Study on Leak Testing Methods

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Abstract— Today's era of perfection, in each sector perfection is must, thus you must be always perfect to sustain in a competitive market. Not only perfection is needed but your product must be ready to use in less time. Around total time consumed on product, 40% of time is wasted in Quality analysis. Thus, idea of automation was enlightened to reduce the time consumed in detecting defects. Leak testing machine is one of the automated methods of detecting leaks. There are many methods of detecting leak and type of test equipment for solving these problems. Each test method is suitable only for a specific leak rate or for fixed forms and technologies. The basic function of leak testing is detection of leakage, measurement of leakage and location of leakage. This paper gives you study report on leak testing methods.

Key words: Quality Analysis, Automation, Leak testing machine, detection of leakage, measurement of leakage and location of leakage

I. Introduction

In Industries, components and systems are tested to ensure that there are no leakages. As some components are used for high precision application so they must able to sustain their accuracy at that level. This Leak Testing Machine is a SPM i.e. Special Purpose Machine; it is specially designed for leak testing of a particular component. The Three Basic Functions of any Leak Testing Machine are-

1) Detecting Leakage
2) Measurement of leak rate
3) Leakage location.

There are many methods and types of test equipment for solving these problems, but unfortunately there is no single technique that fits every situation. Each test method is suitable only for a specific leak type. In most instances where leak detection is used there is no need of leak rate measurement, but the system must be able to recognize if the leak rate is above or below a specified level.

There are general three types of method which are used for leak testing

- Dry testing
- Wet testing

Dry Testing- This method is most widely used and is an initial method of testing any enclosed component. In this method, the component to be tested is first fully enclosed and a pressurised air is passed through it, the pressurised air in the component is monitored. It is noted that if the pressure increases uniformly in the enclosed component, that means the component is okay. But if the pressure suddenly drops that means the component has a crack, then the component is rejected.

Wet Testing- This method is most widely used and is a secondary method of testing any enclosed component. In this method, the component to be tested is first fully enclosed and a pressurised air is passed through it, the pressurised air in the component is monitored after enclosed it in a water tub or vessel full of water. It is noted that if the pressure increases uniformly in the enclosed component, that means the component is okay. But if the pressure suddenly drops and bubbles occur that means the component has a crack, then the component is rejected.

Problem Statement:

There are certain problems which are associated with the parts of the components. i.e. crack, dent, intrusions. From which some of the components which will work against high pressure must be leak tested first.

Cracks in Aluminium Casting:

Casting is a process which carries risk of failure occurrence during all the process of accomplishment of the finished product. Hence necessary action should be taken while manufacturing of cast product so that defect free parts are obtained. Mostly casting defects are concerned with process parameters. Hence one has to control the process parameter to achieve zero defect parts. For controlling process parameter, one must have knowledge about effect of process parameter on casting and their influence on defect.

Fig. 1: Inclusion

To obtain this all knowledge about casting defect, their causes, and defect remedies one has to be analyse casting defects. Casting defect analysis is the process of finding root causes of occurrence of defects in the rejection of casting and taking necessary step to reduce the defects and to improve the casting yield. In this review paper an attempt has been made to provide all casting related defect with their causes and remedies.

Fig. 2: Crack

During the process of casting, there is always a chance where defect will occur. Minor defect can be adjusted easily but high rejected rates could lead to significant change at high cost. Therefore, it is essential for die caster to have knowledge on the type of defect and be able to identify the exact root cause, and their remedies.

II. LEAK TESTING METHODS

A leak can be defined as an unintended crack, hole or porosity in an enveloping wall or joint, which must contain or exclude different fluids and gases allowing the escape of closed medium. Critical leak spots in closed systems are usually connections, gaskets, welded and brazed joints, defects in material, etc. A leak test procedure is usually a quality control step to assure device integrity, and should preferably be a one-time non-destructive test, without impact on the environment and operators. Several leak-testing techniques are available, spanning from very simple approaches to systems that are more complex. The most commonly used leak test methods are underwater bubble test, bubble soap paint, pressure and vacuum decay, and tracer gas detectors (halogen, helium and hydrogen). The first three techniques, due to their characteristics and sensitivity, can be used only for gross leak detection (300 g/y (10.5 oz) or more refrigerant leakages). Tracer gas leak testing methods are much more precise than the previous group but, in many cases, their theoretical sensitivity is more than is required. In a practical sense, however, this is limited by environmental and working conditions. Each method mentioned above and each its advantages and drawbacks are discussed briefly in the following. In annex A, a conversion chart for the most commonly used vacuum and leak rate measurement units is provided. In the diagram below, the performance of various leak-test techniques is summarized.

