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Problems with the operation of automatic transmissions of AW 55-50 type

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Problems with the operation of automatic transmissions of AW 55-50 type

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Abstract. The five-speed automatic transmissions of the AW 55-50 type are widely used in cars. They are used in the transmissions of Opel, Renault, Volvo, Saab, Fiat (Alfa, Lancia), Nissan and GM. Various problems are observed in their operation. Some of the problems are mechanical in nature, requiring major repairs to the transmission. A common defect is a problem in the valve body, which does not require major repairs. Only the valve body is dismantled and repaired without dismantling the entire gearbox. This the report examines characteristics of the linear pressure solenoid (electronic pressure regulator), embedded in automatic transmissions of the type AW 55-50. For this purpose, made special hydraulic fixture with electronic controls, which imitate the work of this pressure regulator under real conditions.

1. Introduction

Automatic transmissions in vehicles have been known since the middle of the last century. During that time, they were hydraulically controlled. Gradually, electronics entered their control. The companies producing modern automatic transmissions use on-off solenoid valves and electronic pressure regulators in their control. Electronic pressure regulators are used not only to regulate the main pressure in older structures and working pressure to gear shifting elements, but for control pressures also. That is why several electronic pressure regulators are used in the control of modern automatic transmissions. Their number depends on the control organisation and varies between three and eight.

Five-speed automatic transmissions of AW 55-50 type are used for propulsion of vehicles with the following makes: Opel, Renault, Volvo, Saab, Fiat (Alfa, Lancia), Nissan and GM. Problems related to both mechanics and hydraulic control are observed during operation. This transmission is well known and there are developments of simulations of its operation [1,2]. It is possible to use deep learning-based cross-domain adaptation for gearbox fault diagnosis [3]. Material failure based information for designing vehicle transmission architecture is expounded in [4].

In this report, we will consider how to control gear shifting and the problems that arise during operation. We will discuss the possibilities to diagnose electronic pressure regulators and how to repair damages.

2. Explanation

The purpose of this study is:

1. To determine the condition of electronic pressure regulator.

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2. If the regulator is defective, it should be repaired, and its condition should be then tested on a stand.

Figure 1 shows a section of this automatic transmission and the elements involved in the operation of gears.

The transmissions of AW 55-50 and AW 55-51 type are used for both front-wheel drive and for all-wheel drive (4x4). During the operation, problems may arise. In some cases, additional sensors can be used for better diagnostics [5,6].

We will conditionally divide them into mechanical and electrohydraulic ones.

1. Mechanical problems:

1.1. Wear of multi-disc clutches and band brake.

1.2. Lock up wear in the torque converter.

1.3. Wear and roll of the bearing bushes on the shafts.

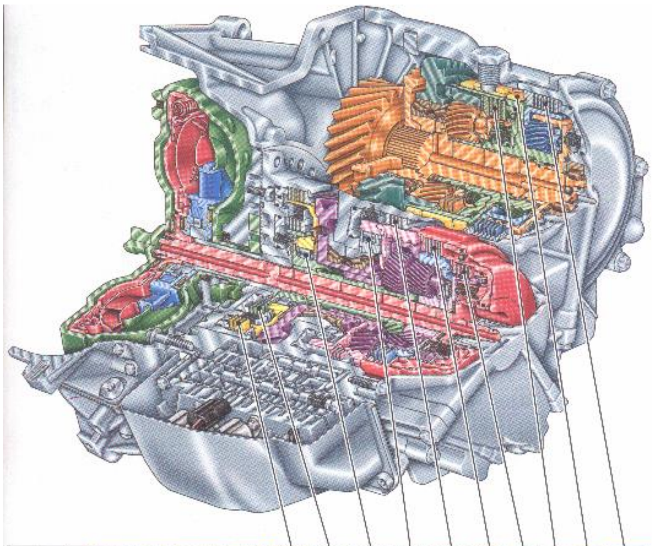
1.4. Wear and roll of the output shaft splines to the distribution box in all-wheel drive (4x4).

These mechanical problems are usually due to low oil levels or used oil (it is very common to avoid to replace the oil).

Mechanical problems are detected and eliminated when removing and disassembling the transmission.

Mechanical problems are often due to improper control operation (valve body).

