# Graphic Technique for Reducing the Shift between the Geometric Axis and the Axis of Rotation of an Industrial Motor Fan Group

**Didier Ilunga Mutonkole[1], Henri Kisanguka Pandakufua[2]**

**Abstract:** ***This article presents the results of a study on the role of a graphic designer of dynamic balancing on site. It consists of reducing the size of the material by the method of the machine. This circumference is divided into a certain number of points which depend on the accuracy of which it is desirable to obtain from the compensating masses. The latter constitutes the points of placement of the masses provided by the graph. The first start of the disconnected from the circuit gives the initial vibration value which represents the radius of the reference circumference at the chosen scale. The radii of deux autres circumferences dans la question d'un point de point de point de la point de la point de la point de la point de la point de la surveillance de la recherche. The intersection of these three circumferences will determine the mass values at the chosen scale. The pattern is one of which is in the unbalance zone and the other in the area of that of unbalance. The elimination of the unbalance will be done by placing the mass opposite the unbalance.***

**Key words:** Vibration, unbalance and equilibrate

## 1. Introduction

This article presents the results of a study carried out with the aim of providing maintenance services with a graphic modeling of dynamic balancing on site of an industrial motorcycle fan unit, it consists in reducing the values of unbalance by masses determined using a hard graph a reference circumference chosen on the dorsal flange of the wheel of the mobile.

The major concern of any manufacturer is to have an organ that does not vibrate. However, there are several factors that can affect the mechanical structure of equipment.

It is therefore important to correct another defect before considering answering the following fundamental question: "Can mechanical unbalance be minimized by rebalancing?"

This practice makes it possible to avoid malfunctions, incidents and accidents in the direct installation environment of the machine and to extend the service life. There are several writings around the world relating to the problem of dynamic balancing of a rotor of a turbomachine, some more scientific.

In the first category we quote "JACKY DUMAS and BRUNO BENNE VAULT (2001), PACHAUD and BOULEGER (1997), DE HOMBREUX stone, measurement and analysis of vibratory signals, MONS polytechnic faculty, September (2001). Summarizes in development of the ability to interpret the dynamic behavior of a device using chart recorded during operation. This technique allows to act in time to guarantee its state avoiding spontaneous stops

In the second category are research works such as H. ITOND, vibration analysis and turbomachine rebalancing principle (2016). the results of which follow the vibration level follow-up on the site for three months, demonstrated that the technical characteristics of the motorcycle fan unit show that the unbalance values taken were significantly higher than those corresponding to the class provided by the ISO 2372. The application of the correcting imbalances allowed the machine to be 35% in its severity class.

To achieve the objective of our study, we will begin by defining the basic concepts of the mechanical structure of the machine. This last allowed us to model the motorcycle fan unit. We have also given the procedure for the use of the vibration measuring apparatus and presented the procedure for the graphic determination of the compensation unbalances and their location on the rotor and illustrated by a numerical

Any work that wants scientist must be able to demonstrate and verify the fact that it must resort to the use of certain methods and techniques to achieve these objectives as well by the very nature of our work, the need and the requirements of the approach we demanded the observational or learned method "why do rotating machines produce vibrating and too many stops during operation? By looking for answers to this question we used the vibrometer to realize it and to propose a graphic technique of reduction of the shifts between the geometrical axis. In our work we used two types of techniques which are: the interview or the interview and the documentary technique:

1) Investigation in the general career company and Mines Sarl; In this section we proceeded by the definition of the basic concepts, the study as given that the device to study was a equipment to use in the production industries.
2) We had taken the case of the General Careers and Mines Group Center in Katanga in Likasi the SHITURU headquarters.

## 2. Definition of Vibration Concepts and Sources in Turbo Machines

### a) Vibration [1]

By definition, the vibration in time is a variation of the value of a given quantity, specific to the movement, or even the position of a mechanical system, when the magnitude in question is either greater or smaller than the average value known as the reference value. A body vibrates when it is animated by an oscillatory movement while it is in equilibrium position. The simplest form of oscillatory motion is the sinusoidal shape characterized by amplitude, frequency, and phase.

A periodic vibration can be:

- Simple: the oscillations are repeated identically at regular intervals
- Complex [2]

Two or more periodic vibrations can be superimposed and give as result a motion which is the position of all the elementary movements. Vibration causes partial progressive degradation or organs.

### b) Unbalanced [3]

After the encyclopedic dictionary, an unbalance is a balancing defect of a rotating part around an axis. In other words, a piece that does not turn round generate rotational contributions due to unbalance installed all the higher as the speed of rotation increases. The vibrations of the resulting machine, under the effect of forces developed by the bearings to oppose the forces of unbalance. The best-known manifestation is frankly a critical speed, coincidence of a natural frequency of the rotor and the speed of rotation.