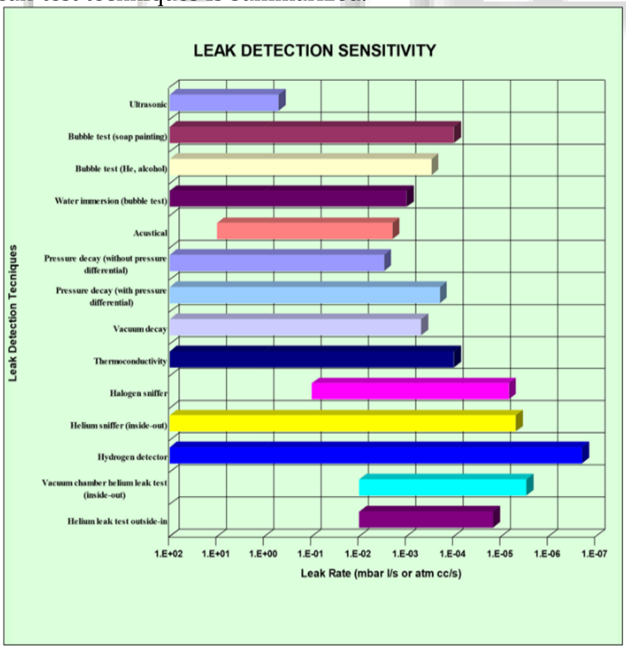

Fig. 3: Leak Detection Sensitivity

A. Water immersion bubble test method:

The water-immersion bubble test, also called "bubble testing" or "dunking", is a traditional and relatively primitive technique of leak detection. It consists of immersing a charged or pressurized part, usually with high-pressure dry air or nitrogen, in a water tank and watching for escaping bubbles. The larger and more frequent the bubbles, the bigger the leakage. Relatively small leaks are possible, but very difficult, to detect.

The main limitation of this method is sensitivity, which is the minimum detectable leak rate. Considering a spherical bubble of radius R, its internal volume V will be:

$$V = 4/3 \cdot \pi \cdot R3$$

Let p the pressure inside the bubble and t the time required to form the first bubble, the leak rate Q will be:

$$Q = (p \cdot V) / t$$

The two key parameters determining the sensitivity of this method are the smallest bubble detectable by the operator and the waiting time for bubble generation. This time must be compatible with the production rate and with operator attention.

It is reasonable to consider that the smallest bubble an operator could detect has 1 mm radius and that the waiting time is 30 seconds. Assuming that the pressure inside the bubble is at atmospheric pressure, it can be stated from the previous equations that the bubble volume is V = 4.2·10-3 cm3 and therefore the minimum detectable leak rate is:

$$Q= (p \cdot V) / t = 1000 * 4.2 \cdot 10\text{-}6 / 30 = 1 \cdot 10\text{-}4 \text{ mbar} \cdot \text{l/s}$$

This is a theoretical value. The real sensitivity is strongly influenced by many external factors, such as illumination conditions, water turbidity, unit location and placement, and water movement. All these issues, together with operator dependency, limit the useful sensitivity to 5·10-4 mbar · l/s, although 1·10-3 mbar · l/s is usually considered. Some tricks to can be used improve to this method.

- Increasing the internal pressure in increments may increase the probability of finding a leak and can be less time-consuming in pinpointing the leak.
- A detergent can be added to the water to decrease surface tension, which helps to prevent the leaking gas from clinging to the side of the component.
- Using different gases (e.g. helium) and/or liquids may give some advantages in system performance, but at a cost disadvantage.
- Hot water in the tank sometimes helps to increase the pressure inside the component or piping system. If dry nitrogen is used, this does not help because nitrogen does not increase its pressure significantly. If refrigerant is contained in the system or component, it may help considerably to increase the pressure and, therefore, increase the chance of finding the leak.

In conclusion, this technique does offer leak detection accuracy in the 10-3 mbar · l/s range in high volume production applications and, in most cases, leak location and is very economical. However, the disadvantages range from a relatively low sensitivity, high operator dependency and possible part contamination, to fluid waste and the likelihood of having to dry the parts after testing. Moreover, especially when dealing with big coils, excessive unit handling, putting parts in and out of tanks, adds to the complexity of production and results in higher part damages. There are also some more hidden costs. In fact, this process requires use of a large amount of space and produces a certain amount of wastewater. This is especially true for big units, such as large heat exchangers; the tank could be very large and require a lot of water. Dryers cost money to operate and maintain as well.