Very often, problems are not found the mechanics, but only in the electrohydraulic control (valve body). This control is designed as a unit mounted in the transmission behind a protective cover. To resolve these problems, it is not necessary to remove the entire transmission, but only the hydraulic unit – figure 2.



RANGE	GEAR	RATIO	REV, 1ST SS VALVE (S1)	2-3, 3-4 SS VALVE (S2)	1-2, 2-3, REV SS VALVE (S3)	3-4, 4-5 SS VALVE (S4)	REVERSE SS VALVE (S5)	SECOND CLUTCH (B2)	SECOND COAST CLUTCH (B1)	SECOND CLUTCH SPRAG (F1)	LOW CLUTCH SPRAG (F2)	LOW AND REVERSE CLUTCH (B3)	FORWARD CLUTCH (C1)	DIRECT CLUTCH (C2)	4-5 CLUTCH (C3)	3RD GEAR BAND (B4)	1-5 REVERSE CLUTCH (B5)
PARK	P	—	OFF	OFF	OFF	OFF	OFF										APPLIED
REVERSE	R	3.177	OFF*	OFF	ON*	OFF	ON*					APPLIED		APPLIED			APPLIED
NEUTRAL	N	—	OFF	OFF	OFF	OFF	OFF										APPLIED
D	1	4.685	ON	OFF	ON	OFF	OFF				HOLDING		APPLIED				APPLIED
	2	2.942	OFF	ON	ON	OFF	OFF	APPLIED	APPLIED	HOLDING			APPLIED				APPLIED
	3	1.903	OFF	ON	ON	ON	OFF	APPLIED	APPLIED	HOLDING			APPLIED			APPLIED	
	4	1.301	OFF	ON	OFF	ON	OFF	APPLIED	APPLIED	HOLDING			APPLIED		APPLIED		
	5	1.000	OFF	OFF	OFF	ON	OFF	APPLIED					APPLIED	APPLIED	APPLIED		
	Emergency	1.000	OFF	OFF	OFF	OFF	OFF	APPLIED					APPLIED	APPLIED	APPLIED		
3	1	4.685	ON	OFF	ON	OFF	OFF				HOLDING		APPLIED				APPLIED
	2	2.942	OFF	ON	ON	OFF	OFF	APPLIED	APPLIED	HOLDING			APPLIED				APPLIED
	3	[illegible]	OFF	ON	ON	ON	OFF	APPLIED	APPLIED	HOLDING			APPLIED			APPLIED	
L	1ST	4.685	ON	OFF	ON	OFF	ON				HOLDING	APPLIED	APPLIED				APPLIED
	2	2.942	OFF	ON	ON	OFF	OFF	APPLIED	APPLIED	HOLDING			APPLIED				APPLIED

* If vehicle speed is above 7 km/h (4 mph), the TCM commands the shift solenoid valves to inhibit reverse.

Note: In case of solenoid failure, Emergency Modes are calibrated in the TCM to compensate for the components affected. See pages 45, 103, and 128A for more information on Emergency Modes.

Figure 1. AW 55-50 - mode of operation.

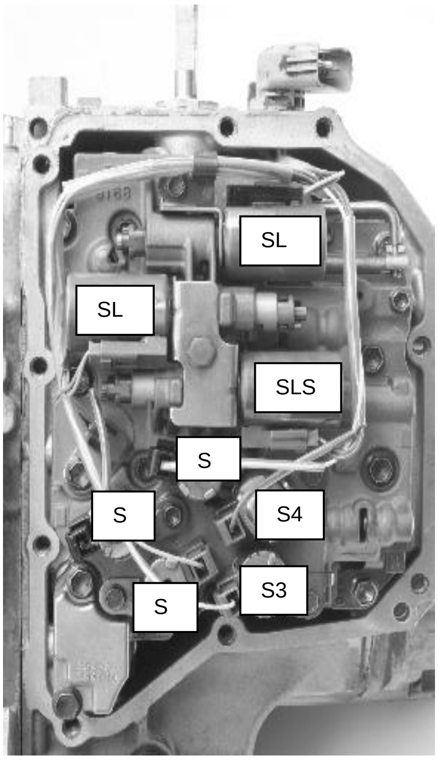


Figure 2. Solenoid valves.