### c) Balancing [4]

Balancing is an operation that consists in minimizing the effect of unbalance on the rotor vibrations and on the forces transmitted to the bearings. The problem is to bring the center of mass back to the axis of rotation. In general, the rotors have several wheels, disc, mass, mounted on a shaft that is longer than the largest outside diameter. The difficulty is that the imbalance distribution along the rotor is unknown and, therefore, the one-off balancer can not be corrected individually. The procedures used to apply, on this distribution unknown unbalance, a finite set of correcting imbalances, so that the set behaves satisfactorily. It is therefore the search for a compromise, the result of which is related to the conditions chosen to achieve the balancing operator. Balancing can be static or dynamic.

**Dynamic balancing**

It is done on site without dismantling the machine and at the rated speed of the rotor. It makes it possible to minimize the unbalances of advantage compared to the static balancing.

**Static balancing**

It usually runs at the workshop. It consists of mounting the rotor to balance on the often smooth support and to print a small rotational movement to the wheel and let it rotate. The stop of the movement must be clear. Any oscillation movement of the rotor reflects the presence of mechanical unbalance.

### d) Origin of unbalance on the mobile

A mobile is composed of a shaft on which are mounted the active parts (wheels, winding, gears) and is maintained in the stator by rotating connections (bearing). There are also composite rotors, in several concentric sections, on a higher number of bearings. The distribution of unbalance of a mobile is related to the position of the chauvinist center of mass of the elementary sections with respect to the line of rotation, itself different from the geometric axis passing through the centers of the bearings.

### 1) Classification of the sources of unbalance

The sources of unbalance are grouped into four classes:

- Mechanical defects;
- Mechanical unbalance;
- Electrical faults;
- Misalignment.

## 3. Theoretical overview of the analytical approach to determine unbalance

### a) Position of the problem

In a rotating machine, in order to impose on a concentrated mass m a circular trajectory of radius r at an angular velocity , it is necessary to exert on this mass a centripetal force $\vec{F}$ of intensity - $-m\omega^2\vec{r}$ (II.1). This force is a rotating force with a non-constant direction because all the time directed towards the center.

This force is a force also acts as an exciter of pulsation vibrations $\vec{\omega}$. If this pulsation $\vec{\omega}$ approaches or reaches one of the own pulsations of the machine or of some of its elements, the resonance conditions are met. In this case, the amplitude of the elements can increase sufficiently to alter the conditions of their good functioning. Assuming, even from conception, the rotating elements (shaft, rotor ...) of geometrical shape with perfect symmetry of revolution, the set of centripetal forces should constitute a system of forces in equilibrium as of the distribution of the masses. This is not the case in reality for economic reasons of construction.

Indeed:

- All the constituent parts of the rotating elements are not machined with precision. there are therefore some geometrical irregularities of the surface, except for example to rolling parts or pads.
- The heterogeneous nature of the materials prevents symmetrical mass distribution, even if the geometric distribution is perfect
- The structure of many rotors makes geometric symmetry impossible.

In addition, a rotating element manufactured, mounted and in service undergoes other phenomena of wear or corrosion which are accentuated especially in the design where the required conditions for proper operation are not respected. Hence the importance of rotating mass balancing of a rotating machine in general and a fan conveying a particular gas.

### b) Overview on the balancing calculation

For a good dynamic balancing, the axis of rotation of the rotating element (shaft, rotor ...) must coincide with a central axis to integrate. The masses must be distributed to reach this condition. In this case, the system of centripetal forces is a system in equilibrium:

1) The sum of the centripetal forces is zero: $\sum_j F_{cj} = 0$ (II.2)

2) The sum of moments of centripetal forces with respect to any point is also zero: $\sum_j MF_{cj} = 0$ (II.3)

It will generally be necessary to introduce at least two centripetal balancing forces, that is to say two balancing masses each located in a different transverse plane.

Suppose a set of discrete or localized masses (mi, (r_i) ⃗) to be balanced with respect to a rotation axis.

