

Development of a High-Filtration-Ratio Automatic Transmission Fluid Strainer

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ABSTRACT

This development project approached the objective of maintaining automatic transmission (“AT”) functionality by focusing on the filtration ratio of the automatic transmission fluid (“ATF”) strainer with respect to contaminants that are primary factors in reducing the operating accuracy of the oil pressure control valve. First, a filter medium was developed that raised the one-pass filtration ratio for contaminants 10 - 40 μm in diameter to twice the ratio achieved by the current nonwoven fabric used. Next, the filter medium was made with pleats so that it would prevent both the increase in pressure loss and the reduction of dust holding capacity in the filtration area required. In order to prevent the pleats from adhering, a lattice-shaped net was bonded to the front of the filter medium, the molded plastic element was clamped inside a plastic case that fits over the top and bottom, the outer edges were vibration welded, and the filter was put in place. The results from application showed that this ATF strainer was able to achieve a 50% increase in the quantity of contaminants that the oil pressure control valve for an AT can tolerate while maintaining its normal operating accuracy.

1. Introduction

In response to the market demand for improvements to automatic transmission function, an effort has been made to be more accurate than conventional models by means such as the use of multiple linear solenoids in the gearshift or lock up clutch volume controls. At the same time, it is necessary to take measures to prevent function deterioration, which leads directly to customer complaints. One of the causes for deterioration is a drop in operating accuracy of the oil pressure control valve due to contaminants. Considering that at present it is extremely difficult to completely prevent contaminants from being mixed in during manufacture or generated during operation, it is important to effectively trap the contaminants with an ATF strainer.

In this project, a filter medium has been developed with an improved filtration ratio against contaminants that have a negative effect on the oil pressure control system. In addition, technology has been developed to hold the filter medium in an ATF strainer case that can be fitted in the current layout space. Furthermore, the effectiveness of this ATF strainer application was verified.

This report provides an outline of the technologies above.

2. Understanding the Current Situation

2.1. Analysis of Contaminants Causing the Problem

A breakdown analysis was made of actual linear solenoid valve bodies that caused concerns in oil pressure control

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valve operation. Figure 1 shows the results of totaling the number of incidents for each particle size of those particles causing problems. With the current non-woven fabric, 100% of particles with a particle size of 100 μm or more are trapped in one pass. Therefore, contaminants with a size less than 100 μm were totaled. The results show that those contaminants with a particle size of 10 - 40 μm , that is to say those that are roughly the size of the valve clearance, give the highest incidence rate due to contaminant entrapment. The necessity of increasing the filtration ratio against this particle size was very clear.

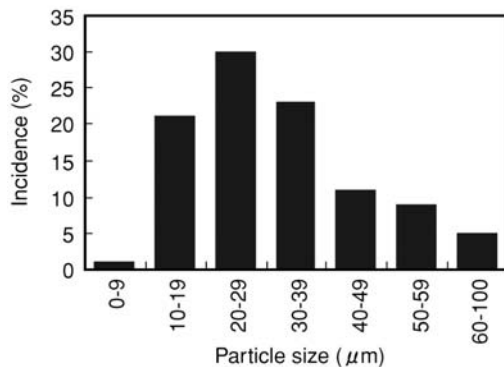


Fig. 1 Incidence of occurrence

2.2. Selection of Test Dust

In order to confirm the effect of countermeasures, it is necessary to select the test dust in advance. It is best if the selected test dust resembles the contaminants actually found in automatic transmissions as closely as possible.

Making a breakdown analysis of automatic transmissions driven in the normal market, the results of contaminant particle size distribution are given in Fig. 2. These results are the total of only those cases concerning automatic transmissions that were not reported as being caused by mechanical problems such as gear damage, etc. Even with new parts or after traveling long distances, there is no significant difference, and it was learned that contaminants were most closely approximated by the market test dust ACCTD (AC Coarse Test Dust).

For these reasons, ACCTD was selected as the market test dust.

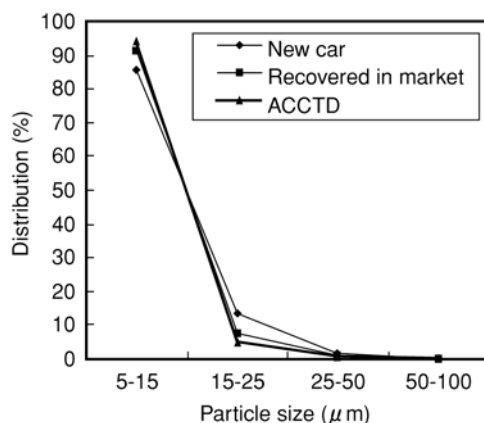


Fig. 2 Particle size distribution

2.3. Current Filter Medium and Filtration Ratio

Figure 3 shows the results of a one-pass filtration ratio test of the current non-woven fabric filter medium, using ACCTD. Focusing on the particles with a particle size of 10 - 40 μm , with one pass there is a filtration ratio of approximately 10 - 45%. It was clear that a new filter medium had to be developed, with a better filtration ratio against this particle size.

