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Research paper

Development of Test Rig for Centrifugal Air Strainer

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Abstract

This paper is a description of an alternative method for the testing of air strainer in the railways. In traditional method they can't test the filter with full accuracy, so semi-automatic method is needed to check the sealing of the filter effectively. Test rig is used to check the sealing of the air strainer. This paper addresses two major issues from the previous method of testing.

(1) Requirement of skilled labors in work.

(2) Precise inspection is not possible.

The test rig being used currently requires more setting up time and the cost of the process is more. This paper describes a test rig which can reduce cost of the process and be able to reduce the human error by semi-automatic method.

Keywords: *Air strainer; Human Error; Semi-automatic method; Test rig*

1. Introduction

Air Brakes are also known as Compressed air Braking System. It works with a principle of friction braking, where air pressure is applied to the piston, which in turn applies the force to brake pad and stops the vehicle. They are usually used in heavy vehicles which have multiple compartment trailers. In 1872, George Westinghouse was the first to develop air brakes to be applied in railways. He then made many changes to improve his invention. This led to variety of types in air brakes. But, it was in the early 20th century, the truck and heavy vehicle production companies started to implement the air brakes after it was proven successful in railways.

After the air braking system is clearly studied and the components are separately studied. Out of those components of air braking system, air strainer is selected.

There are two main Air strainers are used in the railways. These two are selected based on the quality. They are

a) Faiveley

b) Knorr.

The semi-automatic test rig is developed by means of some components like Solenoid valve, Digital pressure gauge and Timers.

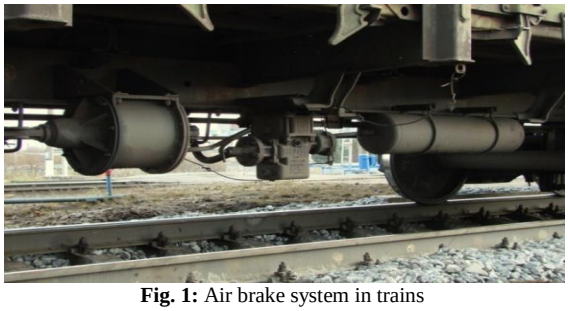


Fig. 1: Air brake system in trains

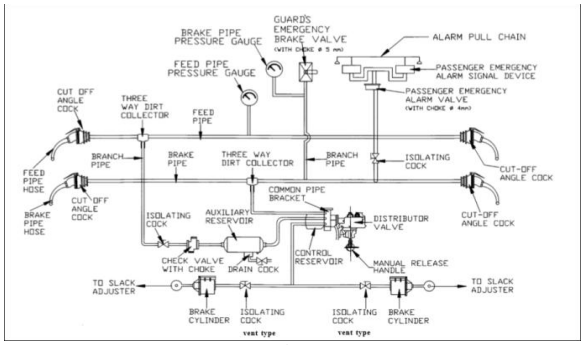


Fig.2: Layout of air brake system

Use of chemical approach for cleaning the surface using hydrogen containing acid (sulfuric acid, hydrochloric acid etc.) sometimes introduce hydrogen in base metal which in long run can diffuse in weld and HAZ and facilitate crack nucleation & propagation (by HIC) besides making well-meant brittle .Further, improper cleaning sometimes leaves impurities on faying surface, which, if are melted or evaporated during the welding then these impurities can induce inclusions in weld metal. Presence of inclusions in weld metal acts as stress raiser for nucleation and growth of cracks and so weakens the joint and lowers fatigue performance. Cutting of hard enable steel plates by thermal cutting methods such as gas cutting also hardens the cut edge. These hardened edges can easily develop cracks in HAZ under the influence of the residual stresses caused by weld thermal cycle associated with welding.

2. Submerged Arc Welding

This submerged arc welding process is used to join two metals by using electric current. In this type, power supply is given to produce an arc between the electrode and the base material. Electric used for this purpose may be AC or DC. Electrodes also can be consumable and non consumable electrodes. The weld zone

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is normally protected by any gas or slag. This process can be of manual method, semi automatic method or fully automatic method. In 19th Century, it was invented initially for ship building process where it was essential in second world war. But, now it an important aspect in the manufactuing of vehicle structures.