Let also (me, (r_e) ⃗) be the set of balancing masses to be determined, then equations (II.2) and (II.3) of the balancing condition are written:

1) $\sum_j F_{cj} = 0 = \sum_i(-m_i\omega^2 r_i) + \sum_e(-m_e\omega^2 r_e) = 0$

2) $\sum_j MF_{cj} =$

$0 = \sum_i(-m_i\omega^2 \ \bar{r_i}.\bar{d_i}) + \sum_e(-m_e\omega^2\vec{r_e}.\vec{d_e}_e) = 0$

With:

- $d_i$, de: distance of centripetal forces from any transverse plane
- ω: speed of rotationω
- $r_i$, $r_e$: mass position
- $m_i$, $m_e$: house of rotating and balancing element

These equations clearly show that the masses do not intervene only by their intensity, but also by their position.

The product $m_ir_i$, $m_er_e$... is called unbalance and this notion is well felt in the equations if we highlight:

1) $\sum_j F_{cj} = 0 = \sum_i(-m_i\omega^2 r_i) + \sum_e(-m_e\omega^2 r_e) = 0$

2) $\sum_j MF_{cj} =$

$0 = \sum_i(-m_i\omega^2 \ \bar{r_i}.\bar{d_i}) + \sum_e(-m_e\omega^2\vec{r_e}.\vec{d_e}_e) = 0$

Which means that the two vector equations (1) and (2) for their resolution will naturally be transformed into two perpendicular equations (analytical or graphical resolution).

If we say 2 balancing weights or 2 balancing weights, the unknowns will be determined

$\left.\begin{array}{l} \text{me1, re1} \\ \\ \text{me2, re2} \end{array}\right\}$ to be determined

From where arbitrarily choose the position (re) or the mass (me) to determine the unknown:

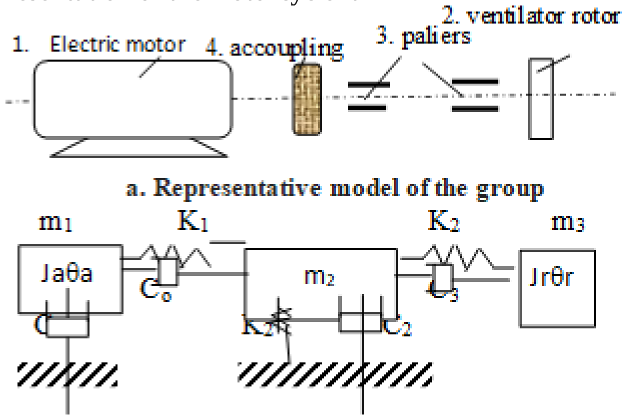
$m_e = \frac{(m_e r_e)}{r_e}$Where $r_e = \frac{(m_e r_e)}{m_e}$

In practice, we add or subtract a small mass.

It is always useful to adapt one of the balancing planes as a reference transverse plane ZZ'so that the balancing mass (the equilibrium unbalance of this plane) does not intervene in the moment equation. .

## 4. On-Site Vibration Level Sampling Methodology

**Presentation of the motorcycle fan**




**a. Representative model of the group**

**b. Group modeling (mass, springs and shock absorber)**

**Figure 2.1**

With

- $m_1$: mass of the coupling (n Kg)
- $m_2$: mass of cannon (n kg)
- $m_3$: mass of the wheel (in kg)
- co: coefficient viscous damping related to the characteristic of way between the coupling and the barrel (in Ns / m)
- $c_1$: viscous damping coefficient taking into account the connection between the coupling and the shaft (n N / Ns / m)
- $c_3$: viscous damping coefficient related to the bending characteristics between the shaft and the wheel (in Ns) m)
- $c_2$: coefficient of damping due to friction and internal damping of the structure (in Ns / m)
- $k_1$: stiffness due to the stiffness of the shaft between the coupling and the barrel [in Nm / rad]
- $k_2$: stiffness due to the internal transmission of the structure (in Nm / rad)
- $k_3$: stiffness due to the rigidity of the shaft between the barrel and the wheel [in Nm / rad]
- da: moment of inertia of coupling (in kgm²)
- dr: moment of inertia of the wheel in (kgm²)

**The sensors [4]**

The most used vibration sensor and the piezoelectric accelerometer. It consists of a flyweight placed on a piezoelectric crystal whose two opposite faces have been made conductive by metal deposition.

It has a very good linearity and a wide bandwidth. A monodirectional sensor stuck on the wall of a frame will measure the accelerations normal to it. Its mass, although slight (about 20gr), still influences all measurements, because on large and relatively thin walls, an added weight can reduce the eigen frequencies by a few percent.

