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Research on improving cleanliness level based on the process of extraction and analysis of impurity particles of automobile engine

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Abstract. Based on the case of the oil-gas separator for engine parts, this article has found the key steps to improve the cleanliness level by extracting and analyzing the impurity particles on its surface, and has reached the limit requirements in the enterprise standard. The whole detection process is divided into two parts: particle extraction and analysis. The impurity particles on the surface of the sample are extracted and collected by pressure washing, and the weight and size of the impurity particles are analyzed using a high-precision balance and a microscope. The test results show that the weight of the impurity particles on the surface of the oil and gas separator is 1.68 mg, and the maximum particle size is 887.31 μ m, which does not meet the product standard requirements. Through the analysis of the actual situation of the case to find the reasons and formulate measures, the final weight of the impurity particles on the surface of the improved sample is 1.22mg, and the maximum particle size is 481.40 μ m, which effectively improves the cleanliness level of the oil and gas separator.

1 Introduction

In recent years, with the development of automotive technology, the quality of automotive products has received widespread attention[1]. Cleanliness refers to the degree of fine particles remaining on the surface of the product, which is generally measured by the type, size, and weight of the impurity particles[2]. The cleanliness of the engine refers to the cleanliness of the whole machine and its parts. It is an important index to evaluate the quality of the engine and is closely related to the life and reliability of the engine[3]. If the cleanliness of the engine is poor, it will increase the friction between the parts, which may cause the engine to pull cylinders, damage the parts and even affect the normal operation of the whole machine[4]. Strengthening the control of engine cleanliness helps reduce the probability of failure, thereby increasing the life of the whole machine, and ultimately achieving the goal of reducing costs and improving product quality.The engine is the main

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component of a car. The quality of the car engine directly affects the overall quality level of the car, customer satisfaction and the company's economic benefits, and the cleanliness index has a direct impact on the overall quality and reliability of the engine[5]. Therefore, in addition to the management of conventional items such as engine parts materials and processing dimensions, engine manufacturers must also strengthen the control and management of engine cleanliness.

The automobile manufacturing, internal combustion engine manufacturing and related industries, in order to meet the increasingly stringent requirements of motor vehicle energy saving, emission, safety and other regulations, cleanliness, a quality indicator closely related to product performance, has received more and more attention[6]. It must be pointed out that how to effectively and targetedly improve the level of cleanliness is a very important part[7]. Based on the case of the oil-gas separator of an engine component, this article points out a more effective way to improve the level of cleanliness by extracting and analyzing the impurity particles on its surface.

2 Test device and method

2.1 Test device

2.1.1 Test plan

At present, the methods for extracting particulate matter mainly include spray washing, lavage, dissolution, air purging, air penetration, ultrasonic cleaning and shaking, etc., which are selected according to the characteristics of the tested product [8]. In this experiment, the pressure washing method was used to extract the particles on the surface of the oil-gas separator.

Figure 1 shows a diagram of the particle extraction device, which is currently used for cleaning parts. It not only has the functions of cleaning liquid recovery and regeneration, but also adds refined functions that can meet the needs of contemporary cleanliness extraction tests, mainly including:

(1) The spray pressure of the cleaning liquid can be set and adjusted within the range of 0~600 kPa.

(2) The flow rate of the cleaning fluid for each (kind) part can be preset. For example, the cleaning of a certain engine cylinder requires 10 L of cleaning fluid, the connecting rod requires 3 L, and the smaller bolt only requires 1 L, and so on. As long as these data (including the spray pressure) are pre-set, in the specific operation, only the part name is input, and the quantitative cleaning under the specified spray pressure can be automatically executed.

(3) The cleaning of the test work area, that is, around the side wall of the cleaning tank, can be automatically completed.

(4) An air curtain system is installed in the work area. During spray washing, filtered clean air can be blown down from the top of the tank, and there is an exhaust pipe at the front of the cubic tank to draw air out, preventing particles and dust in the external environment from entering the work area[9,10].

Fig. 1. Physical picture of washing machine.

