life by 120 days also this dehumidifier is less small in size than the prior one. From obtained moisture content of 37%, we have decreased it to 7%. Also, it is more efficient to replace silica gel easily in this dehumidifier.

KEYWORDS- Dehumidifier, Analysis, Railway locomotive, Engineering and Technology.

I. INTRODUCTION

Basic principle of rail braking system is same as road vehicle usage but operational features are complex because of the need to control multiple linked carriages. In initial days of railways trains used to stop slowly but the application of manually applied brakes in locomotive by train brake shoes but they have given clearly unsatisfactory and slow as well as unreliable response many times. After that major advance was the adoption of a vacuum braking system in which flexible pipes were connected between all the coaches of train and brakes of which would be able to control from locomotive fitted with ejectors venture devices that create vacuum without moving parts. But vacuum brake was less effective at high altitude because it depends on pressure difference and as we know atmospheric pressure is lower at high altitudes hence air brake system was introduced in the railways.

Compressed air is used for obtaining brake application in which brake pipe and feed pipe moves throughout the all coaches which is shown in figure 1 as follows. Brake pipe and feed pipe on in the train are coupled to one another by means of respective hose couplings to form a continuous air flow from the locomotive to the rear end of the train. Compressed air is supplied to brake pipe and feed pipe from locomotive also the magnitude of braking force increases in steps with the corresponding reduction in brake pipe pressure. Single brake pipe system in this there is only one pipe called brake pipe passes from loco to the brake van in order to get continuity of air for the application and release of brakes, which is currently used in goods stock which has releasing time from 45 to 60 seconds (except bcn hl wagons)[1].

A desiccant dehumidifier operates using the adsorption properties of a rotating desiccant wheel or by pressure of air compressor, a bit like a sponge literally soaking up moisture directly from the air. Air is drawn into the dehumidifier and passes through a desiccant wheel. The desiccant absorbs moisture and the dries air is returned to the system. In order to allow the desiccant wheel to without a fix limit absorb moisture, after that the wheel passes through a regeneration area, where it is heated by a secondary hot airstream. A heater frequently heats this secondary airstream to around 120°c before passing it through the wheel. The hot air absorbs the moisture from the desiccant and is then ventilated externally [2] [3].

So, a desiccant dehumidifier has two airstreams first process airstream and a regeneration airstream which passes through the exhausts of moisture collected from the process airstream. As the freshly regenerated section of the wheel is hot, it carries some residual heat when it rotates back into the process airstream. Therefore, as well as drying the process airstream, the desiccant wheel also provides some heat [4].

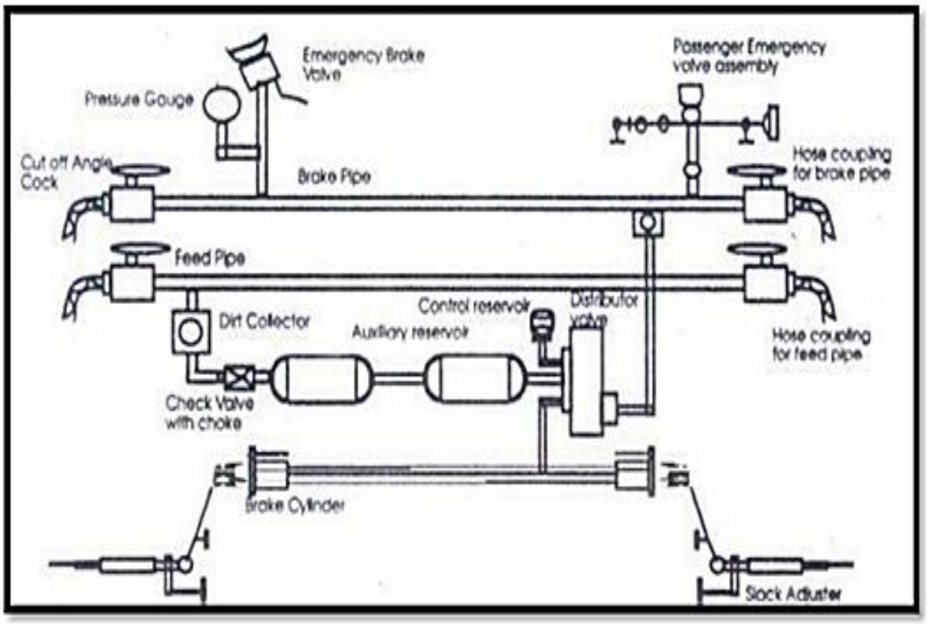

Figure 1: Air brake system of fright stock

The aim of this paper is to optimize the analysis of dehumidifier using distillation method and evaporative system. The specific objectives of this research are:

- Dehumidifiers remove moisture from the air.
- The moisture in the air is quantified as a percentage of relative humidity. This is expressed as a percentage of the total air volume.
- The best humidity range for a living space is between 45% and 65%. If the relative humidity is more than 65%, a desiccant dehumidifier can be used.
- This implies that the dehumidifier or an air dryer tries to generate a clean atmosphere in your workplace, warehouse, or storage.
- Dehumidifier reduces energy expenditures since it improves the effectiveness of your air quality for braking system.

