



METHODS OF THE EQUIPMENTS ALLIGNMENT

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Abstract: The sculpture presents theoretical concepts and process-orientated, for the implementation of the programme required machinery alignment, in keeping 3 alignments and the calculation of "soft leg" types of maintenance, their applicability of rotary machineries.

Key words: machinery alignment, soft leg, maintenance.

1. GENERAL KNOWLEDGES

The alignment plays an important role in operation dynamic rotary machinery [Lal 90].

The alignment unfit to lead the machinery bearings deterioration, fatigue trees, damaging connections, consumption of energy increased, longer excessive internal destruction mechanical interspacing and, implicitly, damage equipment [Bay 99].

Not alignment represents departure from the same axially to two or more cars, which are coupled with one another using connection rigid or elastic (axis of rotation machines are not the same line).

Execution with a quality show following advantages:

- cut stops - output growth;
- reducing the consumption of energy - energy expenditure reduction;
- forces cut the ball bearings to increase service life of camps;
- decrease use vibration - reducing expenses for maintenance.
- reducing wear joint-increasing duration of availability of machinery.

Not alignment is decomposed into two components:

Not alignment radial - or the parallelism, representing the distance between those two axes of symmetry of trees and is measured in [mm] or [μm].

Not alignment angular [Don 02] - represents the angular relative position of symmetry axes and measured in [mm/100mm] or [$\mu\text{m}/\text{mm}$].

2. THE MAIN FACTORS THAT INFLUENCE THE ALIGN

- The alignment may be affected by the way of fixing the foundationless of machinery [Ste 99]. A foundationless weakened, dirty, cracked or damaged may lead to given the "leg soft", and hence the not alignment.
- A thermal is another factor that determined not alignment and to be taken into account when he performed matching warm. These growers influence in direct alignment, i.e. temperature rise machinery due their heating during the operation or due to factors such as: ambient environment, agents working generation with these machines [Lee 04].
- The pipelines link, entering the car component, is another factor which may affect the position of trees.
- The use of modern methods of matching the machinery dynamic rotary leads to increased production, the length of operating the plant, reducing costs of maintenance and increase safety in operation.

3. THE METHOD OF MATCHING RADIAL

In calculating parameters of matching the radial method is considered the next configuration of cars with axle horizontally, as shown in Figure 1.

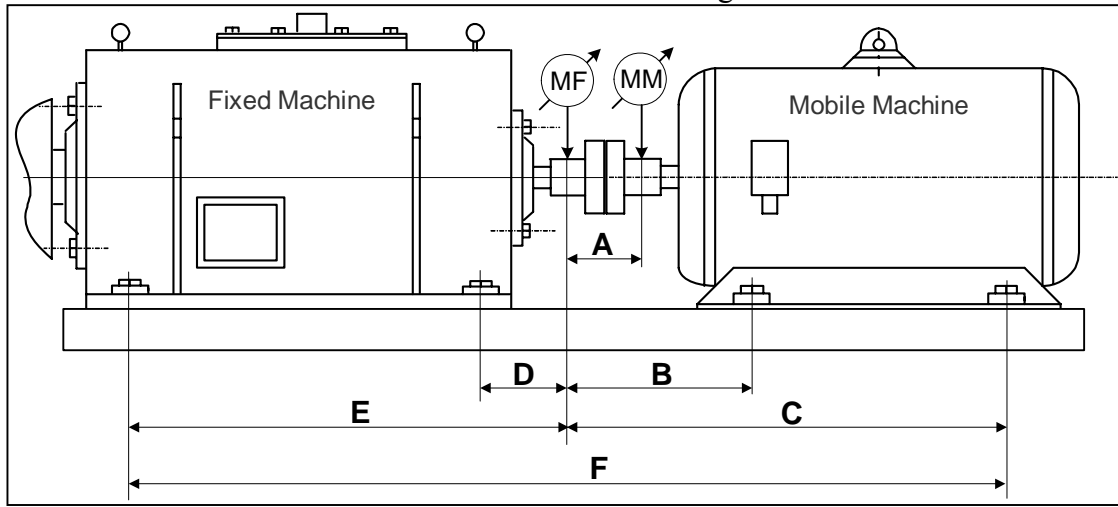



Fig. 1 Scheme of Fixed Machine – Mobile Machine System

Sensors needed carrying alignments are members over the mechanical machinery or the axes, i.e. one sensor on each half linkage.