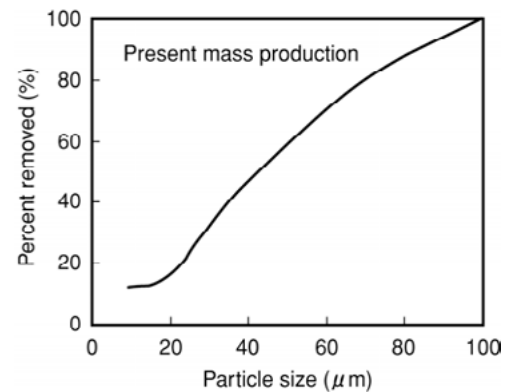


Fig. 3 Particle removal efficiency of filter medium

3. Basic Structure and Basic Performance

3.1. Development Aims

In this project, a filter medium was developed, and a method developed for holding the filter medium in the ATF strainer case.

The specific aims were as follows.

- (1) In comparison with the current non-woven fabric, increase the filtration ratio of contaminants having particle size of 10 - 40 μm .
- (2) As an ATF strainer, keep pressure loss to that with the current part, and maintain dust holding capacity to that of the current part or even better.

3.2. Composition of Filter Medium

The filter medium developed in this project has, in comparison with the current non-woven fabric, a mixed structure of four types of fiber with different components and fiber diameters.

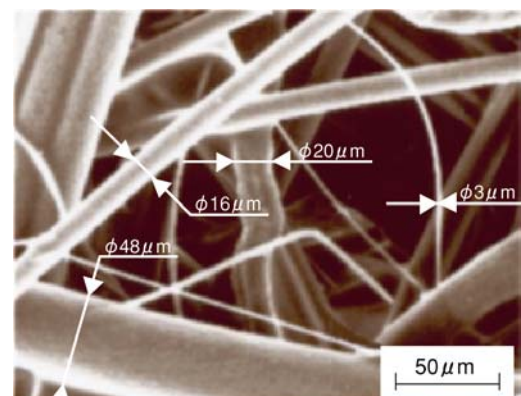


Fig. 4 Fiber composition of new filter medium

- (1) The filtration ratio is increased by making the filter openings smaller by using finer fiber.
- (2) Bulkiness is maintained with thicker fibers while at the same time, fluid passageway surface area is maintained with fine fibers, keeping down any increase in pressure loss.

Fiber composition of the new filter medium is shown in Fig. 4.

3.3. Improving the Filtration Ratio of the Filter Medium

Figure 5 shows the one-pass filtration ratio of the filter medium against the test dust with a particle size of 10 - 40 μm . The filtration ratio is twice that of the current non-woven fabric, and it is possible to reduce the amount of dust going through in one-pass by 40%.

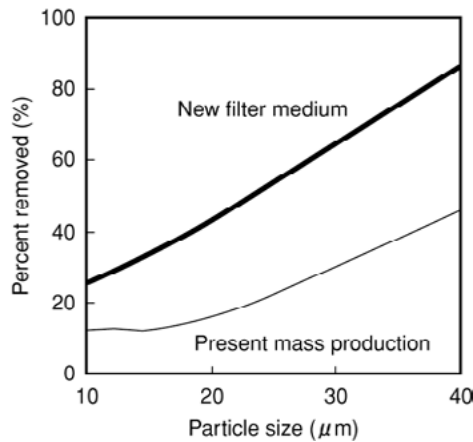


Fig. 5 Particle removal efficiency of filter medium

3.4. Required Effective Filtration Area

An increase in pressure loss and a drop in dust holding capacity, accompanying filter medium filtration ratio increases, will cause a drop in function. Therefore, it is necessary to maintain the required effective filtration area.

An ATF strainer jig was prepared having the same internal shape as the current product. Measurements were made of the relationship between filter medium effective filtration area and pressure loss, and the results are shown in Fig. 6.

