STARDOM UNIVERSITY

# جامعة ستاردوم

## مجلة ستاردوم العلمية للدراسات الطبيعية والهندسية

مجلة ستاردوم العلمية للدراسات الطبيعية والهندسية

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# Stardom Scientific Journal of Natural and Engineering Sciences

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[2] W. Strunk Jr., E.B. White, The Elements of Style, fourth ed., Longman, New York, 2000.

Reference to a chapter in an edited book:

[3] G.R. Mettam, L.B. Adams, How to prepare an electronic version of your article, in: B.S. Jones, R.Z. Smith (Eds.), Introduction to the Electronic Age, E-Publishing Inc., New York, 2009, pp. 281–304.

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# FIELD BALANCING FOR SINGLE BLADE FAN (USING CENTRIFUGAL BLOWER OF AIR-SLID OF CEMENT BACKING DEPARTMENT AT NATIONAL CEMENT COMPANY- NCC) AS CASE STEADY

**By:** Eng. Saleel Saeed Abdo, Preventive Maintenance Engineer at National Cement Company, Yemen.

**Supervised by:** Prof. Dr. Ahmed Saleh Alhunaishi

**Abstract**

• In this research, we summarize the important points in the balancing process.

• These practical points were extracted from external and local experiences on the work site, and these practical points are rarely found.

• Keep in mind that it should not take more than one or two trim runs or there are likely other issues influencing your measurements.

• If your amplitudes actual increase, it is time to stop and determine why. It is reasonable to continue so long as we are achieving a reasonable reduction in vibration with each weight placement.

• Machines that are severely out of balance in the beginning of the reduction has been achieved.

• Be sure to adhere to all safety guidelines and ensure the machine is always properly locked out prior to applying weight to the rotor or touching the shaft.

## ACKNOWLEDGMENT

Knowledge without practice is nothing and if knowledge exceeds the brain intellectuality, then this knowledge will become harmful for that person. Knowledge is the end base of acknowledgment", "Ludwig Wittgenstein", I extend my profoundest gratitude to my research Supervisor **Prof. Dr. Ahmed Saleh Alhunaishi** for finding an appropriate project and allowing me to work on it to expand my horizon and add new skills and knowledge. With his proficiency and his experience, he has opened to me new gateways to many practical realities that will be an asset for our future career.

I would like to thank all the teaching staff at the Mechanical Engineering Department at the prestigious University of Aden, and I also want to thank everyone who helped me during the study, especially my brothers and friends **PM-Manager Mohammed abdurabo**, **Ayman Saeed**, and I would like to specialize the words of thanks and gratitude to my **father, mother, brothers, and sister**.

Especially and individually, I would like to dedicate bouquets of thanks and gratitude to **my dear wife** for standing with me and encouraging me and for bearing my concern and for all that she did for me. I wish **my children** all the best in the future and be a place of pride for them.

***Thank you all, dear.***

## 1.0Introduction:

### 1.1 What is Imbalance?

Imbalance is the force created when a difference between rotational centerline and the mass centerline exists. This force occurs at running speed of the rotating assembly or 1x RPM. The vibration amplitude due to imbalance will increase by the square of the speed. If we double the speed of the rotor, we will increase the vibration amplitude due to the imbalance, by a factor of 4.