Consider the following notations technical for Figure 1:

 The sensor mounted on half linkage MF fixed machine-sensor mounted on mobile half linkage MM

- A - machine-distance sensors [mm]
- B – between - the distance from the sensor Mf the soles of the machine mobile face (incident of fixing the machine on pedestal) [mm]
- C - distance from the sensor Mf soles to the rear of the machine mobile [mm]
- D - distance from the sensor Mf the soles of the [mm] fixed the car's
- E - distance from the sensor Mf soles to the rear of the machine fixed [mm]
- F - distance between rear feet fixed the car and feet in the back of [mm] mobile machine for matching cold machine is sufficient introduction program in the distances A, B and C.

3.1. Parameters calculation for matching

Relations for calculating alignment in the cold in direction vertical and horizontal are listed below:

$$D_f = \frac{B \cdot (O_m + O_f) - A \cdot O_f}{2A} \tag{1.1}$$

$$D_s = \frac{C \cdot (O_m + O_f) - A \cdot O_f}{2A} \tag{1.2}$$

$$V_f = V_{MF} + S_f \tag{1.3}$$

$$V_m = V_{MM} + S_m \tag{1.4}$$

$$A_f = \frac{B \cdot (V_m + V_f) - A \cdot V_f}{2A} \tag{1.5}$$

$$A_s = \frac{C \cdot (V_m + V_f) - A \cdot V_f}{2A} \tag{1.6}$$

$$R_v = - \frac{d \cdot (V_f + V_m) - A \cdot V_f}{2A} \tag{1.7}$$

$$R_o = - \frac{d \cdot (O_f + O_m) - A \cdot O_f}{2A} \tag{1.8}$$

$$U_v = - \frac{(V_f + V_m)}{2A} \cdot 100 \tag{1.9}$$

$$U_o = - \frac{(O_f + O_m)}{2A} \cdot 100 \tag{1.10}$$

where:
 MF - notation car fixed.
 MM - notation mobile machine;

V_f - measured in vertical direction on the clock comparator mounted on the car fixed MF (mm);

V_m - measured in vertical direction on the clock comparator mounted on mobile machine MM, (mm);

V_{MF} - measured in vertical direction to the sensor mounted on the car fixed MF (mm);

V_{MM} - measured in vertical direction to the sensor mounted on mobile machine MM, (mm);

O_h - measured in horizontal to the sensor mounted on the car fixed MF (mm);

O_m - measured in horizontal to the sensor mounted on mobile machine MM, (mm);

S_F - arrow rod rack fixed to the Finance Ministry, where alignment with watches comparator, (mm);

S_M - Arrow rod rack set in mm, where alignment with watches comparator, (mm);

A_s - movement in vertical direction of part of the machine mobile MM, (mm);

A_f - displacement in vertical direction of the party in the back of mobile machine MM, (mm);

D_s - displacement horizontal part of the car back mobile MM, [mm];

D_f - displacement horizontal part of the car back mobile MM, [mm];

R_o - not alignment 3 values horizontal, (mm);

R_v - not alignment 3 values the vertical direction, (mm);

U_o - value not alignment angular horizontal direction, (mm);

U_v - value not alignment angular in vertical direction, (mm).

In the case alignment machinery with sensors laser support the fixing of their couple or axes is different from the point of view geometric and arrow is considered to be zero.