One of the important and most widely used type is shielded metal arc welding (SMAW). Here, power supply is applied to an electrode and the base metal. The electrode is usually made of a material which is suitable for base material. It is coated with a flux which release vapour that acts as shielding agent by forming slag to protect the area to be welded from the atmospheric contamination. The central part of the electrode itself acts as a filler. So a separate filler is unnecessary. This process is much adaptable, low cost and less operator training required. Anyway, the time taken for welding is very slow as the electrodes must be often changed. Also, slag fromed as residue must be chipped away. Although cast iron, nickel aluminium, copper and other metals can be welded, only ferrous products will be usually welded by this method. The adaptability of this process is that it can be used in variety of applications including repair and construction.

Tunsten Inert Gas Welding (TIG) is a welding method in which tungsten electrode along with an inert gas mixture and filler material is used manually. This process uses a stable electric arc and good quality welds which can be used for joining thin materials. But, it needs good operator skill and low operating speeds. Although it can be applied to all weldable metals, it is frequently used for stainless steel and very light metals. As the qualityt of weld is good, it is mostly used in bicycle, naval and aero applications.

Plasma arc welding process also uses the electrode material of tungsten but to produce the arc, plasma is used. The electric arc generated has more concentration than previous process, so transverse control is much more important. The power supply used here is stable. So this method can be used on a variety of material thicknesses compared to other processes and also it is faster process.

This process can be applied to most weldable metals except magnesium. Automated joining process of stainless steel is one of the most vital application of this process. Materials with good strenth, such as HSLA, Aluminium and Titanium alloys can be enbritttlement is happened by hydrogen while using this process. If there are any traces of moisture content in the electrodes, the water decomposes and liberate hydrogen, whicn in turn causes material embrittlement. Such electrodes are packed with moisture proof sealing. Sometimes when there is moisture suspected, it should be baked from 450 to 550 degree celcius in oven. Also, the flux must be retained as moisture free content. Intergranular corrosion is possible in austenitic steels and nicked based alloys. If subjected to temperature of arounf 700 degree celcius for a considerable length of time, chromium can react with the carbon and forms chromium carbide. This depleted the crystal edges of chromium, impairs the resistance to corrosion in the process. This is called as sensitation. Such steel will undergo corrosion near the welding area.

Knife Line Attack (KLA) is a type of weld where the corrosion impacts on the quality of the weld. Nioubium can dissolve in steel at high temperatures. So, after cooling, niobium carbide is unable to precipitate, hence steel behaves as unstabilised due to the formation of the chromium carbide. It affects the vicinity of weld by affecting thin zone, so it makes tedious. Cooling rate after this process is not vital.

3. Material Used for Manifold

- Average density of MS is 7861 kg/m^3 and Young's modulus value is 2.1e^5 MPa.
- Carbon atoms occupy the interstitial spaces of Iron. Hence, it increases strength and hardness of steel. In addition, it reduces the ductility of material.
- These types of steel is more suitable than others for welding purposes, as it conducts power supply more efficiently without damaging material surface. It has ferromagnetic properties, so they are suitable to use in the producing electrical appliances and motors.
- Mild Steel has the properties of low hardness, good malleability. Hence, it is the best choice for using in pipelines, construction materials and daily used products.
- Machining and Shaping of mild steel is very easy due to its material properties. The hardness of the material may increase with heat treatment methods.
- The percentage of carbon in mild steel makes it prone to rust. People usually prefer stainless steel to overcome this issue, where chromium reacts with atmospheric oxygen and forms a protective layer of chromium oxide, which prevents the formation of rust.

The main objective of heat treatment of steel is to alter the mechanical properties. Mostly, young's modulus is unaffected during the heat treatment process. Remaining properties such as hardness, strength can be altered. Steel is heat treated and quenched and low to moderate amount of carbon is allowed to diffuse. This leaves ferrite as precipitate, thus forming martensite at higher rate. Cooling rate of about eutectoid range affects the rate of diffusion of carbon in austenite and forms cementite. Fine grained pearlite and coarser pearlite are formed by altering the cooling rates.

