THE OPTIMIZATED STUDY ON PREPARATION PROCESS OF NANO TIRE PRESSURE SENSOR USED IN AUTO

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ABSTRACT: This topic is derived from the practical problems of L Company. Aiming at the problem of high scrap rate and direct cost loss of tire pressure sensor from L Company, a process optimization scheme was designed. It analyzed the three processes which can lead to ion contamination in the manufacture of tire pressure sensor. The process includes PCB bare board manufacturing and cleaning process, reflow solder process on assembly circuit board as well as finished assembly process. Through the analysis of the sources and hazards of various pollutants and the detection methods, the process optimization scheme was confirmed. In this paper, deionized water was used to clean PCB bare board. Through experimental verification, the experimental results showed that the content of chloride ions in the process was reduced from 4.2μg/in2 to 0.95μg/in2, and the content of sulfate ion decreased from 4.2μg/in2 to 2.4μg/in2. After the optimization for reflow furnace temperature curve and the finished product assembly process, the contents of weak organic acids decreased from 37.8μg/in2 to 3.57μg/in2. In addition, the contents of sodium and ammonium ions decreased from 6μg/in2 to 1μg/in2, and the chloride ion content in the finished product also declined. Through the optimization of the manufacturing process, the problem of high failure rate in the aftermarket is solved, the product quality level and service life are improved. Meanwhile, the failure rate and scrap of product process are reduced, and the competitiveness of the company is improved.
KEY WORDS: Tire pressure sensor, process optimization, PCB bare board cleaning.

1 INTRODUCTION

Tire is one of the most important factors in protecting car performance. Once it is a problem, then the vehicle cannot work continuously. In addition, tire failure will likely lead to very serious traffic accidents due to faster speed when driving on the highway. Statistics show that the three main causes of car puncture are tire leak or lack of pressure, and the temperature of tire surface over 95℃. According to foreign experts and agencies of the survey, only in the United States, traffic accidents happen more than 200,000 every year due to lack of tire pressure. The failure caused by tire pressure or leakage accounts for 75% of the total tire failure. In China, after investigation, we found that 70% of the highway traffic accidentsare caused by the reason of the puncture. Tire pressure monitoring system (TPMS) is used to continuously monitor the tire pressure and temperature after starting the vehicle. And it also can provide early-warning for the abnormal decrease of tire pressure and temperature changes, so it is a protection system forpersonnel life and property safety. If the vehicles are equipped with TPMS, then tire deficency can be found in time. It not only can avoid puncture in the process of driving, but also can extend the service life of tires through inflation in advance. In addition, it can reduce fuel consumption and environmental pollution.

The production of L Company is a direct TPMS that we commonly used, and the product technology of this sensor is relatively mature. In addition, because the application of module produced by semiconductor supplier is relatively wide, and the valve is the standard size, the TPMS can be applied in a variety of tires. This topic comes from the practical problems of a company. During the process design and maintenance for company's tire pressure testing system, the production scrap rate of tire pressure sensor has been high, resulting in a large number of direct cost losses. The quality department always receive feedback from customers about the short life of our product. Customer complaints not only lead to the direct loss of human and material resources, but also lead to a great loss of hidden quality costs. Through the analysis of financial sector, the cost allowance of company's internal and external is very unfavorable for the cost control. Moreover, the corporate net profit cannot continuously increase with the growth of production. With the development of enterprise competition, the company must control and reduce the existing product manufacturing costs, and

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improve the competitiveness of their products through developing product quality to obtain a good market reputation. Based on this, it is possible for enterprise making further investment in upgrading products to maintain market position. The starting point of this paper is the current situation of the production and sale quality of the company from the tire pressure sensor. By studying the influence factors of product life, the manufacturing process of product is optimized, and product obsolescence is reduced. We aim to improve product life in order to reduce the internal and external quality loss and achieve the actual sense of the cost reduction.