2. Electrohydraulic problems:

2.1. Electrical disconnection of any of the solenoid valves, which is very rare. It is diagnosed with a tester.

2.2. Wear of certain control openings. it is diagnosed after disassembly and washing of the control unit, using vacuum test.

2.3. Mechanical locking of some of the five on-off solenoid valves (S1, S2, S3, S4, S5). It is checked by applying voltage to the solenoid valve; however, before doing that we should know which solenoid valve is normally open (NO) and which is normally closed (NC). This is a rare defect.

2.4. Mechanical locking of some of the three pressure regulators, also called "Linear pressure solenoid" (SLT, SLS, SLU). This is a very common defect. It is caused by: wear of the regulator bushings, contamination by wear products, used oil, wear of the needle and opening in the front or presence of antifreeze in oil. As a result, the regulators' performance changes and the transmission starts to slip and to shift the gears with shocks.

The most common and difficult to diagnose and resolve problems of those listed above in this automatic transmission model is the problem described in section 2.4.

SLT regulators (which control working pressure) and SLS regulators (which control switching pressure) have regression performance. SLU regulator (which controls lock-up clutch) has progressive performance. The three solenoid valves receive supply (inlet) pressure from one main. Depending on the control current, which they receive from the computer (TCM), the regulated solenoid valve outlet pressure must comply with the required performance, depending on the transmission mode of operation.

This performance is recorded on a stand, which must accurately imitate their operating modes in the transmission under conditions in which solenoid valves operate.

The record of this performance establishes the condition of solenoid valves and makes a conclusion about their reliability.

2.1. Operating principle.

The performance of modulating pressure is achieved by transmitting pulses from the controller, which controls the transmission (TCM), to the modulating valve according to a pre-set programme. The control signal consists of pulses of different duration (Duty cycle) at constant voltage of 12 volts and constant frequency.

The regulators, which we will test, operate at a frequency of 300 [Hz].

Figure 3. SLT with connection sleeve.

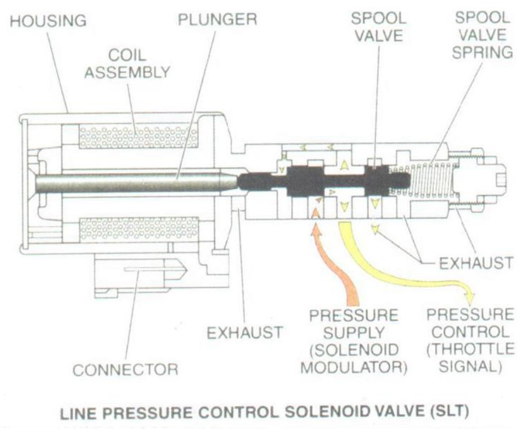


Figure 4. SLT and SLS solenoid valves.

Figure 3 shows SLT solenoid valve mounted on a specially designed sleeve with two nozzles (quick connections), with supply pressure being applied through the right nozzle, and modulating pressure being led from the left nozzle to a strain gauge (pressure sensor) - MPX5999D - [7] to register this pressure. The same pressure is also applied to a pressure gauge to visualise the process.

Figure 4 shows a section of SLT and SLS solenoid valves, which illustrates their operation mode.

The SLU solenoid has a different structure, and for its testing another sleeve with quick connections has been produced.

Power is supplied by an oil pump rotated by electric motor. Pressure gauge measures the supply pressure, which can be regulated. The used oil is ATF - oil for automatic transmissions.

The operating frequency and duty cycle are set by electronic system specifically designed for that purpose. In parallel to the produced signal, oscilloscope for control of control signal is connected.

2.2. Methodology of the Study

To test the performance of electronic pressure regulators, special stand [7], which simulates the real operating conditions of pressure regulator, was made.

6 electronic regulators were tested in the experiment.

Initially, their performance was recorded at room temperature - (18-22) ^{o}C and at operating temperature - (95-110) ^{o}C.

The obtained performance is indicated in tables 1 and 2, and characteristic diagrams are indicated in figures 5 and 6.

The solenoid valves were then repaired. The repair included opening (decapsulating) of the solenoid valve, cleaning of the work surfaces and replacement of bushings in which the coil anchor is mounted. The solenoid valve is opened and closed with the help of a special device that flares and rolls the coil with the control valve.

These solenoid valves have an adjusting screw – figure 4, which can compress or release the spring. Thus, we can correct the tested solenoid performance.