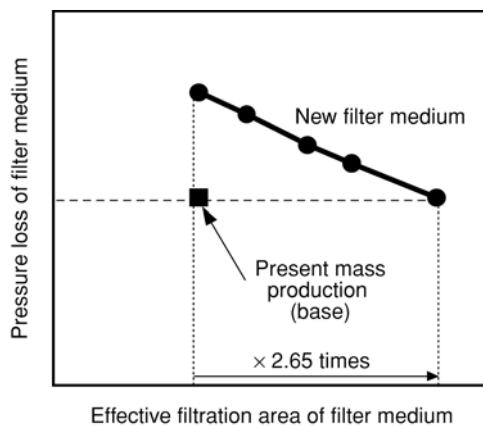


Fig. 6 Pressure loss of filter medium

From these results it is clear that in order to have pressure loss for the ATF strainer as a unit equivalent to that of the current product, the effective filtration area must be increased 2.65 times.

Figure 7 illustrates the concept of holding the filter medium.

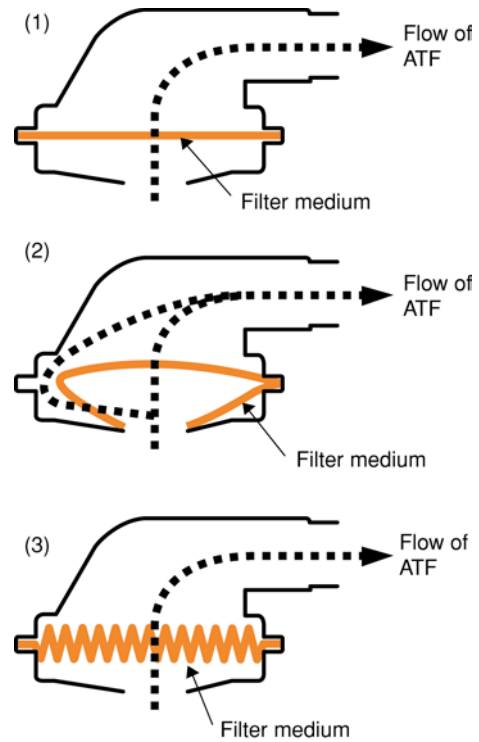


Fig. 7 Cross-sectional view of ATF strainer

In order to maintain an effective filtration area that is 2.65 times that of the current product, it is found that both (1) a single plate and (2) a folded bag shape as with the current part are not feasible. It is necessary to have (3) a pleated shape.

3.5. Maintaining an Effective Filtration Area

If the filter medium is simply pleated and held, when the ATF flow is large, or at low temperatures when viscosity is high, the resistance of the filter medium to the fluid flow

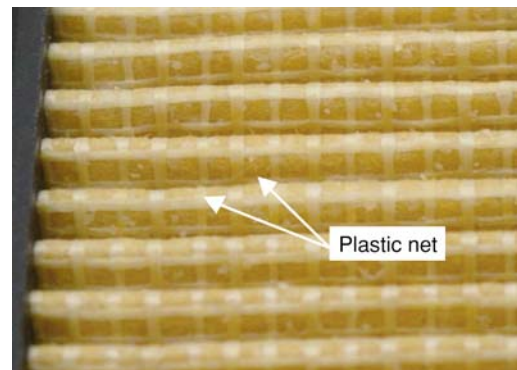


Fig. 8 Surface of new filter medium

becomes high, and there is adhesion of the pleats. If pleat adhesion occurs, the actual effective filtration area decreases, and there is pressure loss in the areas where pleat adhesion occurs, so it is not possible to adopt this type of high filtration ratio filter medium. In order to reliably maintain the pleated shape and prevent pleat adhesion, measures were taken to maintain the strength and stiffness of the filter medium itself, and to maintain the stiffness of the parts supporting the filter medium.

Concerning the filter medium, a plastic, lattice-shaped net was bonded to the surface on the ATF outlet side, and integrated with the filter medium. The filter medium surface appearance is shown in Fig. 8. The lattice pattern is the bonded plastic net.

Figure 9 shows how the filter medium strength is greater by bonding the plastic net. The results of a bursting strength test using a Mullen low-pressure tester, after the filter medium was immersed in 150 °C ATF for 100 hours, show that strength is increased by 5.13 times over what it was before the net was bonded. In addition, an increase of 19 times more than that of the current non-woven fabric filter medium was displayed.