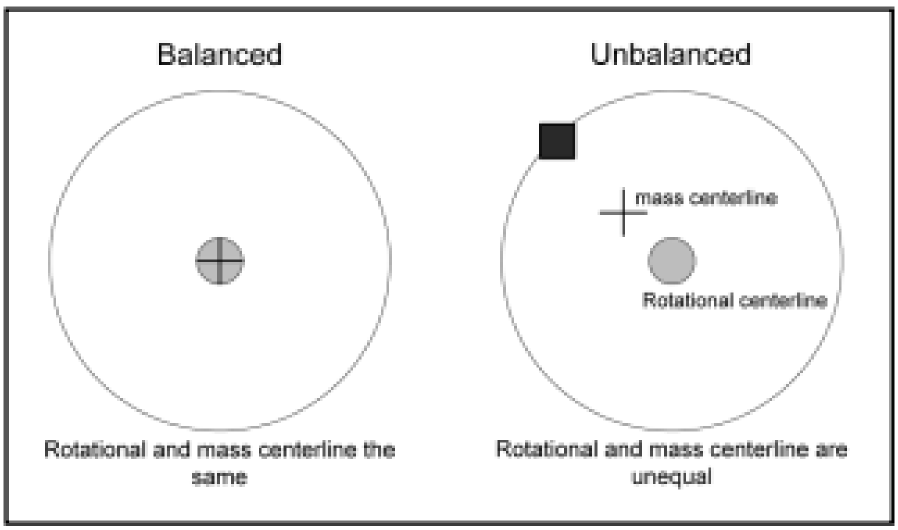



**Figure 1.** Balanced mass and unbalanced mass.

Vibration due to imbalance occurs at 1× rotational speed. The vibration at 1x will dominate the spectrum. The time waveform will be mostly sinusoidal in nature.

Not all 1x is due to imbalance. Other conditions such as an eccentric rotor, bent shaft, some forms of misalignment and resonance can all cause a dominant 1x vibration. The key is the sinusoidal waveform attributed to imbalance.

### 1.2 What Causes Imbalance?

There are several factors that can induce an imbalanced condition in rotating equipment.

- Poor balance tolerances
- Poor balance standards
- Assembly errors
- Incorrect key length
- Machining tolerances allowing assembly error
- Eccentric components
- Voids in casting
- Wear or corrosion
- Thermal or mechanical distortion
- Material build-up
- Bent or broken components

### 1.3 Types of Imbalances

There are three types of imbalances:

force imbalance, couple imbalance and dynamic imbalance. All three types of imbalance exhibit vibration at 1× rotational speed. To distinguish between them, we need to use phase readings.

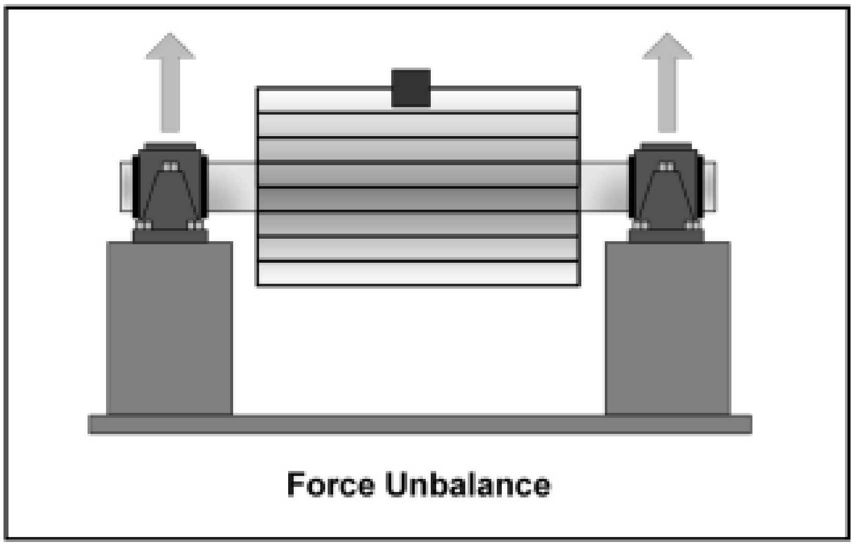



**Figure 2.** Forced unbalance.

### 1.4 Force imbalance

Force imbalance is when the imbalance condition is exhibited in one primary direction. This can be due to a single imbalance force or multiple sources that exhibit imbalance characteristics in the same direction. When force imbalance exists the vibration signature will exhibit a dominant 1x rotational speed amplitude. The horizontal as well as the vertical phase readings will be in phase. There will be a 90-degree phase shift from the horizontal measurement plane to the vertical measurement plane. This type of imbalance can be corrected with a single plane weight placement.

