ANALYSIS OF THERMAL GROWTH INFLUENCE ON V-BELT TRANSMISSION ALIGNMENT PRECISION

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Abstract. V-belt transmission alignment is a necessary criterion of its reliable and accident-free work. Most exact and useful is an alignment by laser equipment. However, during an alignment it is necessary not only exactly and correctly to align the drive and led units, but also to take into account the size of V-belt transmission component thermal growth. In this article the principle of thermal growth size determination will be considered, and also the analysis of thermal growth influence on the V-belt transmission alignment quality and precision will be conducted.

Keywords: laser alignment, reduction gearbox, V-belt transmission, test rig.

V-belt transmission, application and advantages

The V-belt drive is mechanical energy transmission through a flexible element (belt) due to friction forces or meshing forces (toothed belt). The V-belt drive behaves to the friction transmissions with flexible connection [1].

The V-belt transmission, Fig. 1, consists of driving (position 1) and slave (position 2) sheaves and a belt (position 3) put on them. Tension devices and protections can also enter in the complement of the transmission. Application of a few belts and a few slave sheaves is possible. Setting of V-belt transmission is mechanical energy transferring from the motor to the transmission and executive mechanisms, as a rule, with rotation frequency decreasing.

The basic advantages of the belt transmission: possibility of power transmission on a considerable distance is to 15 m and more; smoothness and comparatively quite work; absence of sharp oscillations of loadings due to belt resilient extraction; protection of mechanisms from an overload due to the possible belt slipping; construction and operation simplicity; possibility of shaft different location in space.

The most widespread type of belt transmission is V-belt transmission. It is used at comparatively large ratios of gearings, vertical and sloping location of parallel axes of the shafts, it provides the transmission smallness, possesses the best attractive descriptions, and gives less loading on supports of the shafts [1].

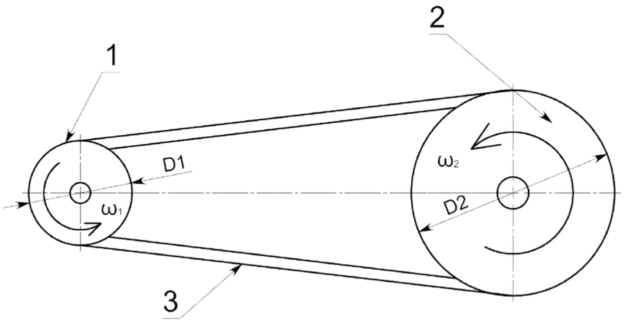

Fig. 1. **V-belt transmission basic components:** 1 – driving sheave; 2 – slave sheave; 3 – belt

V-belt transmission alignment

Misalignment in V-belt drives that employ multiple belts can create a host of other problems as well. Misalignment will alter the tension of the different belts, so some may slip and others may be overloaded. This can obviously lead to premature belt failures [2].

The V-belt transmission laser sheave alignment algorithm is performed as follows [3].

1. Placing the units, Fig. 2.

The laser shall be placed at the Stationary (S) machine and the detector at the Movable (M).

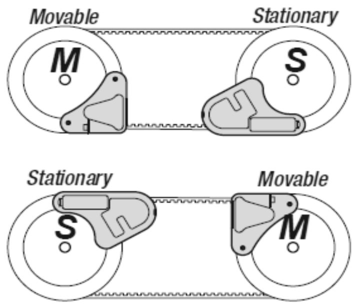

Fig. 2. **Laser alignment unit layout**

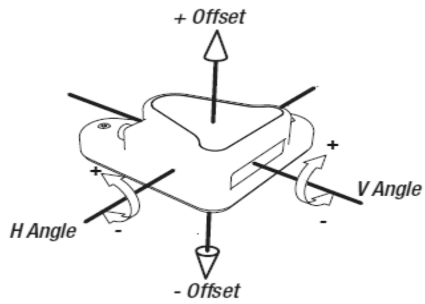

Fig. 3. **Value directions**

2. Value directions

The displayed values refer to the detector as in Fig. 3.

3. Vertical alignment

Read Vertical values (V). If necessary, shim rear or front feet. If the offset is too large, it moves the sheave axially on the shaft within acceptable tolerance, Fig. 4.