2 METHODS

2.1 Summary of optimized scheme

Through the failure analysis of tire pressure sensor, it can be found that the product failure caused by pollutant residue is very common, and its harm degree is high (Li M et al.,2015). In order to improve the product quality of tire pressure sensor and avoid the decrease of product life caused by internal short circuit failure, it is necessary to analyze the source of pollutants and optimize the process and process.

In this paper, in order to compare the effect before and after process improvement, C3 ion chromatograph produced by Foresite Company was used as the cleanliness testing equipment, which can do cleanliness testing for the local area of PCBA surface in a non-destructive way (Friel E et al.2016).At the same time, it can make "clean" or "dirty" judgment according to all kinds of ion content data. The failure of the tire pressure sensor was dismantled, and an unusual appearance was found in the side of tire pressure sensor control chip. Through the microscope, these dark foreign body has caused bridging faults between pins, which is the direct cause of product failure (Mcintyre M D et al.,2016).

We do an Ion chromatographic analysis for the contaminants (foreign matter) and the assembled circuit boards under existing process conditions (Gavin M J et al.2015). Table 1 shows the results of ion analysis of contaminants, and demonstrates the presence of high chloride and sulfate, sodium ions, ammonium ions and WOA residues in foreign matter (Mcintyre M D et al.,2015). High chloride ions and sulphates are usually derived from PCB manufacturing processes. However, flux residue is a typical cause of excessive levels of WOA, sodium and ammonium ions. These two types of pollutant residues are high enough to cause the leakage current and surface corrosion problems presented by the rejects (Peine A et al., 2016).

Fig. 1 showed the results of the ion chromatographic analysis for the assembled circuit boards in the existing process conditions. In the 8 samples, the results of five samples showed an approximate value for the ion content of the above pollutants. It is proved that the existing process may cause corrosion on the surface of the circuit board due to ion pollution, and then result in leakage and product failure. A significant flux residue was found in the two "dirty" products by observing the surface of the circuit board and the parts of the assembly with a microscope. Through the above analysis of the surface contamination of the circuit board and the residue, two reasons for the cause of the pollution failure can be confirmed for theresidue of PCB bare ion contamination and flux in the production process of circuit board assembly (Wei C Z et al. 2011).

Table 1 Test results of pollutants ion chromatographic analysis

Test value unit: ug/in^2		**Ion chromatography test**							**C3 tester**	
Order	Sample	Cl^-	Br^-	$N0_3^-$	SO_4^{2-}	WOA	Na^+	NH_4^+	Result	Time(s)
Ion limited value		2.0	6.0	3.0	3.0	NA	3.0	3.0	Cleaning	>60
1	contaminant	6.85	2.71	0.33	3.89	78.25	4.91	7.94	Smudginess	19
2	contaminant	8.59	2.36	0.12	4.56	63.29	3.22	8.58	Smudginess	11

2.2 Optimization of tire pressure sensor manufacturing process

2.2.1 Optimization of PCB bare board cleaning process

After ion chromatography test for PCB bare board of existing cleaning process, the results showed that the content of Cl- ions and SO4- on the surface of the bare board are higher than the limited requirements and are judged to be dirty. The chloride content and sulfate levels which exceed the limited value constitute a high risk of leakage and corrosion (Vidalis J J et al., 2014). For the PCB bare board in this kind of ion level, the biggest possibility of the residue is tap water.

Table 2 The test results of existing cleaning technology PCB bare board C3

Test value unit: ug/in^2		**Ion chromatography test**							**C3 tester**	
Order	Sample	Cl^-	Br^-	$N0_3^-$	SO_4^{2-}	WOA	Na^+	NH_4^+	Result	Time (s)
Ion limited value		2.0	6.0	3.0	3.0	NA	3.0	3.0	Cleaning	>60
1	The exiting process PCB bare board	4.11	0.46	0.67	3.89	0	2.65	1.05	Smudginess	45
2		4.26	0.36	0.47	4.79	0	2.92	1.36	Smudginess	40
3		4.23	0.61	0.40	3.79	0	3.05	1.07	Smudginess	43