Dry air is the most important thing in air brake system otherwise it may create failure or choke up in air brake system also the dry air improves the braking quality in air brake system.

II. RESEARCH GAP AND PROCESS

A. Research Gap

- Need of dehumidification system in locomotive to improve the quality of air in air brake system and reduce the moisture content from the air brake system because of which we can reduce failure of air brake also able to decrease the maintenance of air brake system by installation of dehumidifier.
- Because moisture can enter the brake system through seals, connection points, calipers, the master cylinder reservoir, and through microscopic pores in the hoses.
- Also, the cycle time of current dehumidifier is less due to which there is frequent maintenance cycle.
- Also, there is need for the changes on design because the design should be as per the locomotive small simple and effective.
- Also, the current absorption rate of moisture is less which is similar to air dryer so foe dehumidifier moisture absorption rate should be higher so that it could provide less moisturized air to the system.
- Due to quality dry air, there are chances of less failure of locomotive and decrease maintenance time.

B. Problem Definition

Dry air is the most important thing in air brake system otherwise it may create failure or choke up in air brake system also the dry air improves the braking quality in air brake system.

C. Objectives

- To design and analysis of dehumidification system for air braking system
- To understand the effect of the dehumidifier system considering the effect of Silica gel with different types of weather conditions (Dry, humid and cold).
- To compare the effect of dehumidifier system for the improvement of air quality passing towards MR-1 tank from air compressor.

D. Flow Diagram of Dehumidified Air Brake System

Figure 2: Flow Diagram

The above figure 2 shows the methodology followed to apply brakes with the help of air dryer. Firstly, the compressor which produces air and after that produced air passes through dehumidifier and goes to mr-1 reservoir in that reservoir dry air is stored. After that dry air is supplied to braking cylinder and then to the braking shoe and then to braking system and then brakes are applied.

III. DESIGN AND CONSIDERATIONS FOR ANALYSIS OF DEHUMIDIFIER

A. Measurement Selection

A part called "dehumidifier" is used in railway braking system is shown in figure 3. The shape of the dehumidifier is simple but assembly is complicated, making it difficult to calculate its theoretical volume. The estimated theoretical volume of the final assembly part is 107293.8 mm3. And to pipes are been assembled on both sides and nozzle for required air flow[5][6].

To optimize the volume and performance it has been designed for practical analysis. The following figure shows the dimension of dehumidifier- are shown in figure 3.

Part 1 185 mm inlet outlet pipe size.
Part 2 middle pipe size 285 mm.
Part 3 outer diameter is 46 mm.
Collar size diameter 37 mm.
Nozzle size 1.5 bsp
Total size of pipe is 670 mm.
Mesh size of the fins for silica gel 3 to 6 mm masher.

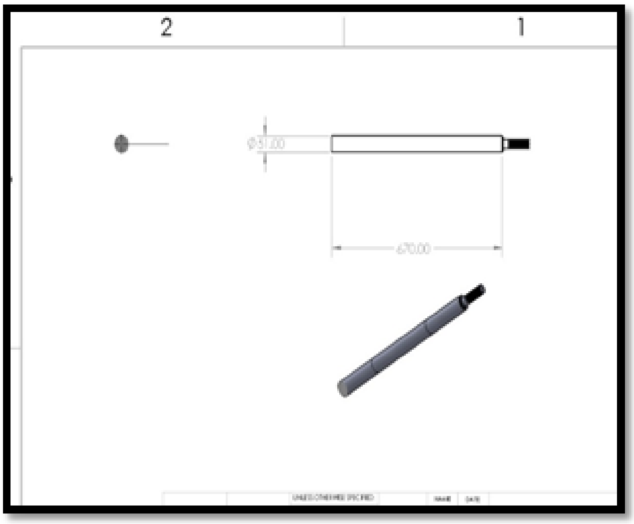

Figure 3: Different sizes of assembly

B. Dehumidifier Design And Its Consideration

Dehumidifier is designed as per the size of railway locomotive piping system as per shown in figure 4 that because design as per that will help to pass air comfortably from dehumidifier and would not hamper size of railway locomotive dimension.