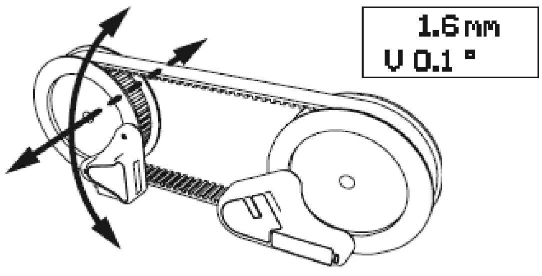

Fig. 4. **Vertical alignment**

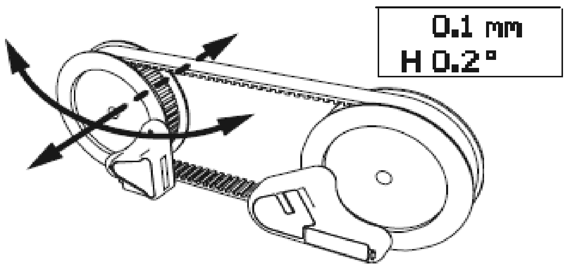

Fig. 5. **Horizontal alignment**

4. Horizontal alignment

Press to shift to Horizontal values (H), and adjust the movable machine within acceptable tolerance, Fig. 5.

Thermal growth of the V-belt transmission components

The coefficient of thermal growth is the standard length or volume of material relative measuring, attributed to a unit of the temperature scale.

Under thermal growth it is necessary to understand the change of the V-belt unit component sizes due to heating of the moving parts. The electro motors of the V-belt unit are most strongly subject to thermal growth. Heating takes place due to mechanical friction and electric energy transformation to thermal energy.

Thermal growth of the stationary and moving machine parts can influence the measuring results. For example, the thermal growth coefficient of steel is approximately equal to 0.01 mm/m on every increasing degree of temperature. If moving and stationary machines have identical working temperatures, then the influence of thermal growth is possible to ignore. Otherwise, it is necessary to conduct the alignment till machines will cool off after shutdown, or it will be necessary to take into account the difference of the temperature growth coefficients. At determination of the temperature growth factor role it is needed always to check the following [4]:

- working temperature of both machines;
- temperature coefficient for both machines;
- influence of the surrounding heat sources at the machine, including isolation of machines and mechanisms, external heat sources, action of the cooling systems [4].

The coefficient of linear thermal growth calculates on a formula (1):

$$X = \frac{\Delta L}{L_0 \Delta T}, \quad (1)$$

where X – coefficient of linear growth;
ΔL – specimen length change at heating or cooling;
L_0 – specimen length at room temperature;
ΔT – difference of temperatures (ºC), which the specimen length change is measured for.

Thermal growth checking experiment and data analysis

For thermal growth influence checking on alignment precision of V-belt transmission an experiment was conducted. For the experiment a special rig is used, Fig. 6, which consists of the electromotor Pos. 1, worm reduction gearbox #1 Pos. 2, worm reduction gearbox #2 Pos. 3, brake mechanism for loading creation Pos. 4, V-belt transmission Pos. 5. Also for the V-belt transmission alignment, the laser alignment system Pos. 6 is used.

The experiment matter consists in the following. At the beginning of the experiment, while the rig parts have room temperature, V-belt transmission laser shaft alignment is conducted. Information about the "cold" alignment is summarized in the first row of Table 1.

Then the rig is turned on, and the electromotor is rotating with frequency 30 Hz (1800 rpm) and works so for 10 minutes. During all experiment the reduction gearbox 1 temperature control is fulfilled, Fig. 7. At the end of the experiment the alignment parameter was measured and the results were summarized in Table 1. Totally 10 experiments were conducted. In Table 1 the first and the tenth results are shown.

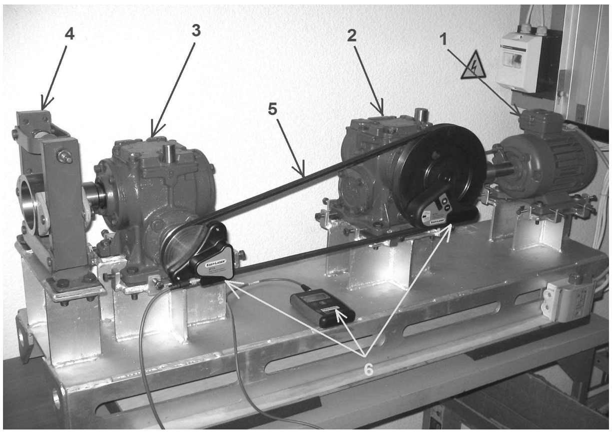

Fig. 6. **Experimental rig:** 1 – electromotor; 2 – worm reduction gearbox #1; 3 – worm reduction gearbox #2; 4 – brake mechanism; 5 – V–belt transmission; 6 – laser alignment system