4. Selection of Components

Here, solenoid valve is used. It is a valve and is operate by electromechanical principle. It is control by power supply via solenoid, where two ports valve flow is used. The solenoid valve switches off and on whenever necessary. Multiple solenoid valves are positioned in a manifold. These solenoid valves are usually used in fluid control elements. Their main objective is to open / release / control and distribute fluids. They have variety of applications. They are safe and reliable. They have long service life. They possess fast switching and compact design.

4.1. Types of Solenoid Valve:

- 1 or 2 Solenoid Valves;
- AC or DC powered;
- Variations in ports and positions

Of these types, we are selecting 2 port 2 positions direct acting normally closed solenoid valve - E12612A.

4.2. Features:

- Variation in Voltage
- Duty Cycle – Continuous
- Less Operating Temperature
- Low noise atmosphere
- 360 degree rotation is possible

4.3. Timers:

Timer is a variant of clock, which specializes in measuring the time gaps. It is of two broad types. Timer counts the value from zero. This is mentioned as stopwatch. Example for these timers is hour-glass. Timers are of two groups, namely hardware and software timers. Here we select XT5042 Timer.



Fig.3: Timer

4.4. Digital - Pressure Gauge:

In the current market, there are numerous types and sizes of digital pressure gauges. For this project, we used E0102504A JANATICS type of pressure gauge.

4.5. Features:

- Adjustable Set pressure selectable
- Pressure limits are independent
- Panel is mountable
- PNP - NPN Variants
- Two outputs