Figure 2 shows a typical high-performance particle size analysis microscope, which is actually a fairly complete cleanliness analysis system. Through the configured automatic stage, bright/dark field observation optical system, PC and corresponding software, it not only has a high degree of automation, repeatability, and reproducibility, but also can meet different needs and cleanliness Standards require selection and setting, targeted analysis and evaluation. Finally, through the image splicing of the entire area of the sample, an analysis report according to a certain standard is automatically generated, and a variety of clear image displays of the largest particles of different shapes, including metals, non-metals, fibers, etc., are attached[11].

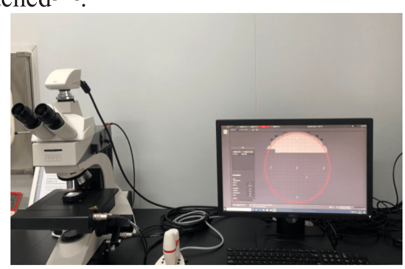

Fig. 2. Physical image of the microscope.

2.1.2 Test device

This article uses a washing machine produced by PALL, USA, which can ensure that the test is carried out in a relatively clean environment that will not introduce new impurities, but can also achieve adjustable pressure, and the inner wall can be automatically washed to avoid the loss of impurities in the tested sample. , Reduce the accuracy of the experiment. The ADP310C vacuum drying oven of Chongqing Yamato Company and the BSA224S precision balance of Sartorius Company were used to dry and weigh the filter membrane covered with impurities. A Leica microscope with automatic identification and counting functions is used to measure the number and particle size distribution of particulate impurities on the filter membrane.

Table 1. Main test equipment.

Equipment name	Equipment model	Manufacturer
Washing machine	PCC61-KC	PALL
Microscope	DM2700M	Leica Instruments GmbH
Vacuum drying oven	ADP310C	Chongqing Yamato Technology Co., Ltd.
Precision balance	BSA224S	Sartorius (Beijing) Co., Ltd.

2.1.3 Test sample

Figure 3 is the physical map of the oil and gas separator to be tested. It can be seen from the figure that this sample is mainly composed of plastic and only a small part of metal. Therefore, when choosing a cleaning solution, choose one that will not corrode plastics and metals. Solution, but also has strong cleaning ability, so we choose water-based neutral cleaning solution as the cleaning solution for this sample cleanliness test.

Fig. 3. Physical map of oil and gas separator.

2.1.4 Attenuation experiment

In order to extract the particles on the sample surface as fully as possible and collect them on the filter membrane, to ensure the effectiveness of the cleaning process and the correct evaluation of the cleanliness level of the sample to be tested, it is necessary to determine the extraction of the sample before testing the cleanliness level of the sample. Parameters [12.13]. Because the same workpiece uses different cleaning amounts for cleanliness testing, the collected residual particles are not the same. Therefore, even the same operator will have human deviation due to the difference in the amount of sprayed washing liquid, which is unavoidable. For this reason, in the VDA 19 and ISO 16232 standards, clear regulations are given. If the set amount of spray washing liquid is Q, when the spray volume of the cleanliness test is greater than or equal to Q, the collected residual particles The amount of error should be controlled within 10%[14,15]. Therefore, it is necessary to do an attenuation experiment before performing routine cleanliness testing, and determine the extraction parameters of the sample through the attenuation curve. The specific operation is as follows: place the filter membrane with constant weight on the filter holder, and then put the sample to be tested into the washing machine , Set the spray gun flow rate to 0.5L/min, the cleaning fluid volume to 0.5L, and the flushing time to 1min. Under these conditions, the surface of the sample is rinsed, and then the inner wall is rinsed automatically. After the cleaning solution is completely filtered, the filter membrane is taken out and dried and weighed.

Figure 4 shows the attenuation curve of the sample surface. It can be seen from the figure that after cleaning the sample for 6 times under this condition, most of the particles on the sample surface can be extracted, and the quality of the impurity particles obtained after the first cleaning is related to The total mass ratio of the 6 cleanings is less than 0.1, indicating that 90% of the impurities and contaminants have been cleaned. From this, it can be determined that the conventional cleanliness detection parameters of this sample are spray gun flow rate, cleaning fluid volume, and rinse time.

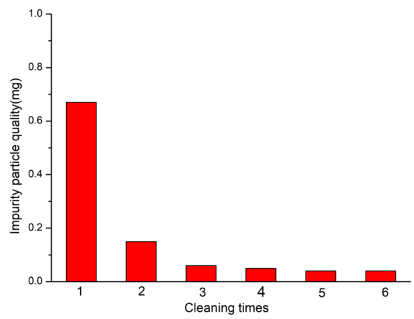

Fig. 4. Attenuation curve.

