Leakage Detection in Wire-Bonding Gas Supply System

Yue.Zhang, Haoming.Chang
ASM Technology Singapore Pte Ltd
2 Yishun Avenue 7, 768924
(65) 6752 6311

Abstract

A leakage detection system and a method used for detecting leakages in the wire bonding gas supply system are introduced. The leakage detection system is connected to the pipeline remotely from the gas outlet. The detection module receives flow rate signal and monitors the flow rate changes that represent the leakage in the pipeline. The importance of leakage detection in wire bonding system will be introduced first. The process of determining the reference flow rate and leakage detection will be illustrated thereafter. An impedance system is then highlighted so as to amplify the changes. The amplification helps to facilitate a more accurate measurement. The experiments are executed through the use of artificial leakages. The results show that any repetition of leakages can be successfully detected.

Problem Statement

In wire-bonding applications, for bonding wires made of reactive materials such as copper or aluminum, when melted molten ball reacts with oxygen in the atmosphere, there is a tendency for the oxidation of molten ball. Oxidation of the molten ball degrades the quality of the subsequent ball bond formed. Therefore, it is usually necessary to provide a shielding gas comprised of a relatively inert gas such as nitrogen or argon gas to occlude the wire during ball formation and prevent contact with oxygen. The shielding gas is generally supplied via a shielding gas implement with an outlet adjacent of the capillary. For example, this can be done so via a slot or sleeve surrounding the capillary tip [1].

It is important to ensure that the supply of shielding gas is stable, so that ball bonds are formed consistently and the surface of bonded ball does not oxidize. If there are any leakages in the pipeline of the gas supply system feeding the shielding gas implement (or other gas implement employed by the wire bonding apparatus), this will affect the stability of the gas feed significantly.

Many leakage detection methods have been developed in the gas or fluid supply system. Some systems utilize different types of sensors, such as the electrostatic sensor [2]. Other systems employ a switching device to detect the leakage in a supply system [3], which require a switch to a second pipeline to assess if there is a leakage.

Flow rate sensors can only measure the flow rate at their inputs. Accordingly, in order to be able to measure leakage in a pipeline reliably, two sensors are required: one at the input end, and one at the output end. A detected difference in flow rates between the inlet and outlet sensors indicates a leakage. A problem with attaching a sensor at the output end of a gas supply system of a wire bonding system is that such a sensor not only adds more cost, but also adds more weight to the system, which is undesirable in most applications. In addition, many flow rate sensors have low resolution, and are unable to sense minimal variations in the flow rate, however still able to induce an effect on ball formation.

Thus, there is a prevalent need for a system and method for the reliable detection of leakages in shielding gas supply systems for wire bonding.

Tandem Leakage Detection Solution

With the problem in mind, we developed a new tandem leakage detection method with no additional sensors or parallel pipe line.

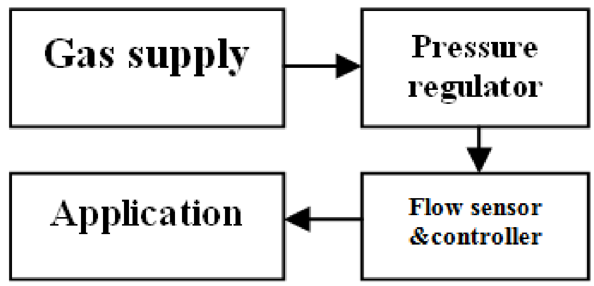

Fig-1

Fig-1 represents a simple gas supply system in the wire bonding system. The system comprises of a supplying source of inert gas coupled to the pressure regulator. A flow sensor and controller are then connected to the pressure regulator to monitor and control the flow rate delivered to the application, for alignment with picture and patent. In this system, any leakage in the pipeline after the flow sensor cannot be detected.

However, if certain flow resistance exists after the flow sensor, then the leakage from the pipeline downstream of the pressure regulator but before the resistance will increase the flow rate. In other words, the pressure regulator will respond to the change in resistance by adjusting its flow rate upwards in order to maintain a desired pressure. The resistance modified system is illustrated in Fig-2.

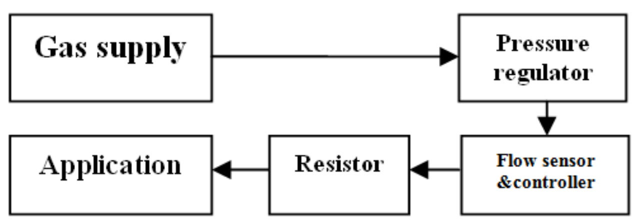

Fig-2

In extreme cases, suppose the resistor in Fig-2 has infinite resistance, this blocked the pipeline. In this case, the flow sensor will detect no flow rate or “zero”. Once certain leakage occurs between the sensor and resistor, the flow sensor will reveal readings.