3.2. "Soft leg" calculating

The programme also includes the option of calculating the leg (stalk) soft and the relationship to it are listed below:

$$P_{fd} = \frac{B \cdot (P_{fdMM} + P_{fdMF})}{A} - P_{fdMF} \quad (1.11)$$

$$P_{fs} = \frac{B \cdot (P_{fsMM} + P_{fsMF})}{A} - P_{fsMF} \quad (1.12)$$

$$P_{sd} = \frac{C \cdot (P_{sdMM} + P_{sdMF})}{A} - P_{sdMF} \quad (1.13)$$

$$P_{ss} = \frac{C \cdot (P_{ssMM} + P_{ssMF})}{A} - P_{ssMF} \quad (1.14)$$

where:

P_{fd} - Addition of material for correction stalk soft soles MM face the right, (mm);

P_{fs} - Convention-Addition of material for correction stalk soft soles MM face the left, (mm);

P_{sd} - Addition of material for correction stalk soft soles MM back at right, (mm);

P_{ss} - the addition of material for correction stalk soft soles MM back to left, (mm);

P_{fdMM} -value sensor indication for the calculation MM stalk soft face right (mm);

P_{fsMM} -value sensor indication for the calculation MM stalk soft face left, (mm);

P_{sdMM} -value sensor indication for the calculation MM stalk soft back right, (mm);

P_{ssMM} -value sensor indication for the calculation MM stalk soft back left, (mm);

P_{fdMF} -value sensor indication for the MF calculation stalk soft face right (mm);

P_{fsMF} -value sensor indication for the MF calculation stalk soft face left, (mm);

P_{sdMF} -value sensor indication for the MF calculation stalk soft back right, (mm);

P_{ssMF} -value sensor indication for the MF calculation stalk soft back left, (mm).

3.3. The heat growing calculation

For matching warm reasonable machinery is necessary for each calculation thermal growing soles to the machinery, according relations:

$$d_{s1} = (T_{ar} - T_0) \cdot H_{MF} \cdot \alpha \cdot 10^{-6} \quad (1.15)$$

$$d_{f1} = (T_{ar} - T_0) \cdot H_{MF} \cdot \alpha \cdot 10^{-6} \quad (1.16)$$

$$d_{s2} = (T_{ar} - T_0) \cdot H_{MM} \cdot \alpha \cdot 10^{-6} \quad (1.17)$$

$$d_{f2} = (T_{ar} - T_0) \cdot H_{MM} \cdot \alpha \cdot 10^{-6} \quad (1.18)$$

where:

d_{s1} - thermal particular back; Mf, (mm);

d_{f1} - thermal face particular Mf, (mm);

d_{s2} - particular heat back mm, (mm);

d_{f2} - particular heat back mm, (mm);

T_{ar} - mean temperature corresponding to each soles in hand, (°C);

T_0 - ambient temperature, (°C);

α - coefficient of particular heat ($\mu\text{m}/\text{m}^\circ\text{C}$);

H_{MF} - height center axis bar Mf the pedestal, (mm);

H_{MM} - height center axis bar mm from the pedestal MM, (mm).

a) Indication sensor MM for matching hot and cold in the simulation MM

$$V_{F2} = \frac{2 \cdot (E \cdot d_{s2} - C \cdot d_{f2})}{C - B} \quad (1.19)$$

$$V_{M2} = \frac{2 \cdot [(A - B) \cdot d_{s2} + (C - A) \cdot d_{f2}]}{C - B} \quad (1.20)$$

MM displacement for the thermal growing is:

$$d_{fc2} = d_{f2} \quad (1.21)$$

$$d_{sc2} = d_{s2} \quad (1.22)$$

where:

V_{F2} - MM values indication sensor in the simulation, (mm);

V_{M2} - Values indication Mf sensor in the simulation, (mm);

d_{sc2} - movement back mm, (mm);

d_{fc2} - moving front mm, (mm).