Fig. 4: Digital pressure gauge

5. Design and Analysis of Manifold

5.1 Auto Cad Design of Faiveley Manifold:

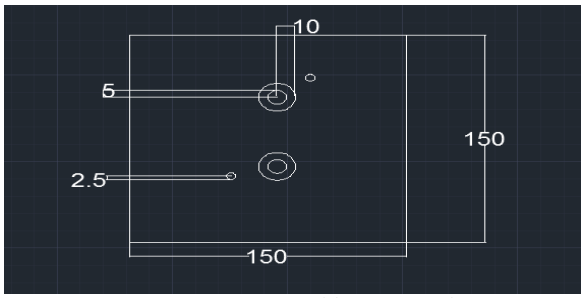


Fig.5: AutoCAD model of faiveley manifold

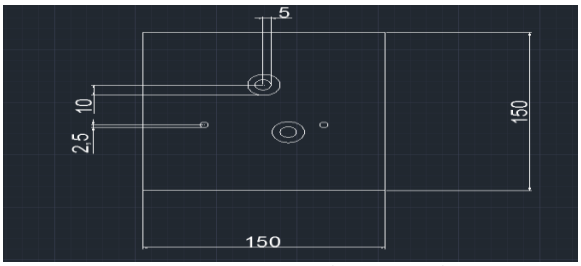


Fig.6: AutoCAD model of Knorr manifold

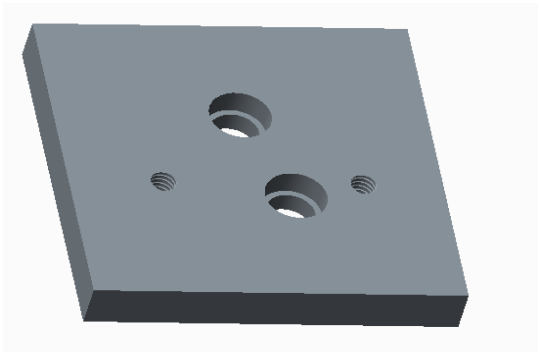


Fig .7: 3D model of Faiveley manifold

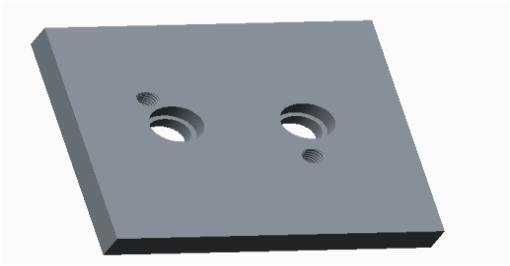


Fig.8: 3D model of Knorr manifold

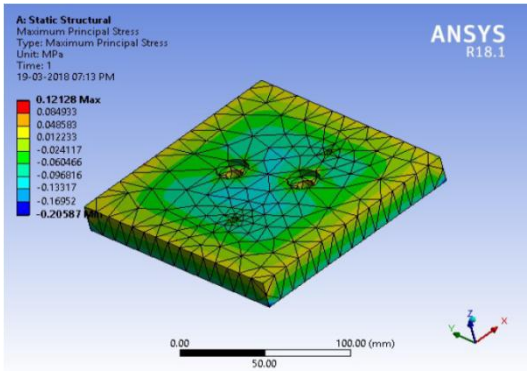


Fig. 9: Analysis of faiveley manifold

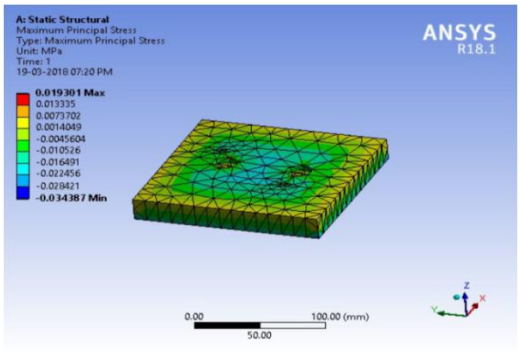


Fig. 10: Analysis of Knorr manifold

All the above diagram clearly depicts the design and analysis of Faiveley and Knorr manifold.

6. Assembly and Development of Test Rig

Initially we studied about the solenoid valve, Digital pressure gauge, relays and timer. We got a clear idea about all accessories. Then we took those accessories from the mechatronics laboratory. There are two major mechatronics products are available in the southern railways mechatronics laboratory. One is JANATICS and another one is AVCON. We chose JANATICS because it is preferable one in railways when compared to AVCON. We need to select the solenoid valve that can be operating at 0-10 bar pressure, 220V

AC and should be in NC (Normally closed) condition. For that we had selected E12612A.This solenoid valve is satisfying all our required needs.
We need to select the digital pressure gauge that will have to withstand 0-10 bar pressure, less power consumption and should be less response time. For that we had selected PS0102504. This digital pressure gauge contains all the required specification. The timer that we want to select, should be used to set and reset the timings at the beginning and the end of the process. So we choose XT5042. It clearly shows second, minute and hour. The cost of the timer is cheap and reliable when compared to the other timer brands.

6.1 Electronic Arrangements:

We can't check two filters at a time. So we need to fix the separate solenoid valve for FAVELEY and KNORR strainers. Apart from these two, we take 3 more solenoid valves. One is for allowing the air to the digital pressure gauge to check, whether the air is 10 bar. Second one is used to fill the strainer. Third one is used to drain the air out of the strainer. The solenoid valve, Digital pressure gauge and the timer connection are made by means of relay.
The below picture clearly shows the detailed assembly of solenoid valves, Digital pressure gauge, Timer and relay.

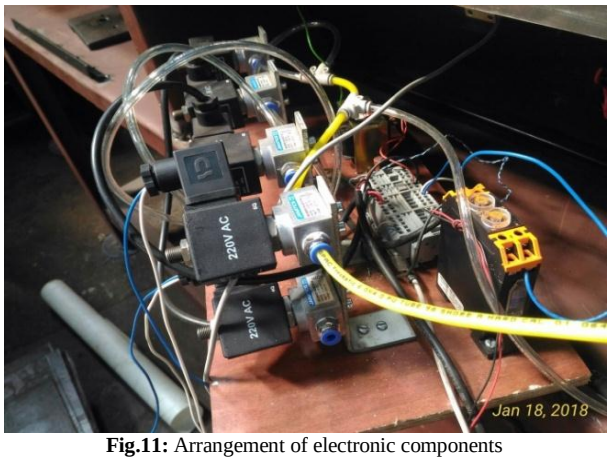


Fig.11: Arrangement of electronic components

The first 3 solenoid valves are for both the filters (FAVELEY and KNORR). And the other 2 solenoid valves are for alternating the flow of air to Faiveley and Knorr. The opening and closing of the solenoid valves are controlled by the timers. Relay is like a junction, where all the connections are made easy and effective. The whole electronic arrangements are mounted backside of the frame. After mounting of the arrangements, they are closed by wooden plywood. This plywood protects electronic arrangements from the outside activities. Increase no of orders from client and find more clients. The implementation of above mentioned solution number 1, 3 and 4 will improve Efficiency.

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