

## RVS TECHNOLOGY TEST ON A GEAR TRANSMISSION

### 1. General

The test gear was an educational one-gear transmission with oblique teeth, the gear ratio of which is 2.7. The transmission was loaded by a hydraulic pump, the pressure of which was 21 bar. The teeth of the gear were in a bad condition (worn and visible hollows on some of them).

The type of the electric motor was HXUR 182A2B3 and its power was 1.1 kW. The motor was loaded at almost maximum current that was at the beginning of the test only by 0.1 A lower than the set value of the over load protection system. The rotation speed of the motor was at the beginning of the test 1,451 l/min (24.10 Hz).

During the test the transmission was located in a room with a stable temperature.

### 2. The measuring methods and equipment

#### The measuring methods

The following measurements were taken during the test:

- measurement of the temperature of the transmission oil
- measurement of the current taken by the electric motor
- vibration measurements as follows:
  - measurement of the effective value of speed  $v_{rms}$  (vibration exertion)
  - measurement of acceleration (g) on the frequency band of 0-5,000 Hz
  - envelope measurement on the filtration band of 500-10,000 Hz

At the vibration measurements the results were also examined at time and frequency level.

The measurement of the temperature was taken directly in the transmission oil and the measuring equipment was on the entire time recording the temperature after every 12 seconds.

Other types of measurement were taken frequently.

#### Measuring equipment

An apparatus HYDAC HMG-2010 took the measurement of the temperature.

A vibration analyser SKF CMVA 60 took the vibration measurement and the data was recorded in a Prism<sup>4</sup> program.

A Microlog analyser took the measurement of the current taken by the electric motor and current tongs so that the stator current spectrum was measured on one of the phases of the power supply. The current was defined on the spectrum on the amplitude of the frequency of the net (50 Hz).

### 3. The test process

1. At first the transmission was run without the additive appr. 8 hours after which all the values were measured using all the methods.
2. Then the first treatment took place, after which the transmission was run appr. 5 hours.
3. After that the second treatment took place and the transmission was run appr. 24 hours.
4. At the end of the period of the second treatment the oil was changed and the third treatment took place.  
After the third treatment the transmission was run continuously appr. 72 hours.
5. After that treatment the oil was changed and the fourth treatment took place. After the fourth treatment the transmission was run continuously appr. a week, after which the final measurements took place and the test was finished.

*During the first and the second treatment the RVS additive was added twice the standard amount due to errors in the directions.*

### 4. The results of the measurements

#### General observations

After the second and the third treatments the oil got very dirty; for which reason the oil was changed.

About an hour after the first and the second treatment the overload protection system went off. One can conclude that the load of the transmission increased after the RVS was added.

The temperature of the transmission oil increased remarkably after the second treatment and stayed at that level during all the test period until the third treatment. After the third and the fourth treatments the temperature increased immediately until it started to decrease and reached a level below the level before the previous treatment. (Figure 1)

As one can observe on the results of the measurements, both the current taken by the electric motor and the values of the vibration measurement decreased after the first treatment but increased heavily after the second one. They started to evenly decrease after the third treatment towards the end of the test. (Figures 2,3,4,6)

On the figures of time level one can observe a clear change due to the decreasing impacts caused by the tooth contact and the decreasing tooth load. (Figure 5)

The speed of the electric motor increased during the test from the value of 1451 l/min to 1458 l/min.