The research on tire pressure sensor PCB bare board support process found that PCB bare board were used DI water (deionized water) to clean in the other sites. The tap water was only used in the process of cleaning step. The specific process steps are: feed—rinsing by pressurized tap water—polish upper brush—polish lower brush—rinsing by medium pressure tap water--ultrasonic water washing-- rinsing by pressurized tap water--tap water washing--high pressure drying - hot air drying—material--packaging (Nagaraju M B et al.,2015). The removal for ion pollution from tap water is not as good as deionized water, and the content of its own chloride ion detection results are very high in the local tap water of PCB manufacturers. Therefore, it is necessary to optimize the process steps. The optimized PCB bare board was tested by the C3 tester and compared with the former result to confirm the optimization effect. The tap water cleaning in the molding process step is replaced by deionized water, and the step of cleaning with deionized water is added before the packaging (Esler D R, 2016). The specific route is shown in Fig. 1.

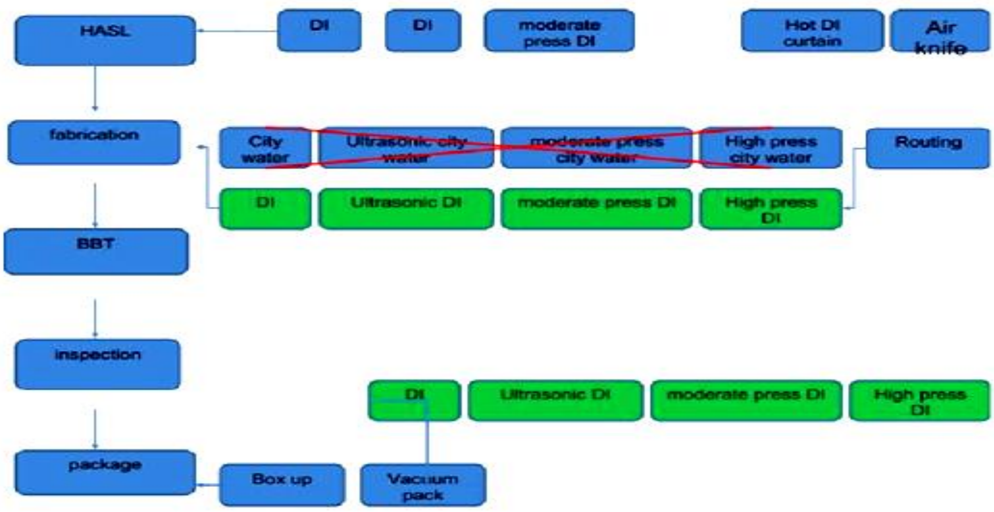

Fig. 1 DI water instead of tap water in circuit board molding process cleaning

2.2.2 Optimization of reflow soldering temperature curve

In the foregoing analysis, it is known that the assembled circuit board remains a large amount of WOA, sodium ions and ammonium ions after reflow soldering under the existing process conditions (Esler D R,2016).

The main source of these materials is the flux in the solder paste. Since the activation of the flux and the removal of the surface contamination are mainly achieved in the early stages of the insulationand the weldzone, it is necessary to optimize the process conditions of the two regions in order to improve the residual flux (Hufenbach W et al., 2013).

The main direction of optimization is to increase the activation time, and reduce the speed (ie, track speed) of PCB board by adjusting the heating model. At the same time, the appropriate adjustment of the insulation zone and the temperature of the welding area is is conducive to improve the quality of circuit board welding. Table 3 is the specific optimization details of furnace temperature curve parameters (Rendl K et al.,2015).

Table 3 The optimization subsidiary of furnace temperature curve

Optimization item	The original temperature curve	The temperature curve after optimization
Conveyor speed	80mm/mins	65mm/mins
Activation time	74~77s	105~111s
Refluxing time	62~67s	78～82s
Temperature setting for heat preservation zone	180℃ /205℃	175 ℃/ 200℃
Temperature setting for weld zone	215℃/240℃	215℃ / 245℃

2.2.3 Optimization of assembly process

The assembly of lithium battery in the tire pressure sensor assembly process is essential. The optimal solution is to replace the battery assembly from manual welding to automation equipment welding. This optimization can effectively avoid the premature failure of product caused by human operation on ESD, but also can effectively control the use of welding tin wire and tip temperature to reduce the use of flux within the solder flux and its residual on the PCB board (Kubba A E et al.,2016).