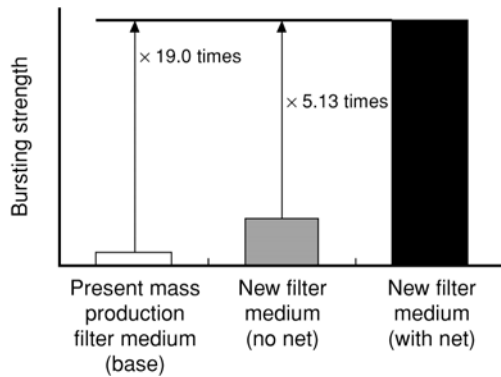


Fig. 9 Bursting strength of filter medium

To support the filter medium, an edging was created for the filter medium and a reinforcement rib was added perpendicularly through the ridges of the pleats. These form an integrated, molded plastic element. This plastic molded element is shown in Fig. 10. In the center, the reinforcement rib that is perpendicular to the filter medium ridgelines can be seen.

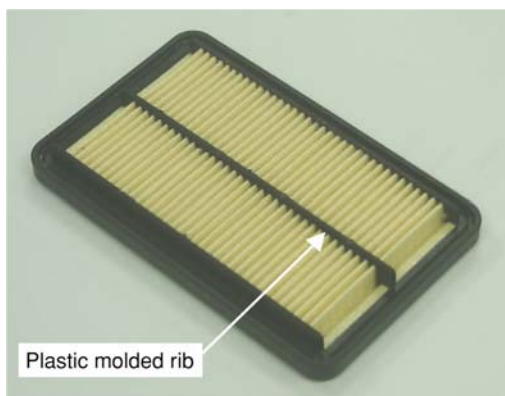


Fig. 10 External view of plastic molded element

3.6. Filter Medium Holding Method

The plastic element created is clamped in place by the plastic top and bottom cases, and the edging is vibration welded, holding the filter medium. This holding method is the first of its kind in the world for an ATF strainer.

The ATF strainer's structure is shown in Fig.11.

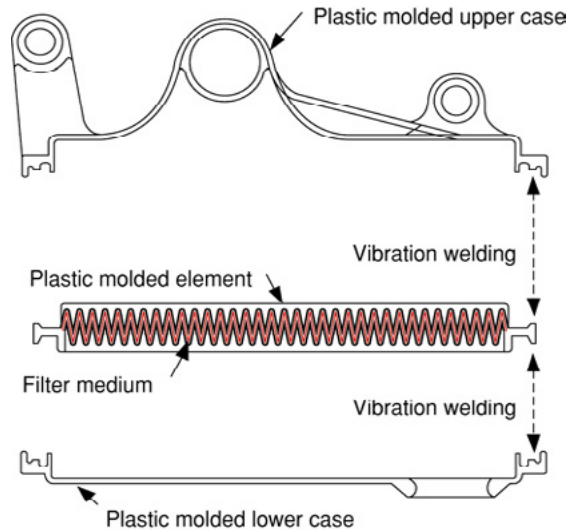


Fig. 11 Structure of new ATF strainer

The ATF strainer's appearance is shown in Fig. 12.



Fig. 12 External view of new ATF strainer

3.7. ATF Strainer Performance

Figure 13 provides pressure loss testing results, with ATF temperature parameters. The ATF strainer unit performance itself is equivalent to the current product. With the support countermeasures for the filter medium and the filter medium support parts, even when ATF flow is large or when viscosity is high and temperatures low, it is possible to prevent pleat adhesion.

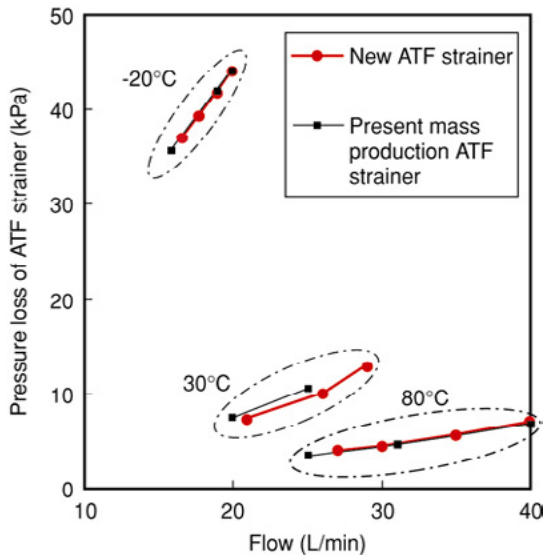


Fig. 13 Pressure loss of ATF strainer

The test results of dust holding capacity, or how much can be held until there is clogging, are shown in Fig. 14. It is clear that the ATF strainer unit can maintain a dust holding capacity that is 3.45 times that of the current product.