2.2 Test method

Figure 5 is a flow chart of the cleanliness test. First place the constant weight filter membrane on the filter membrane holder, use 2L cleaning solution to rinse the inner cavity of the washing machine when the sample is not put in, remove the filter membrane after washing, and put it in a vacuum drying oven at 90℃ dry it for 30 minutes, after it cools, weigh it and record the reading at this time as m_1, and m_1 minus the mass of the filter membrane is the mass of impurities in the blank test. Then put the sample to be tested into the washing machine, use 2L cleaning solution to rinse the surface of the sample to be tested, remove the filter membrane after rinsing and filtering, put it in a vacuum drying oven, and dry it at 90℃ for 30 minutes, and let it cool down. The weighing record reads m_2 at this time. M_2 minus the mass of the filter membrane is the mass of impurities on the sample surface. Finally, the filter membranes of the test sample of the blank test filter cartridge are placed under the microscope one after another, and the types and numbers of the blank test and the impurity particles on the sample surface are obtained after automatic scanning and analysis.

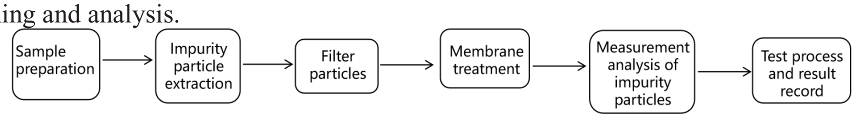

Fig. 5. Flow chart of cleanliness test.

3 Results and analysis

3.1 Surface cleanliness of oil and gas separator

3.1.1 Impurity quality

Table 2 shows the blank test and the weight of impurity particles on the surface of the oil and gas separator. For the measurement operation of the "blank value" before the test, it is necessary to perform a test on the working area of the equipment that does not contain the workpiece with the same flushing parameters to prove that its own cleanliness meets the requirements[16-18]. It can be seen from the table that the weight of the impurity contained in the blank test, that is, the washing machine is 0.12mg, which meets the cleanliness level of the measurement environment required by the enterprise standard. The measured weight of the impurity particles on the surface of the oil and gas separator is 1.68mg , It also meets the impurity quality limit of 2mg stipulated by the enterprise standard.

Table 2. Surface impurity quality of oil and gas separator.

Test sample	Test result/mg
Blank	0.12
1#	1.68

3.1.2 Particle size distribution of impurities

Table 3 shows the types and size distribution of the impurity particles on the surface of the oil and gas separator tested. From the table, it can be seen that the impurity particles on the surface of the oil and gas separator are mainly composed of metal and non-metal particles, most of which are non-metal particles[19-21]. There are only a few metal particles. The size of the largest non-metallic particles is grade J, ranging from 600μm to 1000μm. The size grade of the largest metal particles is H grade, ranging from 200μm to 400μm.

Table 3. Particle size distribution of impurities on the surface of the oil and gas separator.

Size Class	B	C	D	E	F	G	H	I	J
Length $Ferret_{max}$(μm)	5≤X ＜15	15 ≤X ＜ 25	25 ≤X ＜50	50 ≤X＜ 100	100 ≤X＜ 150	150 ≤X ＜200	200 ≤X ＜400	400 ≤X＜ 600	600 ≤X ＜1000
Blank Value	80	73	2	0	0	0	0	0	0
Total particles	2555	2006	1714	385	77	25	9	0	1
Metal particles	0	2	3	0	1	2	2	0	0
Non-metallic particles	9487	8455	9626	1282	102	30	20	0	1

Figure 6 shows the overall view of the analysis filter membrane and the morphology of the largest particles on the surface of the oil and gas separator. The largest particles on the surface of the sample in the picture are non-metallic particles with a particle size of about 887.31μm.