After the repair, solenoid valves are placed on the stand again and the characteristics of cold and hot oil are recorded. The obtained characteristics are compared and the condition of the repaired solenoid is evaluated. It is best to make a comparison with characteristics of a new solenoid valve. The results obtained are presented in table 3, and the characteristic diagrams are presented in figure 7. Solenoid valve performance after repair is shown only for hot oil in table 3 and in figure 7. Cold oil characteristics are also recorded. They are perfect.

Table 1. Data, cold oil t = 20^{o} C.

Duty[%]	SLT	SLS	SLU	SLT 1	SLS 1	SLU 1
0	6.22	6.08	0.07	6.17	6.13	0.07
4	6.22	6.06	0.07	6.17	6.10	0.07
9	6.06	5.95	0.07	6.04	5.99	0.07
15	5.48	5.37	0.27	5.48	5.46	0.18
20	4.97	4.91	0.78	5.06	5.04	0.62
25	4.37	4.33	1.42	4.51	4.53	1.22
29	3.66	3.64	2.18	3.88	3.93	1.91
34	2.04	2.02	4.11	2.38	2.42	3.66
40	1.33	1.33	4.66	1.60	1.64	4.46
45	0.78	0.82	5.46	1.00	1.02	5.28
50	0.64	0.40	6.08	0.18	0.18	6.48
54	0.58	0.18	6.59	0.07	0.07	6.95
59	0.09	0.07	6.66	0.07	0.07	7.35
65	0.07	0.07	6.97	0.07	0.07	8.10

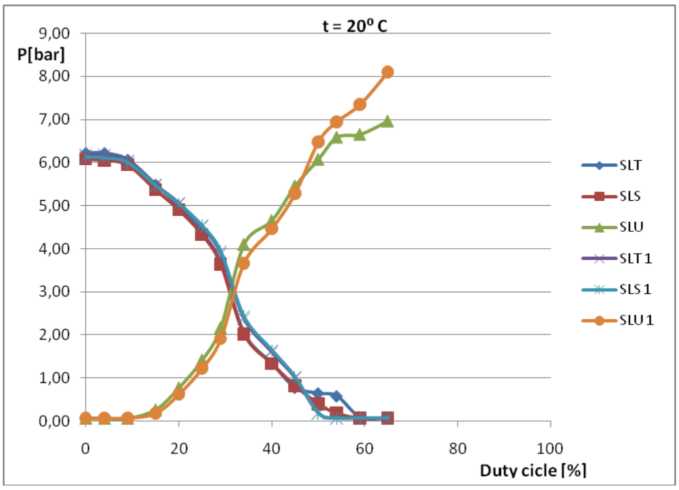


Figure 5. Characteristics - cold oil.

Table 2. Data, hot oil - t = (95-110) ° C.

Duty[%]	SLT	SLS	SLU	SLT 1	SLS 1	SLU 1
0	6.13	5.42	0.80	6.17	6.22	0.07
4	6.13	5.42	0.80	6.17	6.17	0.07
9	6.13	5.42	0.80	6.04	6.06	0.07
15	6.13	5.42	0.80	5.39	5.66	0.09
20	5.90	5.42	0.80	4.97	5.02	0.40
25	5.46	5.42	0.80	4.42	4.44	0.84
29	5.02	4.86	0.80	3.75	3.80	1.33
34	3.84	3.73	1.15	2.06	2.15	2.44
40	3.20	3.13	2.33	1.44	1.58	3.15
45	2.73	2.49	3.04	0.91	1.07	3.95
50	1.66	1.40	4.51	0.11	0.27	5.22
54	1.64	1.35	4.46	0.07	0.27	5.64
59	1.11	0.84	4.46	0.07	0.07	6.08
65	0.82	0.44	5.22	0.07	0.07	7.10