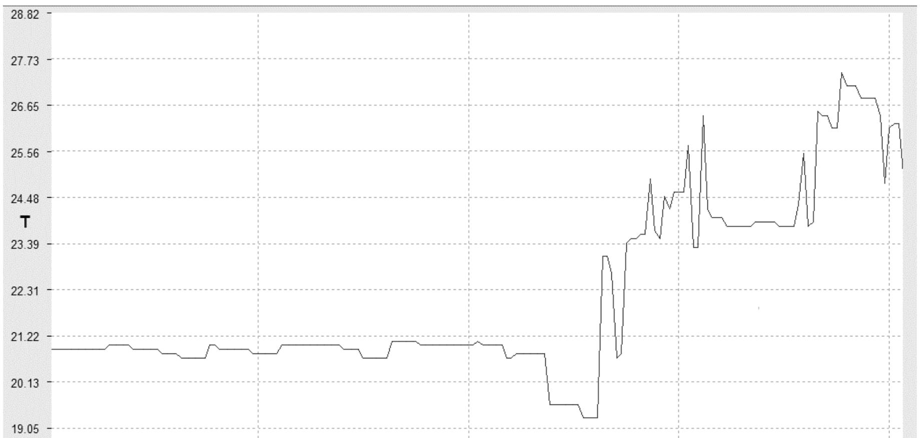

Fig. 7. **Temperature chart of reduction gearbox 1 during the experiment**

Table 1

Experimental data

Vertical offset value, mm	Vertical angular value, mm	Horizontal offset value, mm	Horizontal angular value, mm	Temperature *t*, ºC
0.01	0.00	0.00	-0.01	20.8
0.04	0.01	0.05	0.01	27.4

a)

Effect Estimates; Var.:Horizontal Offset Value; R-sqr=,87788; Adj:,72522 (Spreadsheet3.sta)
2 factors, 1 Blocks, 10 Runs; MS Residual=,0000882
DV: Horizontal Offset Value

Factor	Effect	Std.Err.	t(4)	p	-95,% Cnf.Limt	+95,% Cnf.Limt	Coeff.	Std.Err. Coeff.	-95,% Cnf.Limt	+95,% Cnf.Limt
Mean/Interc.	0,018077	0,008434	2,143440	0,098706	-0,005339	0,041494	0,018077	0,008434	-0,005339	0,041494
(1)Horizontal Angular Value(L)	0,010200	0,012186	0,837017	0,449676	-0,023635	0,044035	0,005100	0,006093	-0,011817	0,022018
Horizontal Angular Value(Q)	0,010362	0,014848	0,697879	0,523693	-0,030863	0,051588	0,005181	0,007424	-0,015432	0,025794
(2)Temperature(L)	0,043391	0,012201	3,556421	0,023662	0,009516	0,077266	0,021696	0,006100	0,004758	0,038633
Temperature(Q)	0,000720	0,029083	0,024748	0,981441	-0,080029	0,081468	0,000360	0,014542	-0,040014	0,040734
1L by 2L	0,000246	0,013673	0,017978	0,986518	-0,037717	0,038208	0,000123	0,006837	-0,018858	0,019104

b)

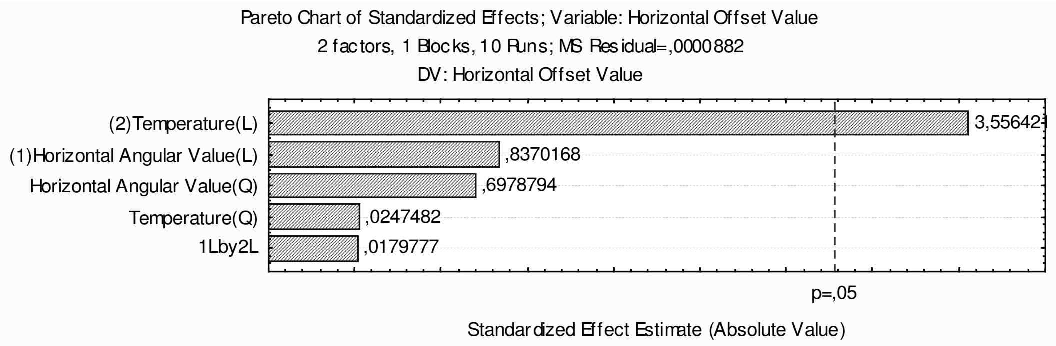

Fig. 8. **Results of the conducted experiment:**
a) summary effects estimate b) Pareto chart of effects

Conclusions and recommendations

In the result of the conducted experiment, it is possible to make the followings conclusions:

1. The thermal growth size of the V-belt transmission components is straight proportional to the temperature of the workings parts – Fig. 8 (factor (2) temperature (L)).
2. Thermal growth renders considerable influence on the laser alignment precision. Thus, the influence appears more on the offset size than on the angular value, Table 2.

As recommendations it is possible to mark the following: the size of thermal growth needs to be necessarily taken into account during the V-belt transmission laser alignment. For this purpose it is necessary to have information about the working temperature of the V-belt transmission components till alignment implementation. Such supervisions can be conducted during work of the equipment. And during the alignment, it is necessary to take into account the working temperature and the growth, and to bring in the required correction.

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