3 THE EXPERIMENT AND DISCUSSION OF RESULTS

3.1 The optimization result of bare board cleaning

Table 4 is the second ion chromatography analysis for PCB bare board after process optimization. Compared to the test result of PCB bare board ion chromatography before and after cleaning process optimization, we can clearly see that the contents of chlorine Ion and sulfate ion in optimized PCB bare board was significantly reduced. Theresult reached a limited value below the test, so the test is classified as "clean". At this level, it is possible to effectively avoid the risk of ion transport leakage after the assembly of circuit board (Deepika et al.,2012).

Table 4 Test results of PCB bare board C3 after cleaning process optimization

Test value unit: ug/in^2		Ion chromatography test							C3 tester	
Order	Sample	Cl^-	Br^-	$N0_3^-$	SO_4^{2-}	WOA	Na^+	NH_4^+	Result	Time（s）
Ion limited value		2.0	6.0	3.0	3.0	NA	3.0	3.0	Cleaning	>60
1	PCB bare bard after process optimization	1.12	0.81	0.35	2.42	0	2.05	2.18	Cleaning	163
2		0.81	0.47	0.47	1.89	0	2.56	2.25	Cleaning	180
3		0.88	0.44	0.46	1.70	0	1.89	2.44	Cleaning	124
4		0.63	0.66	0.41	2.99	0	2.19	2.75	Cleaning	159
5		1.80	0.49	1.02	2.52	0	1.76	2.31	Cleaning	112
6		0.68	0.49	0.29	0.96	0	1.58	2.76	Cleaning	180
7		1.28	0.73	0.46	2.46	0	2.1	2.63	Cleaning	180
8		1.06	0.7	0.52	1.87	0	1.35	3.01	Cleaning	180
9		0.65	0.77	0.44	2.85	0	2.43	2.88	Cleaning	155
10		0.96	0.65	0.38	2.89	0	1.65	2.42	Cleaning	180
11		0.70	0.71	0.42	2.98	0	2.13	2.86	Cleaning	180
12		0.96	0.75	0.65	2.39	0	2.03	2.57	Cleaning	107
13		1.27	0.73	0.67	2.92	0	2.62	2.29	Cleaning	180
14		0.52	0.75	0.39	2.79	0	2.81	2.79	Cleaning	180

3.2 Optimization results of reflow curve process

Using the same PCB and solder paste materials, the temperature curve before and after optimization was used for reflow soldering, respectively (Kim J K et al.,2013). The results of the original reflow soldering process showed that there is a certain amount of flux residue on the 1C pin. The optimized soldering effect is that the pins on the same position are bright without flux remains (Zhang J et al.,2014).

Table 5 showed the results of ion chromatographic analysis of the assembly circuit board in existing process conditions. There are eight samples, and five of the test results and the contaminants of the pollutant ion content results are very similar. In order to verify the effect of process optimization, the PCB bare board optimized by thecleaning process was burnt in the temperature curve of reflow soldering after optimization. And then the C3 tester was used to do IC analysis (Wei C et al., 2012).The results showed that the ion residuals of all the 17 test samples were within the limits, and the results are "clean" (Table 6). The result proved the effectiveness of process optimization (Wang X et al.,2009).