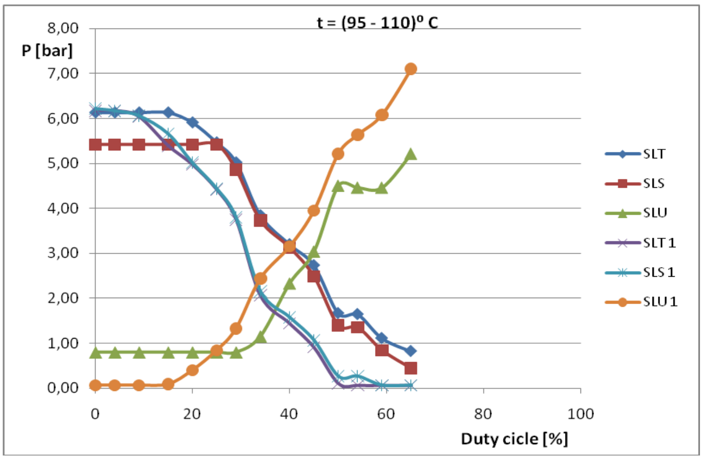


Figure 6. Characteristics - hot oil.

Table 3. Data, t = (95-110) ºC - after repair.

Duty[%]	SLT	SLS	SLU	SLT 1	SLS 1	SLU 1
0	5.86	5.77	0.07	5.82	5.77	0.07
4	5.84	5.77	0.07	5.79	5.75	0.07
9	5.73	5.68	0.07	5.66	5.66	0.07
15	5.46	5.44	0.11	5.39	5.42	0.13
20	5.17	5.15	0.36	5.08	5.13	0.44
25	4.75	4.75	0.84	4.66	4.73	0.95
29	4.26	4.26	1.38	4.15	4.26	1.55
34	3.64	3.62	2.22	3.51	3.66	2.35
40	2.84	2.84	3.06	2.69	2.89	3.24
45	2.04	2.06	3.88	1.91	2.13	4.11
50	1.29	1.27	4.77	1.18	1.35	4.97
54	0.75	0.69	5.39	0.67	0.78	5.55
59	0.27	0.24	5.86	0.22	0.31	6.06
65	0.07	0.07	6.46	0.07	0.07	6.59

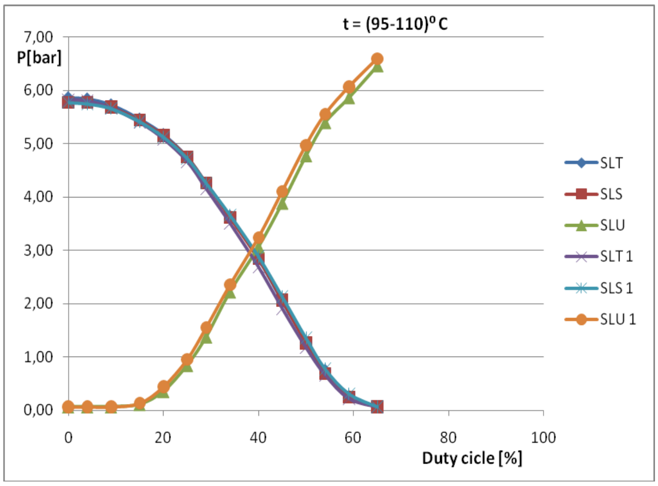


Figure 7. Characteristics - hot oil - after repair.

2.3. Analysis of the Test Results

The practice shows that when the oil is cold the transmission operates normally or with small deviations. The more the oil in the transmission warms up, the more the problems are exacerbated. This is also proven by the results obtained upon completion of the stand test of solenoid valves.

Figure 5 shows that when the oil is cold the pressure deviations are not very large. The two transmissions where solenoid valves are cold, behaved relatively well.

Figure 6 shows that when the oil is hot, large deviations in performance are observed in the first set of solenoid valves (SLT, SLS and SLU). The vehicle was unable move normally on the road. With the second set of solenoid valves (SLT 1, SLS 1 and SLU 1), the vehicle was moving, but the transmission shifted the gears with shocks and slips between gears.

After repair of the valve bodies and solenoid valves and their setting on the stand - figure 7, the transmissions of the two vehicles behaved normally during road tests.

3. Conclusion

The major observations and conclusions of this study are:

- By examining the performance of electronic pressure regulators on a stand, a conclusion about the regulator's reliability can be made.

- The nature of regulator's performance can explain the improper operation of the transmission in different modes of vehicle' movement.
- Electronic pressure regulators can be successfully repaired; however, after the repair, their performance must be checked again and set on the stand.
- The proper diagnostics and repair of the valve body and solenoid valves can save a lot of money, time and effort when repairing AW 55-50 type transmissions.

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