B. Soap solution bubble test:

Instead of submersing the part in water, the pressurized unit to be tested is sprayed with a soap solution and the operator is able to see the bubbles formed by gas escaping from where the leak is. Soap solutions are available in many different types. Some have a brush applicator and others have a dabber (an absorbent ball attached to a stiff wire inside of the cap.) Some brands may even have a spray applicator to quickly cover large areas of tubing in a short amount of time. This is an advantage but is also messy and time consuming to clean up.

Some soap solutions even have an antifreeze base to prevent them from freezing in the winter time. Others may have a lower density to make them even more sensitive to very tiny leaks.

This method has a higher sensitivity than water immersion. It allows detection of leaks up to 10-5 mbar · l/s and is suitable for very large systems. In this case, the soap solution is only used in that specific area to test for and pinpoint a leak. It is This soap solution method is best used when the approximate area where a leak may exist is the simplest and least expensive method, material wise, known today. However, if the operator does not know where the leak might be, it can be more expensive because of labour costs.

Pressure decay test

This method consists of pressurizing the system with a high-pressure gas, usually dry air or nitrogen. Then the part is isolated from the gas supply and, after a stabilizing period, its internal pressure is monitored over time. The pressure drop Δp is measured in the time Δt. If the pressure in the system drops fast, there is a large leak present in that component or section of the system. If the system's pressure drops slowly, there is a small leak present. If the pressure remains the same, that component is leak-free. The leak rate Q can easily be computed considering the volume V of the component. That is:

$$Q = (\Delta p \cdot V) / \Delta t$$

Leak detection sensitivity is related to the testing time, the pressure transducer resolution and the volume. The most advanced systems allow for measuring pressure variation up to 70 Pa (0.010 psig) at test pressure and, depending on the volume of the units to be tested, the leak detection cycle can be as short as 30 seconds and guarantees high resolution. Considering V = 1.5 dm3 (0.4 gal) internal volume component with a Δp = 70 Pa (0.010 psig) of pressure decay at 3450 kPa (500 psig) test pressure in Δt = 60 seconds, the leak rate is:

$$Q = (\Delta p \cdot V) / \Delta t = 0.7 \cdot 1.5/60 = 1.7 \cdot 10\text{-}2 \text{ mbar} \cdot \text{l/s}$$

This leak testing technique has some advantages. This method will positively identify whether or not a leak exists by monitoring the pressure drop. If any pressure drop occurs, it means a leak is definitely present. Furthermore, this method can be realized completely automatically, so as to avoid operator errors. This procedure is a preliminary leak test that detects large leaks before the final automatic leak test operation using a tracer gas, e.g. helium.

C. Sniffing:

"Sniffing" is the simplest realization of an "inside-out" test. The sniffing technique of leak detection utilizes a detector probe or sniffer to sense leaks from a unit previously filled and pressurized with a tracer gas. Before filling the unit with a tracer gas, it must be evacuated, so a pumping group, even a small one, is required. This method is very operator dependent. In fact, the probe (or wand) is moved over the part and detects the leak as it passes over that leak. The speed, distance from the part and the probe sensitivity determine the accuracy of leak detection. However, sniffing will locate a leak on a part, unlike the other methods described, and has the ability to sense leaks as small as 10-7 mbar · l/s, depending on the tracer gas. Sniffing is not recommended in a high-volume production environment, other than for locating leaks for repair. Depending on the tracer gas, sniffing may involve a relatively low tooling cost investment, representing an economical method of leak detection. However, the cost of the tracer gas may be significant and, in case of a particularly expensive gas, the use of a suitable gas recovery and reclaim system should be considered, further increasing the overall costs.

D. Principle of Direct Pressure (Drop) Type Air Leak Test:

In this method, a leak is detected by charging test pressure to the work and measuring the change in the test pressure in the work after a given time.

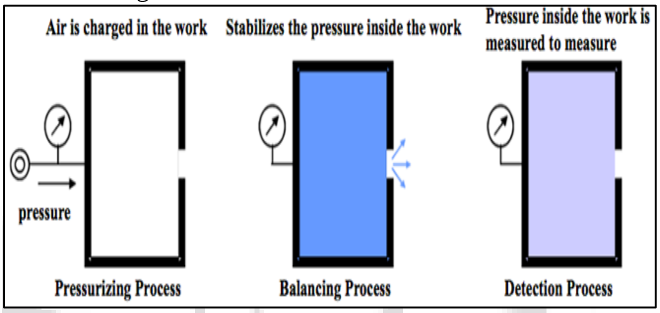

Fig. 4: Principle of Direct Pressure (Drop) Type Air Leak Test

Pressure change inside the work during the air leak test is shown in the figure 1. Pressure inside the work sharply increases during the pressurization process. This is because the temperature inside the work increases by pressurization and affects the pressure. The pressure change by temperature and other effects is stabilized (balancing process) and then the leak is measured (detection process). Constant value will be maintained and no pressure change in work will be detected when the work has no leak. However, the value will decrease at a constant rate due to decrease of pressure inside the work when the work has a leak. The direct pressure type air leak tester detects leak of work through this pressure change and judges the result.