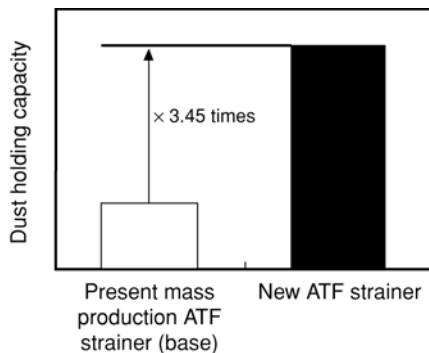


Fig. 14 Dust holding capacity of ATF strainer

From the results above, it was confirmed that a new ATF strainer has been developed with a better filtration ratio, yet having no negative effect on pressure loss or on dust holding capacity.

4. Confirmation of Application Effectiveness on Current Automatic Transmissions

4.1. Improved Multi-pass Filtration Ratio

A multi-pass test was carried out with the new ATF strainer fitted to a current automatic transmission, with all the

test dust introduced at the initial stage and the transmission operated. A comparison was made with the existing strainer, examining the drop in the number of particles having a size of 10 - 40 μm that reached the linear solenoid valve. These results are shown in Fig. 15. The effectiveness in reducing the number of particles passing through the filter medium in one pass was 40%, as shown in Fig. 5. As for multi-pass, with elapsed time, the effectiveness in reducing the number is better than with just one pass.

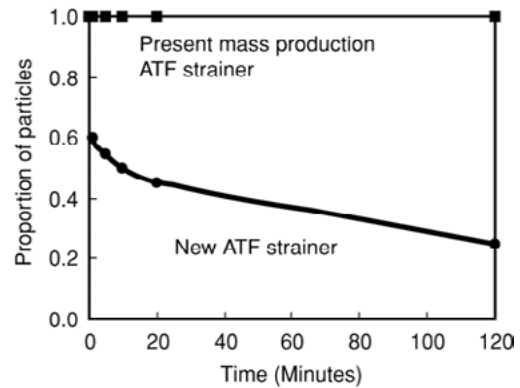


Fig. 15 Decrease of proportion of particles

4.2. Increasing the Tolerated Contaminant Amount

The new ATF strainer was fitted to a current automatic transmission and a certain amount of test dust was introduced at fixed intervals. A comparison was made of the tolerated amount of dust introduced enabling the linear solenoid valve operation accuracy to be properly maintained. The results of this comparison are given in Fig. 16. The amount of contaminants tolerated by the automatic transmission was increased by 50%, and this effect resembles that of the reduction in number of particles that pass through in multi-pass. From these results, the ATF strainer filtration ratio increase proved to be effective in supporting automatic transmission function in an environment with contaminants.

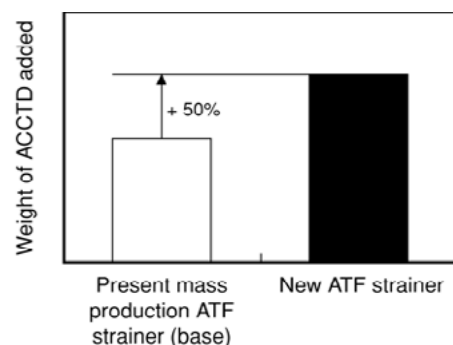


Fig. 16 Effect of lifetime extension by new ATF

5. Summary

By focusing on the ATF strainer's filtration ratio for contaminants and avoiding a drop in ATF strainer oil pressure control valve operation accuracy, the effectiveness of the new strainer in supporting automatic transmission function was verified. The following achievements were observed.

- (1) A filter medium was developed having a one-pass filtration ratio against contaminants having a particle size of 10 - 40 μm that was twice that of the current non-woven fabric filter medium. As a result, the number of particles passing through in one pass was reduced by 40%.
- (2) While this new filter medium was held in the ATF strainer case that fits in the current layout space, the filter medium was pleated in order to maintain the required effective filtration area. To prevent pleat adhesion, a lattice-shaped net was bonded to the surface of the filter medium, a molded plastic element was clamped by the plastic top and bottom cases, and the edging was bonded using vibration welding. By using this holding method, this ATF strainer, the first of its kind in the world, realized a totally new ATF strainer that has a better filtration ratio without having a negative effect on pressure loss or dust holding capacity.
- (3) As a result of the application of this ATF strainer, it was possible to increase by 50% the amount of contaminant tolerated in the maintenance of operation accuracy of the oil pressure control valve. Also, increases in filtration ratio confirmed to be effective in maintaining automatic transmission function in an environment with contaminants.

6. Acknowledgements

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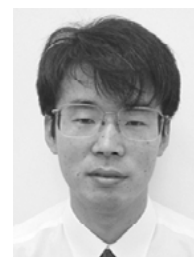
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