b) Indication Mf sensor for matching hot and cold in the simulation Mf

$$V_{F1} = \frac{2 \cdot (E \cdot d_{f1} - D \cdot d_{s1})}{E - D} \quad (1.23)$$

$$V_{M1} = \frac{2 \cdot [(A + D) \cdot d_{s1} - (A + E) \cdot d_{f1}]}{E - D} \quad (1.24)$$

MM displacement for the thermal growing and simulation is:

$$d_{fc1} = \frac{B \cdot (V_{F1} + V_{M1}) - A \cdot V_{F1}}{2 \cdot A} \quad (1.25)$$

$$d_{sc1} = \frac{C \cdot (V_{F1} + V_{M1}) - A \cdot V_{F1}}{2 \cdot A} \quad (1.26)$$

$$d_{fc} = -(d_{fc1} + d_{fc2}) \quad (1.27)$$

$$d_{sc} = -(d_{sc1} + d_{sc2}) \quad (1.28)$$

where:

V_{F1} - MM values indication sensor in the simulation, (mm);

V_{M1} - Values indication Mf sensor in the simulation, (mm);

d_{sc1} - MM movement back in the growing thermal (mm);

d_{fc1} - MM movement towards the thermal growing, (mm);

d_{sc} - MM movement back in the simulation, (mm);

d_{fc} - MM movement towards the simulation, (mm).

c) Final sensor indication, in case of alignment with comparative watches, for the hot align MF-MM

$$V_{FTC} = V_{F2} + V_{F1} \quad (1.29)$$

$$V_{MTC} = V_{M2} + V_{M1} \quad (1.30)$$

$$V_{FT} = -(V_{FTC} - V_f) \quad (1.31)$$

$$V_{MT} = -(V_{MTC} - V_m) \quad (1.32)$$

MM displacement for the thermal growing and simulation is:

$$A_{fc} = A_f + d_{fc} \quad (1.33)$$

$$A_{sc} = A_s + d_{sc} \quad (1.34)$$

where:

V_{FTC} - MM values clock indication the simulation, (mm);

V_{MTC} - Values indication clock Mf the simulation, (mm);
 V_{FT} - real values of the deviations Mf the simulation, (mm);
 V_{MT} - MM values real irregularities in the simulation, (mm);
 A_{fc} - MM movement towards the simulation, (mm);
 A_{sc} - MM movement back in the simulation, (mm).

4. THE METHOD OF MATCHING RADIAL-AXIAL

In case the machinery alignment method radial-axial a sensor will be mounted in the axial direction and another in the radial direction as in the 1 figure.

4.1. The parameters calculation for alignment

Relations for calculating parameters are listed below:

$$D_f = O_a \frac{B}{A} + \frac{O_r}{2} \quad (1.35)$$

$$D_s = O_a \frac{B+C}{A} + \frac{O_r}{2} \quad (1.36)$$

$$V_r = V_R + S \quad (1.37)$$

$$V_a = V_A \quad (1.38)$$

$$A_f = \frac{V_a \cdot B}{A} + \frac{V_r}{2} \quad (1.39)$$

$$A_s = \frac{V_a \cdot (B+C)}{A} + \frac{V_r}{2} \quad (1.40)$$

$$R_v = \frac{V_r}{2} \quad (1.41)$$

$$R_o = \frac{O_r}{2} \quad (1.42)$$

$$U_v = \frac{V_a}{A} \cdot 100 \quad (1.43)$$

$$U_o = \frac{O_a}{A} \cdot 100 \quad (1.44)$$

where:

R- sensor mounted in the direction radial;

A- sensor mounted in axial direction;
d- diameter assembly horizontal sensor;
 D_s - displacement horizontal part of the real of the machine mobile MM, [mm];
 D_f -displacement horizontal part of the car back mobile MM, [mm];
 O_r - measured in horizontal to the sensor mounted radially (mm);
 O_a - the measured in horizontal to the sensor mounted axially (mm);
 V_r - measured in vertical direction to the sensor R depending on the arrow (mm);
 V_a or V_A - measured in vertical direction to the A sensor, (mm);
 V_r - measured in vertical direction to the sensor R, (mm);
S- arrow rod rack of fixing the sensors, [mm];
 A_s - movement in vertical direction of the party in the rear of the machine mobile MM, (mm);
 A_f - displacement in vertical direction of part of the machine mobile MM (mm);
 R_o - no alignment 3 values horizontal, (mm);
 R_v - no alignment 3 values vertical direction, (mm);
 U_o - value no alignment angular horizontal, (mm);
 U_v - value no alignment angular in vertical direction, (mm).