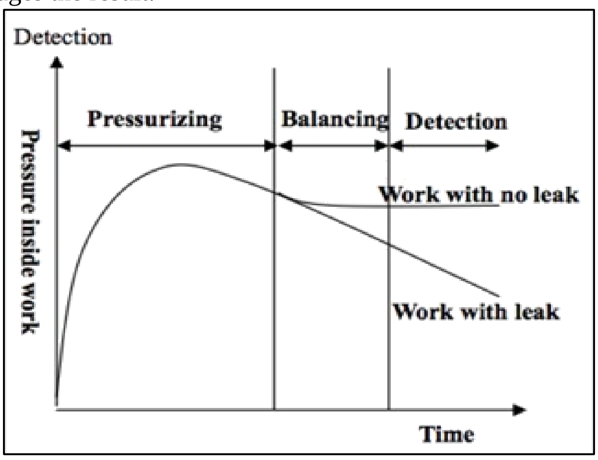

Fig. 5: Graph Pressure inside work vs Time

E. Principle of Differential Pressure Type Leak Test:

The instrument is used to precisely measure a weight close to the balancing weight (a reference value) by increasing the weight value on the opposite side. The differential pressure type air leak tester uses the same principle as the balancing scale. The same air pressure is charged to both the work (tested work) and the master work (work with no leak) and the change in pressure balance within a fixed time is checked for the presence of a leak.

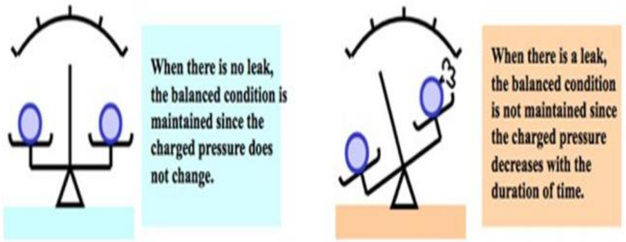

Fig. 6: Principle of Differential Pressure Type Leak Test

Pressure change inside the work during the air leak test is shown the below figure. Pressure inside the work and master work sharply increases during the pressurization process. This is because the temperature inside the work and master work increases by pressurization and affects the pressure. The pressure change by temperature and other effects is stabilized (balancing process) and then the leak is measured (detection process). After the balancing process, the constant value will be maintained with no pressure change in the master work since it has no leak. However, when the work has a leak, the value will decrease at a constant rate due to decrease of pressure inside the work. Also, when the work does not have any leak, the constant value will be maintained with no pressure change inside the work. A leak is detected by calculating the difference of pressure change between the master work and work.

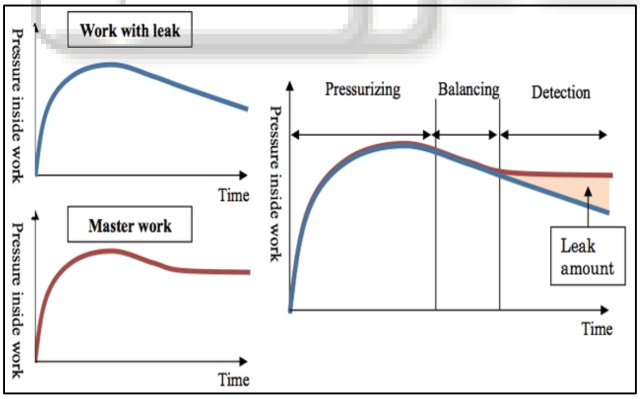

Fig. 7: Graph Differential Pressure Type Leak Test

III. CONCLUSION

Proper selection and implementation of a production leak test method starts with an understanding of WHY the test is being performed, followed by establishing what the leak rate limit is, and finally a determination of how the leak test will be performed. A careful and thoughtful evaluation at each of these steps, combined with the selection of high quality leak test hardware, will result in a cost effective, high performance, and reliable production leak test. This project has described methods for the finding the leaks and their location in the part and helps in the field of automation and also to improve quality.

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