#### 4.1. Temperature measurements

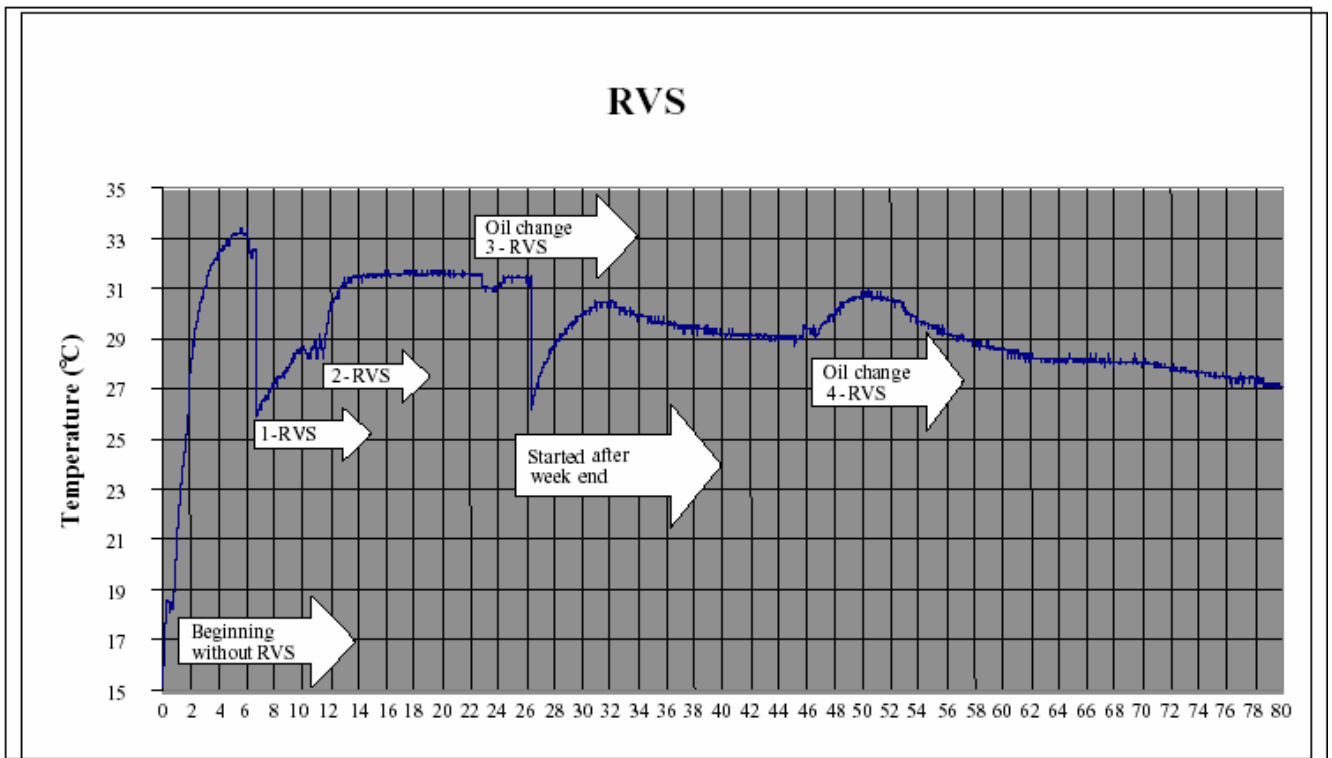


Figure 1: The transmission oil temperature changes during the test

The initial temperature before the RVS treatment was 33.1 °C and the final temperature at the end of the test after the fourth treatment was 27.3 °C. The temperature decreased by 5.8 °C during the test, which corresponds to a change of 17.5 %<sup>1</sup>.

It was noticed during the test that RVS has to work for 24-48 hours before its influence can be seen in the temperature values.

<sup>1</sup> Translator notice: It is not fair to indicate the temperature change in percent using 0°C as a comparing point. 0°C has nothing to do with the test. We have to use the temperature of the room where the transmission was located during the test. It has not been measured but we can define it approximately using the Figure 1, in which we see that the curve starts at 16 °C. If we use this value as a comparing point, the change corresponds to 33.9 %. Rautaruukki approved this point of view by telephone after this report had been written.