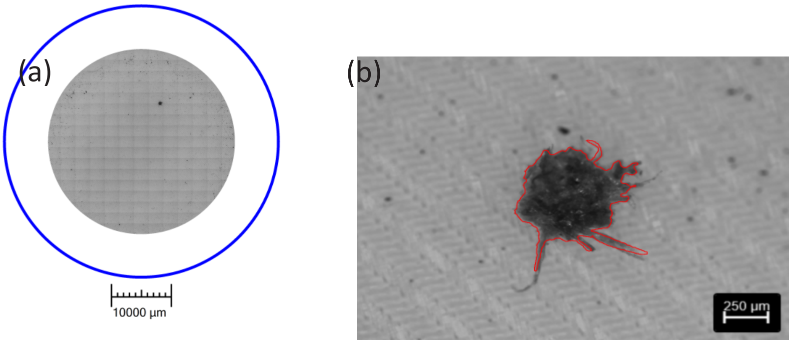

Fig. 6. (a) Analyze the overall view of the filter membrane; (b) the largest particle morphology of the sample surface.

4 Analysis of factors affecting cleanliness

Judging from the cleanliness test results of the sample, the quality of the contaminants contained on the surface is within the limit required by the standard, but the particle size of the contaminants exceeds the limit required by the standard. This may also cause a certain risk to the normal operation of the product in the future, which may affect the life of the engine[22-25].

After analyzing the low level of cleanliness of the sample, there are two main reasons. One is that the test sample has introduced large-particle contaminants during the production process and has not been removed; the other is that the sample on the production line is transported from the packaging to the Contaminants were introduced during the site inspection

In order to further determine the reason why the cleanliness level of the samples did not meet the standard limits, we selected samples from the same production batch for cleanliness verification tests.

5 Verification of the cleanliness of the oil and gas separator

5.1 Comparison of surface cleanliness of oil and gas separators in different packages

5.1.1 Impurity quality

Figure 7 is a comparison chart of the quality of impurity particles on the surface of oil and gas separators produced in the same batch and packaged to different degrees. Among them, 1# sample is the sample tested before, 2# is the sample produced in the same batch as 1# without good packaging, and 3# is the sample with good packaging produced in the same batch of 1# and 2#. It can be seen from the figure that the quality of impurities contained in the surface of 3# well-encapsulated samples is relatively small. Compared with 1#, the quality of impurities and contaminants contained in 2# is similar to that of 1#, indicating that it is necessary to ensure the cleanliness of the sample. The degree level must be encapsulated to a certain degree as much as possible before the sample is transported to prevent the introduction of new impurities from the sample from the production to the market, and increase the probability of failure.

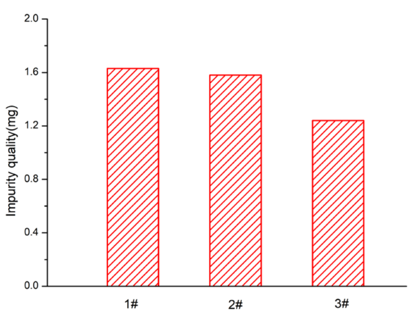

Fig. 7. Comparison of surface impurity quality of several samples.

5.1.2 Comparison of impurity particle size

Table 4 shows the comparison of the particle size of the largest impurity particles contained on the sample surface of the three oil and gas separators of 1#,2#,3#. It can be seen from the table that the size of the largest impurity particle contained on the surface of a well-encapsulated sample is 481.40μm, and the size of the largest impurity particle contained on the surface of a sample that has not been well-encapsulated is 1895.47μm, which also exceeds The particle size of the largest particle allowed by the sample further verifies that the large-size impurity particles contained on the surface of the sample are from the impurities introduced during the transportation of the sample, and not directly from the sample itself on the production line.

Table 4. Comparison of the largest particle size on the surface of the oil and gas separator.

Sample	Maximum particle size/μm
1#	887.31
2#	1899.47
3#	481.40

Figure 8 (a1) and (b1) are the overall picture of sample 2# analysis filter membrane and the topography of the largest particle contained on the surface of sample 2#, and (a2) and (b2) in Figure 8 are sample 3# respectively Analyze the overall picture of the filter membrane and the morphology of the largest particles contained on the surface of sample 3#. From figure (b1), it can be seen that the largest particles on the surface of sample 2# are non-metallic particles with a particle size of about 1895.47μm. Figure (b2) shows that the largest particles on the surface of sample 3# are non-metallic particles with a particle size of about 481.40μm.