Air coming from compressor should pass through silica gel of dehumidifier easily without any blockage. Silica gel is filled on top and bottom both side of the dehumidifier cylinder[7][8].

Also, in dehumidifier cylinder we have kept two nozzle which don't hamper the velocity of air passing through dehumidifier.

Maintenance: The dehumidifier is designed in such a way that its maintenance can be done easily by removing the masher and then replacing silica gel when its color become pink and it fails to dehumidify air with the help of silica gel [9-11].

Figure 4: Opening for maintenance of silica gel

C. As Per The Standard Guidelines, The Design of The Dehumidifier Is As Per The Following Steps:

- The distance between the outermost last pipes is of 185 mm on both side to maintain the same amount of silica gel to be filled.
- Undercut pitch of thread = 1.5 mm
- Internal angle for thread is 50
- Middle pipe which is open is 285 mm
- Nozzle size is as per standard 1.5 bsp
- Inner diameter of the pipe is 46 mm and outer diameter of pipe is 51 mm.
- Masher size for silica gel is 3 to 6 mm
- Total pipe size is 670 mm

As per the component, we select circular cross-section for dehumidifier.

Below figure 5, figure 6, figure 7, figure 8 shows assembly of dehumidifier as per process.

Figure 5: Assembly of dehumidifier

Figure 6: Assembly of dehumidifier

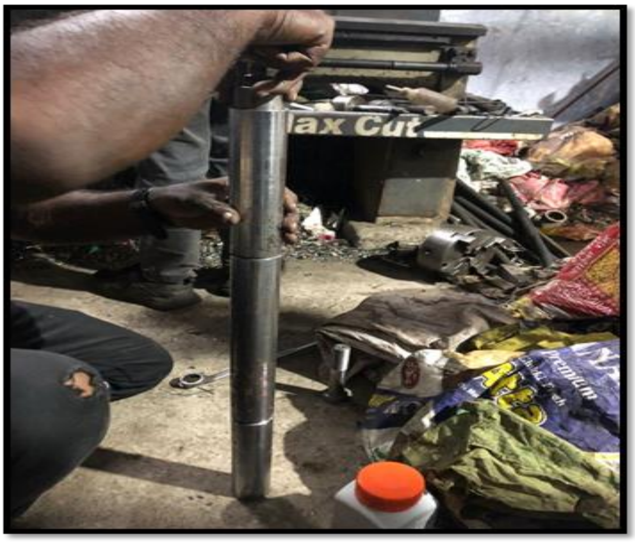

Figure 7: Assembly of dehumidifier

Figure 8: Assembly of dehumidifier

IV. RESULT AND DISCUSSION

The experiments conducted for the different preforms using the dehumidifier for different time zone for 8 hours we have got a satisfactory result where we have decreased moisture content from 37% to 7% and moisture removal about 81.08% and silica gel has become from blue crystal to white which shows that there is satisfactory moisture absorption occur and silica gel life will be around 3 months as per the railway locomotive maintenance cycle.

A. Distillation Method to Know the Moisture Content

The distillation method shows the removal of moisture content with the help of silica gel. In contrast, evaporation methods are used.

On indirect measurement of the amount of water removed by evaporation.

Formula for it is - % moisture = 100 (m initial – m dried)/ m (initial)

So according to our result we get, % moisture = 100(37% - 7%)/37

= 100(30%)/37

=100 * (0.8108)

= 81.08% moisture removal.

B. Flow And Volume of Dehumidifier

Volume flow rate is (q*60)/(t*14.7)

Q= compressor flow rate in (cfm)

T= time

14.7 standard atmospheric pressure

So, 1750*60/8*14.7 = 192937.5 m3/s

Compressed air going in dehumidifier is at flow rate of 1750 lpm (litre per minute).

C. Saving In Life of Silica Gel

Amount of silica gel used in dehumidifier.

W=170*v+d*f where w= weight in gram v= volume in cubic meter d= weight in gram of other material, f= silica gel as per moisture content.

So, we get w= 170*1.7293 + 50*1/5 = 300 gram.

Silica gel life as per standard is per meter in 500 gram will withstand 180 days of its life. Ultimately, as we have used 300-gram silica gel so it will withstand 120 days.

V. CONCLUSION

In this research paper, an attempt has been made to optimize the preform design for the dehumidifier as per the result we have got positive result with 81.08% removal of moisture content from 37% to 7% so this setup is efficient for railway locomotive and truck brake system and for automatic machines where air is needed during manufacturing process.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest between them and with any third party.

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