## 4.2 Vibration measurements

### 4.2.1 Vibration exertion

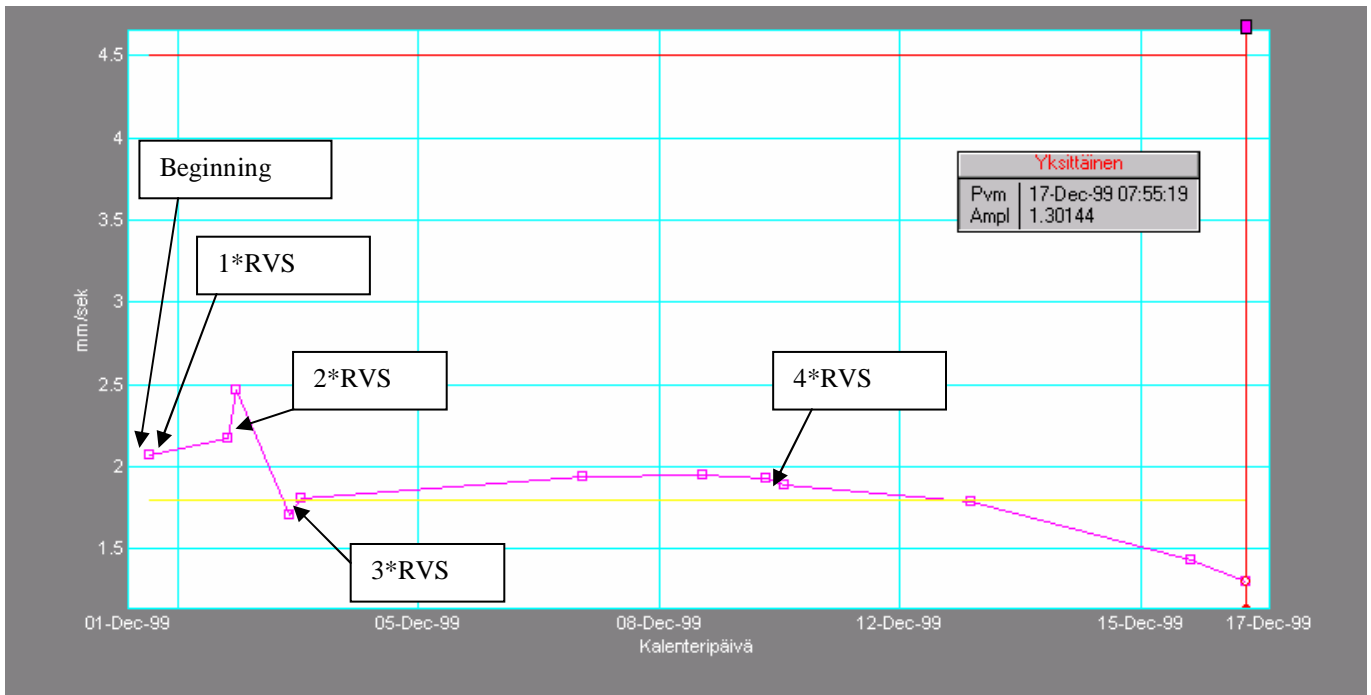


Figure 2: The change of the vibration exertion during the test

The vibration exertion has been measured as an effective value of the speed ( $v_{rms}$ ) on the frequency band of 10-1,000 Hz.

The total level of vibration has changed during the test from the value of 2.07 mm/s to 1.3 mm/s, which corresponds to a change of 37.1 %.