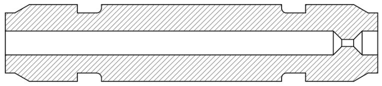

Fig-3

In real life applications, a resistor as illustrated in Fig-3 was built in to the application modules. This resistance decreases the flow rate to a lower value. With leakage artificially introduced into pipeline, the system can demonstrate more than 10% flow rate increment in the flow sensor. The flow rate measured by the flow sensor for the "no leakage" and "with leakage" cases are shown in Table-1.

regulator pressure (MPa)	flow rate – no leakage (L/minute)	flow rate - small leakage (L/minute)	increase
0.1	1.10	1.30	18.2%
0.2	1.80	2.17	20.6%
0.3	2.43	2.96	21.8%

Table -1

In other applications, the flow rate setting is very low. For example, it flows at 0.3 liters per minute. In such cases, even with the resistor, the flow rate increases with a high percentage but with a very small absolute value. This is very challenging for a conventional flow sensor with moderate resolution. Thus, a transient flow rate increase is necessary for an accurate and reliable detection process.

Leakage detection process flow

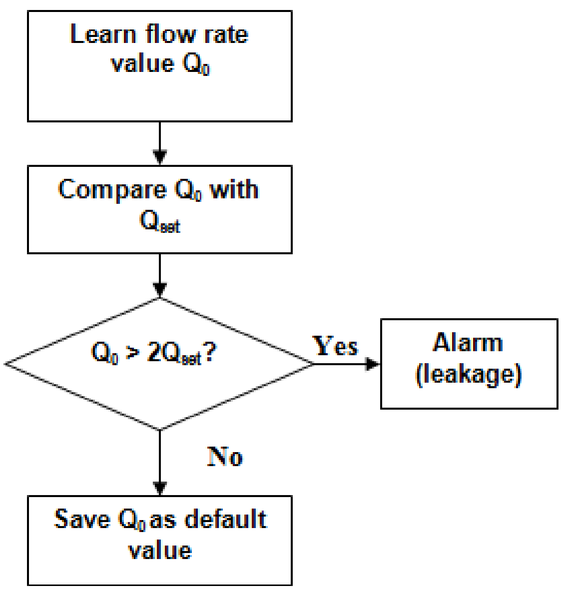

Fig-4

Fig-4 is an outline of process for determining the reference value for each individual system. The Q0 read from this process is compared to a Q-set value during machine assembly, when leakage- free is guaranteed. Process illustrated in Fig-4 is to eliminate the initial variation between different machine connections.

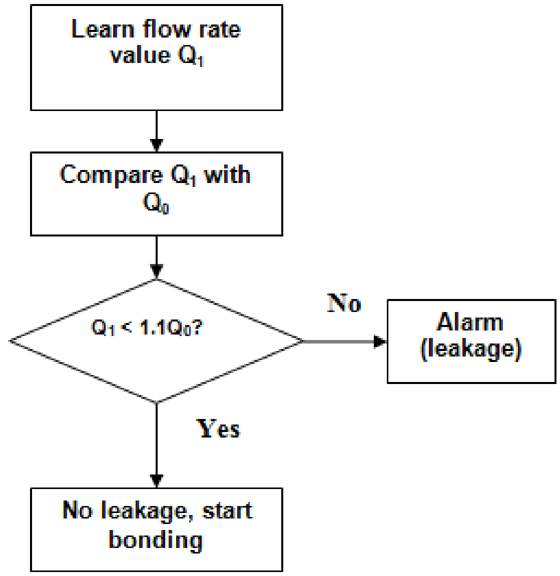

Fig-5

Fig-5 shows an exemplary leakage detection process carried out by leakage detection module. The module monitors the flow rate Q1 and compares it with the reference value Q0, which is obtained from the process illustrated in Fig-4. If Q1 is found to be larger than 1.1 times (an adjustable factor) of the the reference value, the system triggers an alarm, signaling a leakage.

Conclusion

This paper started off with explaining the leakage detection problem and limitations in wire bonding system, followed by presenting a novel method for leakage detection. After years of experimenting, this detection method proves to be an accurate and reliable alarm in case of a leakage or damage in the pipeline. With a reliable detection method, the oxidation of molten ball caused by unstable inert gas can be significantly reduced or even eliminated.

Lastly, in view of the detailed description of this product in this report, we are open to suggestions on further modifications and variations of this invention.

References

1. Wong, Kenny Kwan. "Apparatus for delivering shielding gas during wire bonding", US Patent No. 7,628,307
2. Ian Care, Mark L. "Leakage drain", US Patent No.7,146,849
3. Kunio K et al, "Piping leakage detection appratus" US Patent No. 5,866,802