THERMAL GROWTH INFLUENCE ON THE SHAFT ALIGNMENT AND VIBRATION OF CENTRIFUGAL PUMP

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Abstract: *Shaft alignment of any rotor equipment is an important task. It must do an alignment after repair of equipment, and also periodically to check the alignment of shafts. During alignment works it is recommended to take into account thermal growth of pumping unit components that strongly influences on the capacity of pump and on the vibration level. In this article the analysis of vibration level dependence from shaft alignment quality and thermal growth is resulted.*

KEY WORDS: *SHAFT ALIGNMENT, VIBRATION, ANALYSIS, IMPELLER, BEARING*

1. Introduction

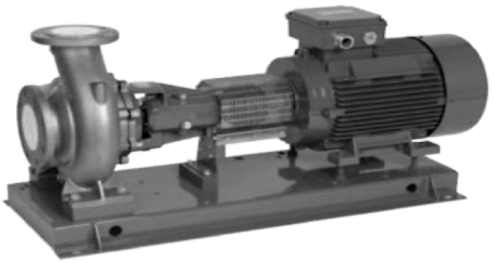

Figure 1. Centrifugal pumping unit [1; 2]

A centrifugal pumping unit consists of pump and electromotor. The pump consists of corps and impeller revolved in it. At the wheel rotation in the stream of liquid there is a difference of pressures for both sides of every blade and, consequently, power interaction of stream with an impeller. The increase of liquid stream energy in an impeller depends on a flow rate, rotation frequency of wheel, it dimensions and form of the blade.

The hydraulic energy of liquid increasing takes place in the revolved impeller. In the tale races of corps kinetic energy of liquid will be transformed in pressure energy.

Energy content, obtained by a liquid in a pump, expended on resistances and counterpressure overcoming in the system.

The centrifugal pumping units' application domain is vast: for a domestic and industrial water-supply, in circulation, feeding, network and other settings of power-stations, in land-reclamation, introduction of a heating system, in pumping, in paper, mining, metallurgical, chemical industry etc. [3]. Therefore it is very important to provide the reliable capacity of pumping unit. One of important protracted pumping units' capacity providing methods is a shaft alignment. The procedure of the shaft alignment must be carried out by experienced personnel, with the modern devices using, and also taking into account compensation of thermal growth.

2. Centrifugal pumps shaft alignment methods

The centrifugal pumping unit's methods are differing nothing from the majority of rotor equipment shaft alignment methods. At an alignment the followings methods are used:

- By a caliper or probes is measuring of radial and butt-end gaps on couplings. (Fig.2, a)
- By equipment with the sentinel type indicators:
  a) A rim and face method, (Fig.2, b);
  b) Reversed indicators method, (Fig.2, c);
- By the scopes.
- By devices with the contactless sensors of shaft pulsations.
- By laser devices. Laser sensors location, accordingly, on the **S**-machine and M-machine. Where S – immobile (stationary), and M – movable machines. (Fig.2, d)

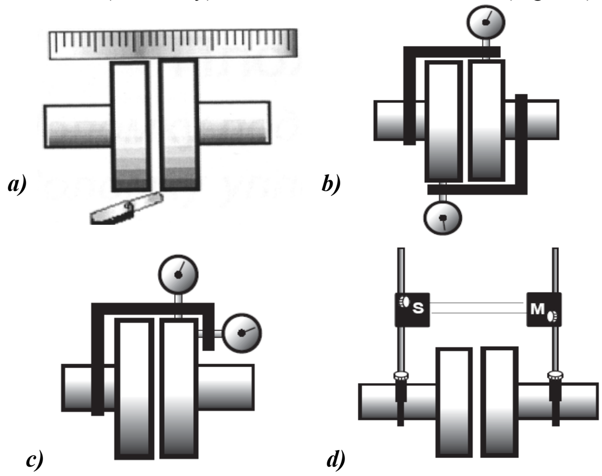

Figure 2. Shaft alignment methods [4]

For the shaft alignment of all rotor equipment, including centrifugal pumps , it is most correct to apply a laser method. This method abbreviates time of alignment, not only considerably, but also allows to conduct alignment with maximal exactness (up to 0,001 мм).

Most modern laser shaft alignment systems have the thermal growth compensation function, that very influences on quality of alignment and on the pumping unit efficiency.