4.2.2. The total level of acceleration

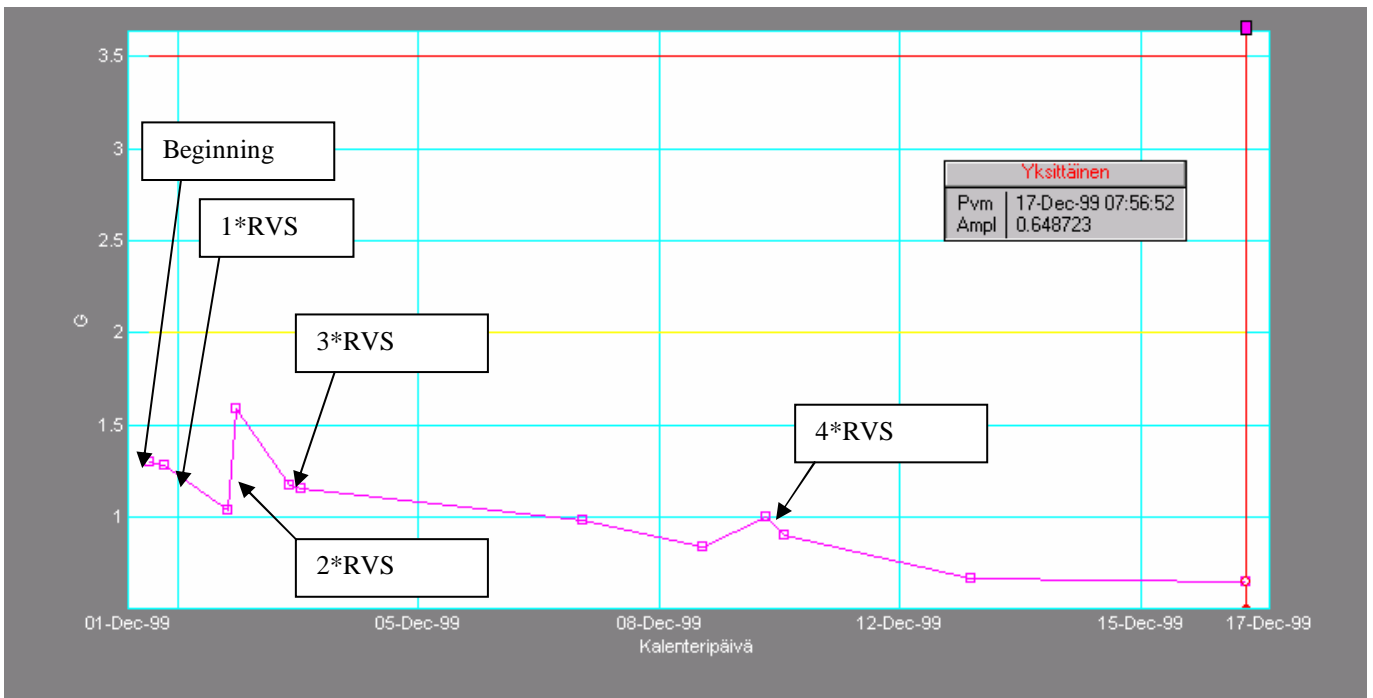


Figure 3: The change in the values of acceleration measurements during the test

The acceleration of vibration has been measured as an effective value of acceleration (g<sub>rms</sub>) on the frequency band of 0-5,000 Hz.

The total level of acceleration has changed during the test from the value of 1.3 g to 0.65 g, which corresponds to a change of 50 %.