4.2. Calculating "soft leg"

The relations for the soft leg are:

$$P_{fd} = \frac{B \cdot (P_{fd1} + P_{fd2})}{A} - P_{fd1} \quad (1.45)$$

$$P_{fs} = \frac{B \cdot (P_{fs1} + P_{fs2})}{A} - P_{fs1} \quad (1.46)$$

$$P_{sd} = \frac{B \cdot (P_{sd1} + P_{sd2})}{A} - P_{sd1} \quad (1.47)$$

$$P_{ss} = \frac{B \cdot (P_{ss1} + P_{ss2})}{A} - P_{ss1} \quad (1.48)$$

4.3 Calculating of the thermal growing

The corresponding relations are:

$$d_{s1} = (T_{ar} - T_0) \cdot H_{MF} \cdot \alpha \cdot 10^{-6} \quad (1.49)$$

$$d_{f1} = (T_{ar} - T_0) \cdot H_{MF} \cdot \alpha \cdot 10^{-6} \quad (1.50)$$

$$d_{s2} = (T_{ar} - T_0) \cdot H_{MM} \cdot \alpha \cdot 10^{-6} \quad (1.51)$$

$$d_{f2} = (T_{ar} - T_0) \cdot H_{MM} \cdot \alpha \cdot 10^{-6} \quad (1.52)$$

a) Indication of sensors R and A for the alignment at hot and cold following the MM simulation:

$$V_{r2} = 2 \cdot \left[d_{f2} - \frac{B \cdot (d_{s2} - d_{f2})}{C} \right] \quad (1.53)$$

$$V_{a2} = \frac{A \cdot (d_{s2} - d_{f2})}{C} \quad (1.54)$$

The MM displacement following cold thermal alignment:

$$d_{fc2} = d_{f2} \quad (1.55)$$

$$d_{sc2} = d_{s2} \quad (1.56)$$

where:

V_{r2} - values indication sensor R the simulation, (mm);

V_{a2} - values sensor indication of the simulation, (mm);

d_{sc2} - movement back MM, (mm);

d_{fc2} - moving front mm, (mm).

b) Indication sensors R and a matching hot and cold in the simulation MF

$$V_{r1} = 2 \cdot \left[d_{f1} - \frac{D \cdot (d_{s1} - d_{f1})}{E} \right] \quad (1.59)$$

$$V_{a1} = \frac{D \cdot (d_{s1} - d_{f1})}{E} \quad (1.60)$$

The MM displacement following cold thermal alignment:

$$d_{fc1} = V_{a1} \frac{B}{A} + \frac{V_{r1}}{2} \quad (1.61)$$

$$d_{sc1} = V_{a1} \frac{B+C}{A} + \frac{V_{r1}}{2} \quad (1.62)$$

$$d_{fc} = -(d_{fc1} + d_{fc2}) \quad (1.63)$$

$$d_{sc} = -(d_{sc1} + d_{sc2}) \quad (1.64)$$

where:

V_{r1} -Values indication sensor R the simulation, (mm);

V_{a1} -Values sensor indication of the simulation, (mm);

d_{sc1} -mm movement back in the thermal growing (mm);

d_{fc2} -mm movement towards the thermal growing, (mm);

d_{sc} - MM movement back in the simulation, (mm);

d_{fc} - MM movement towards the simulation, (mm).