3. Thermal growth

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

Under thermal growth it is necessary to understand the change of pumping unit components sizes due to heating of moving parts. The electro motors of pumping 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 stationary and moving machines parts can influence on the measuring results. For example, the thermal growth coefficient of steel is approximately equal 0,01 mm/m on every increasing degree of temperature. If moving and stationary machines have identical workings temperatures, then influence of thermal growth it is possible to ignore. Otherwise, it is necessary to conduct an alignment till machines will cool off after a shutdown, or it will be necessary to take into account the difference of temperature growth coefficients. At determination of temperature growth factor role it is needed always to check following:

- Working temperature of both machines
- Temperature coefficient for both machines
- Influence of surrounding heat sources at machine, including machines and mechanisms isolation, 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 (^0C); ΔL - specimen length change at heating or cooling; L_0 - specimen length at a room temperature; ΔT - difference of temperatures (^0C), which the specimen length change is measured for.

4. Centrifugal pumps vibration

Thermal growth of centrifugal pumping unit components straight influences on a vibration. If at an alignment thermal growth is not taken into account or make a wrong calculation one, in that case takes place vibration level increasing, both at general level measuring and on informative frequencies. At general vibration level measuring it is possible only roughly to judge about the unit condition. In an order to expose a concrete defect, it is necessary to measure a direct spectrum and envelope spectrum of vibration and conduct the analysis of informative frequencies of pumping unit. Mainly, at rotation machinery vibrodiagnostics informative frequencies of bearings are analyzed.

Rolling bearing's work in centrifugal pump composition and at presence faults in it can influence on a vibration and modulating it processes with the followings fundamental frequencies:

- Rotation frequency of movable ring in relation to immobile: f_{rot} ;
- Rotation frequency of separator in relation to an outer ring:

$$f_r = \frac{1}{2} \cdot f_{rot} \cdot \left(1 - \frac{d_{sr}}{d_r} \cdot \cos(\alpha)\right); \quad (2)$$

Where: d_{sr} - solid of revolution diameter;

$d_r \approx \frac{1}{2}(d_{out} - d_{in})$ - Diameter of separator;

d_{out} - Diameter of outer ring;

d_{in} - Diameter of inner ring;

α - contact angle of bodies and rolling paths;

- Rolling frequency of solid of revolution on an outer ring:

$$f_{out} = \frac{1}{2} \cdot f_{rot} \left(1 - \frac{d_{sr}}{d_r} \cdot \cos(\alpha)\right) \cdot z = f_r \cdot z; \quad (3)$$

Where: z - solid of revolution number;

- Rolling frequency of solid of revolution on an inner ring:

$$f_{in} = \frac{1}{2} \cdot f_{rot} \left(1 + \frac{d_{sr}}{d_r} \cdot \cos(\alpha)\right) \cdot z = (f_{rot} - f_r) \cdot z; \quad (4)$$

- Rolling frequency of solid of revolution in relation to the surface of rings:

$$f_{sr} = \frac{1}{2} \cdot f_{rot} \cdot \frac{d_r}{d_{sr}} \left(1 - \frac{d_{sr}^2}{d_r^2} \cdot \cos^2(\alpha)\right); \quad (5)$$

Expressions (Eq.2, Eq.3, Eq.4, and Eq.5) are evaluating only basic harmonics frequencies in the vibration spectrums and envelope of its high-frequency components at the different types of defects. [5]

5. Conclusion

Compensation of thermal growth is a very important factor which must be taken into account at the shaft alignment of centrifugal pumping unit. This value influences not only on shaft alignment quality, but also on the vibration level, and also on the capacity of the unit. During pumping unit operation there almost always is a difference in a temperature between a pump and electromotor. In order that it is correct to define the value of thermal growth, it is necessary to conduct regular temperature control of the pumping unit components, take into account the operation conditions and pumping liquid description. Also at vibration control it is necessary to conduct the analysis of spectrums before and after an alignment.

6. Literature

1. http://www.darwin-pumps.ru/pdf/ctlg_dk_dkb_dkl.pdf
2. www.tapflo.lv/lv/.../Industrial_centrifugal_pumps_br_web_LV.pdf
3. Михайлов А.К., Малюшенко В.В.Лопастные насосы. Теория, расчет и конструирование. – Москва: Машиностроение, 1977. – 288 с.
4. Measurement and alignment systems «Easy Laser». Manual 05-0100 Rev.7// Damalini AB, - 2005.p. A2-F8.,
5. Барков А.В., Баркова Н.А., Азовцев А.Ю., Мониторинг и диагностика роторных машин по вибрации. – Санкт Петербург: Изд. Центр СПбГМТУ, 2000. -159с.