4.2.3. The envelope measurements

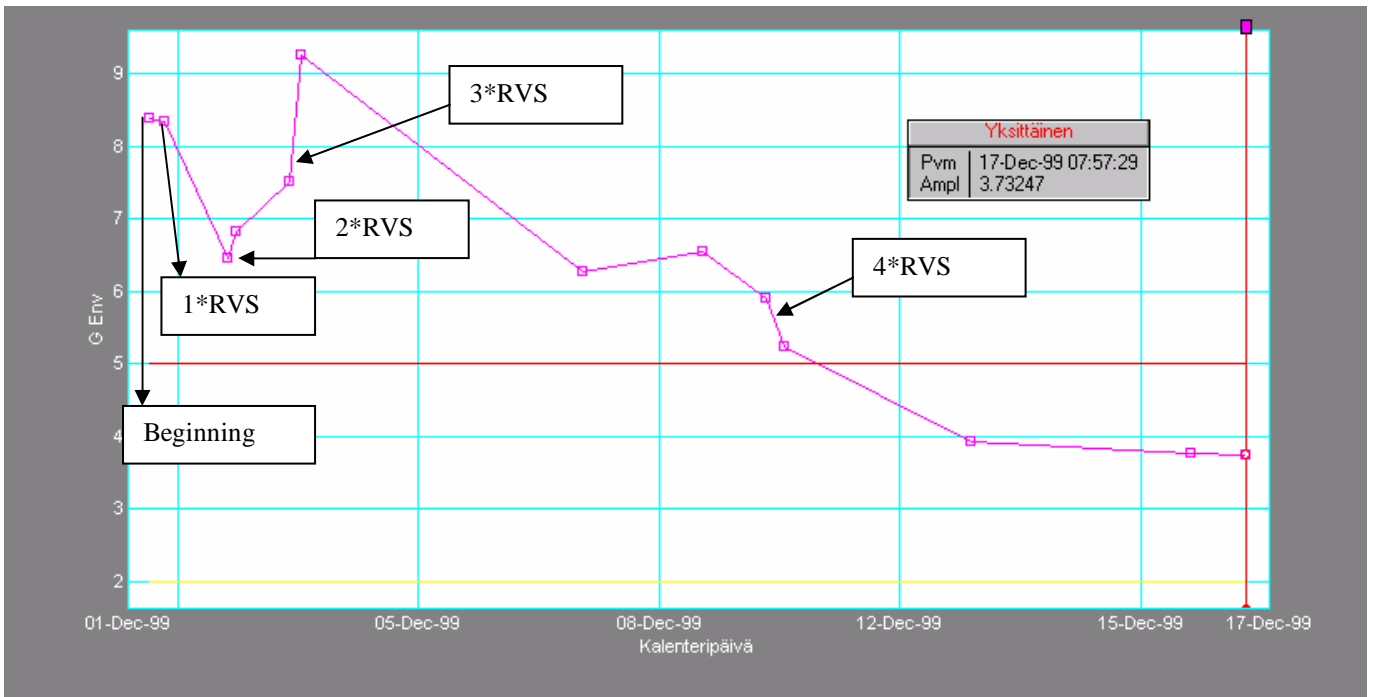


Figure 4: The change of the total level of the envelope during the test

The measurement has been taken as the maximum value of the envelope ( $g_{PK}$ ) on the filtration band of 500-10,000 Hz. The spectrum of the total level has been calculated and measured on the frequency band of 2-1,000 Hz.

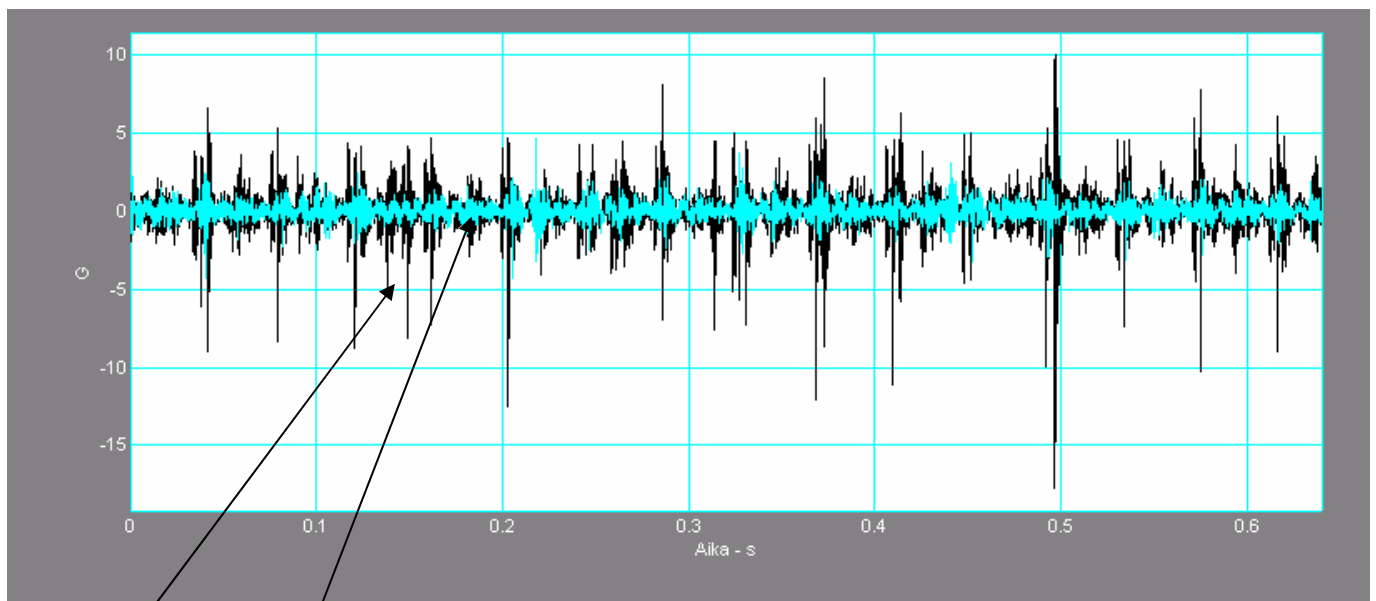
The values of the total level of the envelope have changed from the value of 8.4 g to 3.7 g, which corresponds to a change of 55 %.

#### 4.2.4. The measurements on the time level

By the measurements on the time level one can observe tooth contact of individual teeth, impacts caused by them and tooth loads. On the time level picture there is a signal directly from the acceleration bulb and every peak on it is caused by an impact caused by a tooth contact.

In this measurement there has been taken 0.64 seconds of time sample, which means in this case that there are 15.5 rotations of the primary axle of the transmission.