c) Indication final sensor, the alignment with comparator clocks, for matching warm MF- MM

$$V_{rTC} = V_{r2} + V_{r1} \quad (1.65)$$

$$V_{aTC} = V_{a2} + V_{a1} \quad (1.66)$$

$$V_{rT} = -(V_{rTC} - V_r) \quad (1.67)$$

$$V_{aT} = -(V_{aTC} - V_a) \quad (1.68)$$

The MM displacement following the thermal growing and simulation:

$$A_{fc} = A_f + d_{fc} \quad (1.69)$$

$$A_{sc} = A_s + d_{sc} \quad (1.70)$$

where:

V_{rTC} - values indication clock R the simulation MM, (mm);

V_{aTC} - values clock indication of the simulation; MF, (mm);

V_{rT} - real values of the deviations R the simulation MM, (mm);

V_{aT} - real values of the deviations of the simulation; MF, (mm);

A_{fc} - MM movement towards the simulation, (mm);

A_{sc} - MM movement back in the simulation, (mm).

5. ALIGNMENT OF THE HORIZONTAL SHAFTS WITH THE PROGRAMM POCKETPC – ALINIÈRE

For carrying out the radial method costs by horizontal shafts was carried out a program installed on POCKETPC, named ALINIÈRE, which includes the following options:

- given the detection leg soft;
- matching cold;
- calculation thermal growing;
- matching hot;
- alignment simulations in vertical and horizontal directions;
- alignment quality of elastic connections, function by number of machine revolving;
- graphic design of align;
- generate automatic report or technical documents of matching.

Program has been tested successfully on various machines align shafts rotary who is inside of mechanical chain, as have: electric motor - reducing, engine - pumps, groups acting bands, engine-fan etc.

A special case represents align rotary machines who work at the temperatures where appear heat growing's.

The heat growing's appears, generally in vertical, but they may also occur in horizontal because of machine configuration, lateral pipelines to link heated, no uniform heating-machine due process technology etc.

The programme PocketPC-ALINIÈRE shall have the opportunity to carry out both matching warm in vertical and horizontal.

6. CONCLUSIONS

In order to achieve a comprehensive study of dynamic a car with rotor measurement is needed following parameters:

- amplitude function frequency;
- amplitude function of time (the form of wavelength);

- amplitude function of frequency and function of time;
- figure Lissajous (orbit movement of precession);
- amplitude phase depending on speed of shaft.

To that end, it requires careful analysis of phase, and as much as possible, should be determined form distorted the tree. Unlike the vibration analysis systems fever, liabilities, situation in which he gave up easily to the analysis phase, where cars with rotor, this parameter is the most important, because he is the link between the movement of rotation and the vibration (movement of precession). Also, the variation phase and amplitude of vibration, in the field of interest, helped to determine critical revolving of a rotor, speeds that are extremely important for the smooth operation of a car dynamic.

Practice has shown that the main defect appeared in the dynamic rotary machines are disturbing the balance static and dynamic rotors. To eliminate this defect imposing balancing is carrying out in situ or sitting, which, in fact, is one of the most important action that is taking place in the compartments for maintenance.

Equilibration means by which action corrective mass distribution of the verified rotor and, if necessary, is corrected, so that the vibration had one and forces from camps to learn the limits prescribed for appropriate alone functional revolving speed.

Another defect often encountered in dynamic rotary machines is no alignment, which represents a departure from coaxiality two or more shafts, which are coupled among them using connections rigid or elastic. The corrective action regarding this type of defect is matching.

Implementation of matching (alignment) tools are a necessity for any enterprise or industrial company, regardless of what category is part, this concept the opportunity to predict defects and to intervenes promptly on machinery, avoiding the kind of failure, with direct effect on production.

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METODE DE ALINIERE A UTILAJELOR

Rezumat: Lucrarea prezintă noțiunile teoretice și aplicative, pentru realizarea unui program necesar în alinierea utilajelor, în menținerea alinierii radiale și a calulului de „picior moale” pe tipurile de mentenanță, aplicabilitatea acestora mașinilor rotative.

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