Table 5 The test result of ion chromatography before the optimization of reflow soldering curve

Test vslue unit: ug/in^2		**Ion chromatography test**							**C3 tester**	
Order	Sample	Cl^-	Br^-	$N0_3^-$	SO_4^{2-}	WOA	Na^+	NH_4^+	Result	Time（s）
Ion limited value		2.0	6.0	3.0	3.0	NA	3.0	3.0	Cleaning	>60
1	Assembly circuit board in existing process	1.71	0.69	0.24	0.91	19.26	1.09	2.33	Cleaning	162
2		9.47	0.61	1.12	3.42	42.36	5.26	8.51	Smudginess	24
3		15.06	0.45	0.22	6.91	71.99	5.26	9.51	Smudginess	5
4		11.00	0.88	1.98	3.69	53.26	4.15	7.36	Smudginess	17
5		5.98	0.73	1.66	3.26	39.51	6.32	6.48	Smudginess	26
6		1.97	0.29	0.22	0.29	18.45	1.95	1.95	Cleaning	180
7		5.91	0.36	0.51	4.37	53.26	3.97	7.11	Smudginess	42
8		1.52	0.46	0.39	1.26	12.22	1.54	2.16	Cleaning	180

Table 6 The test result of ion chromatography after the optimization of reflow soldering curve

Test value unit: ug/in^2		**Ion chromatography test**							**C3 tester**	
Order	Sample	Cl^-	Br^-	$N0_3^-$	SO_4^{2-}	WOA	Na^+	NH_4^+	Result	Time（s）
Ion limited value		2.0	6.0	3.0	3.0	NA	3.0	3.0	Cleaning	>60
1	PCB bare board cleaning optimization and assembly circuit board after the optimization of reflow soldering process	1.43	0.51	1.11	0	2.54	0.99	0.81	Cleaning	106
2		1.34	0.61	0.50	0	3.34	0.98	0.96	Cleaning	177
3		1.14	0.82	0.67	0	4.36	0.86	0.99	Cleaning	180
4		1.08	0.78	0.43	0	3.26	0.94	1.60	Cleaning	180
5		1.32	0.51	0.67	0	4.22	0.87	1.48	Cleaning	169
6		1.25	0.70	0.40	0	2.43	0.98	1.02	Cleaning	180
7		1.26	0.54	0.88	0	2.82	0.87	1.44	Cleaning	180

8		1.40	0.61	0.67	0	3.87	0.91	2.28	Cleaning	180
9		1.32	1.29	0.73	0	7.01	1.02	1.87	Cleaning	180
10		1.33	1.15	0.60	0	2.76	0.85	1.31	Cleaning	179
11		1.06	0.76	0.49	0	3.01	0.96	0.78	Cleaning	180
12		1.90	0.76	1.11	0	2.71	1.01	0.77	Cleaning	180
13		1.63	0.81	0.52	0	3.10	1.11	0.89	Cleaning	178
14		1.27	0.81	0.85	0	3.04	1.02	1.01	Cleaning	180
15		1.70	0.85	0.56	0	2.78	1.13	0.87	Cleaning	180
16		1.05	0.69	0.84	0	5.25	1.03	1.64	Cleaning	180
17		1.36	1.39	0.77	0	4.18	1.32	2.17	Cleaning	180

4 CONCLUSION

In this paper, the analysis of the contaminants of the defective products was carried out first. Based on the pollution sources, the PCB bare board cleaning, the reflow temperature curve of circuit board and the product assembly process are optimized, and the optimization results is validated by experiment (Nagaraju M B et al.,2015). In PCB bare board cleaning process, the tap water is replaced by deionized water to cleaning before the packaging, which can effectively reduce the content of halogen ions and sulfate ions. The optimization for the reflow process and assembly process can reduce the content of halogen ions in the finished product, and also can effectively reduce the content of weak organic acid. In addition, it can reduce the surface residue of flux.

Although this paper has made some achievements in product failure research and optimization of the whole tire pressure sensor manufacturing process, it is limited by its own knowledge reserve and research ability, and the hasty caused by time constraints. Currently, the optimizaiton is carried out in part of manufacturing process only through some theoretical basis and experience accumulation. In the process of experiment verification, the optimization for parameters has not been applied to the orthogonal experiment. The subsequent optimization for products will extend the direction to the wiring of the circuit board and the percentage of flux in the solder paste, as well as the optimization of the DFM design. It can further enhance the product quality and service life to improve the product competitiveness.

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