The measurements on the time level have not been taken as synchronized. This means that the impacts caused by different teeth are not at the same place on the screen of the time level.



Initial time level

Final time level

Figure 5: The time level before the RVS treatment (darker) and the one at the end of the test (lighter) one on the other

In the time level figures one can notice that the impacts caused by teeth in a bad condition have decreased remarkably during the treatment.

5. The measurement of the current of the motor

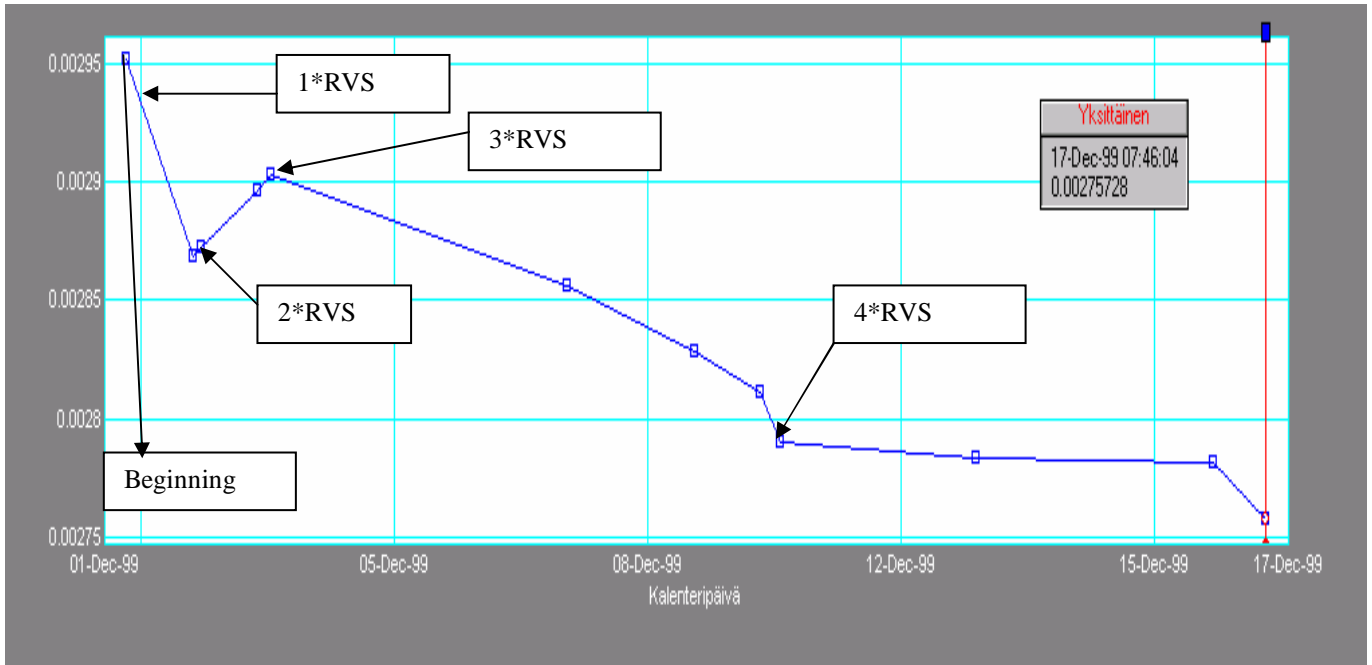


Figure 6: The change of the current taken by the motor during the test

The current taken by the motor has decreased during the test from the value of 2.94 A to 2.75 A, which corresponds to a change of 6.25 %.

The amplitude values on the Y scale of the diagram have to be multiplied by 1,000 (the transformer ratio of the current tong) in order to define the actual current taken by the motor.

6. Summary

All the values of all the measuring quantities have decreased compared to the initial values before the RVS treatment as can be seen in figures 1-6.

Visible changes began only to appear after the third treatment when the running hours between the treatments were increased. It seems, at least as far as it concerns this particular transmission, that the transmission has to be run after the treatment for over 48 hours before the changes in the measurement results were seen.

After the first treatment the running period was apparently too short as there was not seen any clear change.

After the second treatment all the measurement values increased and stayed on a high level during all the running period, appr. 24 hours. In this case the double dosing and/or too short running time may have had their influence on the values. The RVS specialists can perhaps give a more accurate explanation on this.