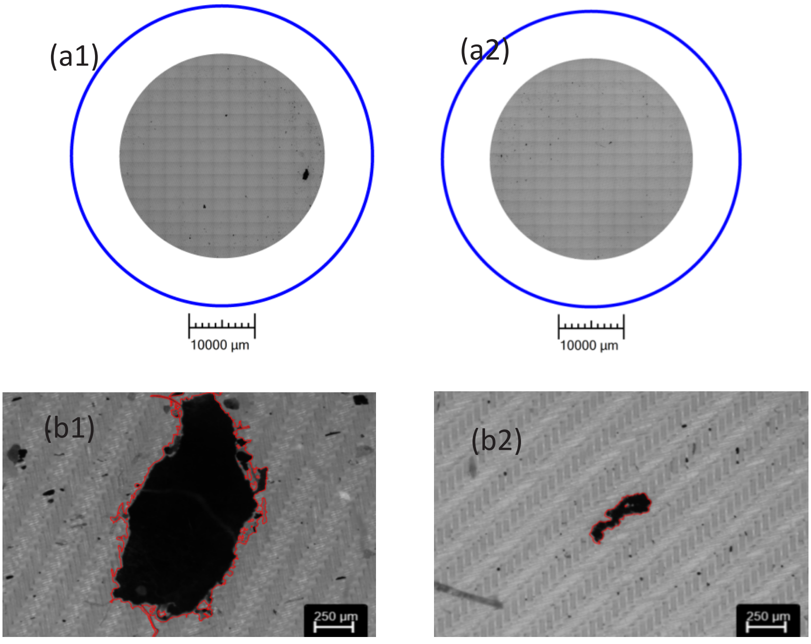

Fig. 8. (a1) 2# sample analysis filter overall picture; (a2) 3# sample analysis filter overall picture; (b1) 2# sample surface maximum particle morphology diagram; (b2) 3# sample surface maximum particle morphology Figure.

6 Conclusion

Based on the case of the oil-gas separator for engine parts, this paper draws the following conclusions by extracting and analyzing the impurity particles on its surface:

Using 2L cleaning solution, pressure flushing the sample for 4 minutes at a spray gun flow rate of 0.5mL/min, then the impurity particles on the surface can be extracted;

(2) The measured mass of impurities contained in the surface of the oil and gas separator sample is 1.68mg, and the particle size of the impurities is in the range of 5-1000 μm. Among them, the largest impurity particles contained in the sample are non-metallic particles with a particle size of approximately 887.31 μm, which does not meet the requirements of the enterprise. The maximum size of the impurity particles on the surface of the sample cannot exceed 800 μm, which does not reach the cleanliness level of the factory sample.

(3) The reason for the low level of cleanliness of the sample verified by further experiments comes from the fact that it is not well packaged during transportation, which results in the inclusion of larger-sized particles.

(4) The impurity mass on the surface of the well-encapsulated sample is 1.22mg, and the size of the largest particle contained on the surface is 481.40 μm, which has reached the cleanliness level required by the sample, indicating that good packaging is important for maintaining the cleanliness level of the sample The role of.

(5) In order to avoid contamination of the inspected parts during transportation, a dedicated fully-sealed trolley must be used. In addition to the basic requirement of effectively isolating and sealing from the outside world, this special transport trolley should also possess the following three points[26,27]:

a. The internal structure of the trolley needs to take into account the shape of the workpiece, and can hold some parts to the maximum. In terms of these two points, trolleys are generally divided into two categories, namely, shaft parts and box parts. When the size of the workpiece is small and the weight is lighter, it can also be made into upper and lower layers; this lower layer puts larger and heavier parts, and the upper layer puts smaller and lighter parts.

b. It must be ensured that the parts will not collide with each other during the conveying process, and that the wear of the contact part caused by the support of the workpiece will not occur. It is necessary to prevent damage to the important working surface of the part. For this reason, engineering plastics should be used to make the support Body, its shape also needs to match the part.

c. The inside of the trolley must be kept clean, and it must be cleaned after each use. In fact, except for very rare cases, the so-called sealed car cannot be completely isolated from the external environment. Therefore, all parts to be tested for cleanliness, regardless of size, metal or non-metallic materials, must be individually packaged.

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