Fixing the sensor on the structures can have a real influence on the quality of the signal collected. It can be fixed in various ways on the machine: screwed into the structure, screwed on a callused base, magnetic for the ferric metal structure, or attached with a touch point. This attachment plays an important role in the measurement result, and the



Paper ID: 12081801 DOI: 10.21275/12081801

bandwidth may be affected. The accelerometer must be placed in places of the machine where the maximum mobility for the frequency band studied / the current tendency is always to place the sensor as close to the component to follow; thus limiting

## 5. Construction of the Balance Weight Chart

### 1) Position of the problem

Determine balancing balances of a fan so that it has a permissible vibration for the proper functioning of the machine. There are indeed thresholds not to exceed by machine and record by the manufacturer.

### 2) Graphic solution

#### a) Path to follow

- Precaution: disconnected the machine in the network
- A first for a few minutes (3 or 4) gives the initial vibration Vi in mm / s that must be reduced if it is outside the permissible range
- Draw the first circle (c1) of radius vi represented on a well chosen scale. This circle representing the configuration of the wheel will be subdivided into sectors, according to the number of balancing pockets, if they were planned at the design or according to the number of vanes. These subdivisions are numbered and will position the balance weights.
- Choose an initial balancing mass equal to plus or minus 10 times the value of the initial vibration. With the mase fixed at any accessible point of the wheel
- Start the machine again for 3 to 4 minutes and read the vibration Vx in mm / s due to the presence of the mass x at this position x.
- Draw a circle Cx of radius Vx represented at the scale adopted for Vi, and of center x. the circle Cx translates the first alternative with the mass mx.
- With the same mid position placed at the opposite point y of point x on the same plane and start the machine again for 3 or 4 minutes. Read the vibration Vy in mm / s due to the change of the position of mi.
- Draw a circle Cy of radius Vy to represent at the same adopted scale and center y. The circle Cy translates the second alternative with the new position of mi.
- The intersection of the Cs and Cy circles thus determines the value and position of the overall balancing mass (mg). If the mg position does not coincide with the subdivisions chosen initially, it will be divided into two balancing masses mei. Since the positions of these new masses are known from the starting subdivisions, their values are deduced by equilibrium equations of moments around each of the two neighboring points where the real position is between these two points.
- This determination of balancing balances (mass + position) leads us to a verification start to see if the vibration vii is in the admissible walk.

In the opposite case, the operation recommends starting from the choice of another initial mass mii with the last vibration as departure vei. For the puddle without balancing pockets, the reference circumference shall be plotted or the balancing masses will be placed. The radius must be great to have a good sensitivity and a great moment.

## 6. Result

Our study led to the realization of a graph to reduce the shift between axes. And that presented two possibilities to know that of reducing and that of increasing the unbalance, We placed the mass of 2g at point 4 and we reduced the vibrations going from 3.7 mm/s to 0.95 mm/s. We have again placed the mass of 7.37g at point 3 and the vibrations have risen from 3.7mm / s to 5.1mm /s

## 7. Conclusion

This study was conducted to present a simple model for unbalance determination and location using graphs.

In fact, imbalances generate vibrations that are harmful to the behavior of the machine organs and the entire direct environment of the implantations. This approach consists in ensuring that only the mechanical unbalance is preponderant (after control of the machine), to operate dynamic balancing on site at the speed of the machine (motorcycle fan unit).

For wheels equipped with balancing pockets, the compensation masses will be fixed in the latter. If the wheels are devoid of pockets, a circumference of unbalance should be chosen. It will be subdivided into equal parts that will represent the pockets. Choices of the initial mass is

The unbalance graph is plotted using three quantities obtained from three tests (machine launch) represented at the appropriate scale. The first test is massless and gives the value of the initial vibration. The other two tests are done by placing the initial mass each time first on the first point chosen arbitrarily and then on the opposite one of the latter.

The compensation mass quantities are given by line segments at the chosen scale. The graph gives two possibilities, one of which corresponds to the optimal balancing position of the rotor. In principle, two tests should be done corresponding to these two possibilities.

## References

[1] JACKY DUMAS and BRUNO BENNEVAULT: Starting the vibratory measurement, 01 Bstelle (2001)
[2] PACHAUD © and BOULENGER (A), Surveillance and Diagnosis by Vibration Analysis, AIF, 1997
[3] Pierre DE HOMBREUX, Measurement and analysis of vibratory signals, Polytechnic Faculty of Mons, September (2001)
[4] H. ITOND, Vibration Analysis and Rebalancing Principle of Turbo machinery, TFE, UNILI, Likasi, (2016)
[5] DAVID AUGIEX, Vibration Analysis of Rotating Machinery, Engineering Technique, BM 5.145
[6] François NTAMBWE, "balancing and mechanical vibrations course", 2nd Electromechanical Engineering, UNILI Unpublished.