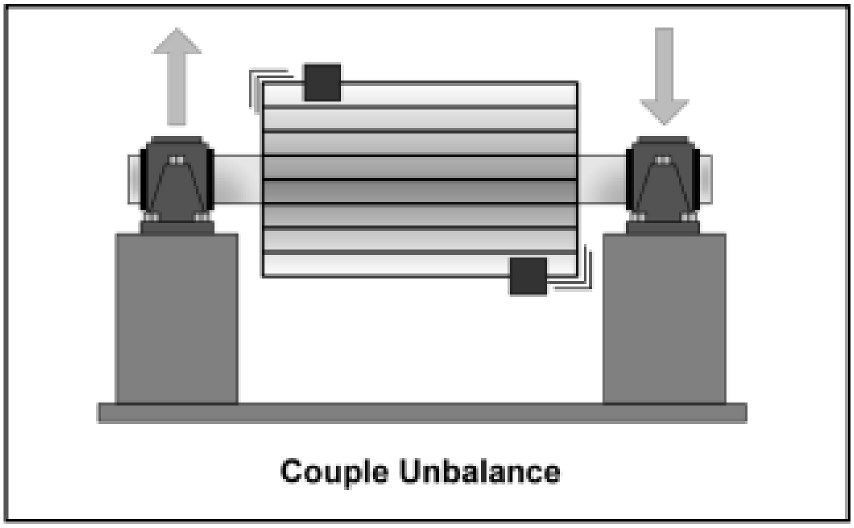



**Figure 3.** Couple unbalance.

## 1.5 Couple imbalance

Couple imbalance is where two separate imbalance forces exist 180 degrees from each other separated by a distance. When couple imbalance exists the vibration signature will exhibit a vibration response similar to force imbalance. In addition, couple imbalance can exhibit high axial amplitudes as well as high radial amplitudes. The horizontal and vertical phase readings should exhibit a 180-degree shift. There should be a 90-degree phase shift from the horizontal plane to the vertical plane. Couple imbalance will require two-plane or multiple-plane weight placement to correct.

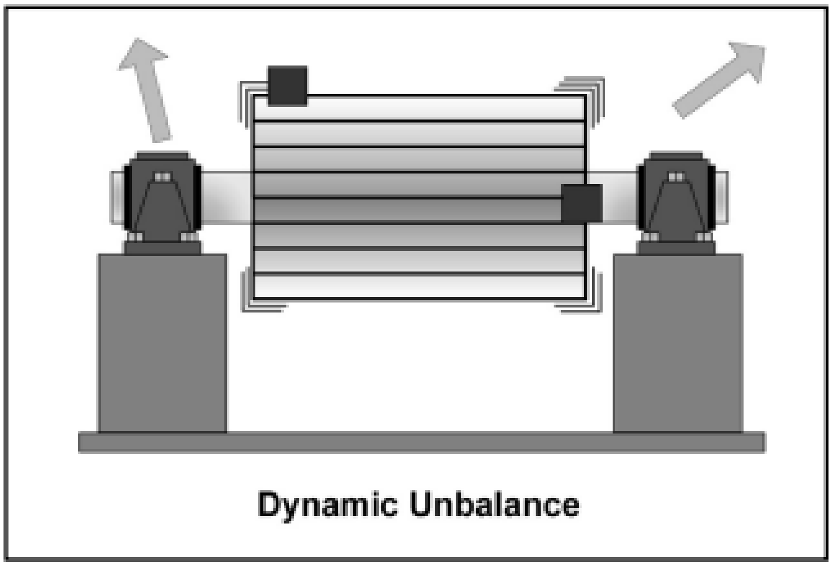



**Figure 4.** Dynamic unbalance.

## 1.6 Dynamic imbalance

Dynamic imbalance is a combination of force imbalance and couple imbalance. The dominant vibration amplitudes will occur at 1× rotational speed. Radial phase readings will be unsteady from 0 to 180 degrees. The horizontal shift should match the vertical shift. Dynamic imbalance will certainly require a multiple-plane weight placement to correct.

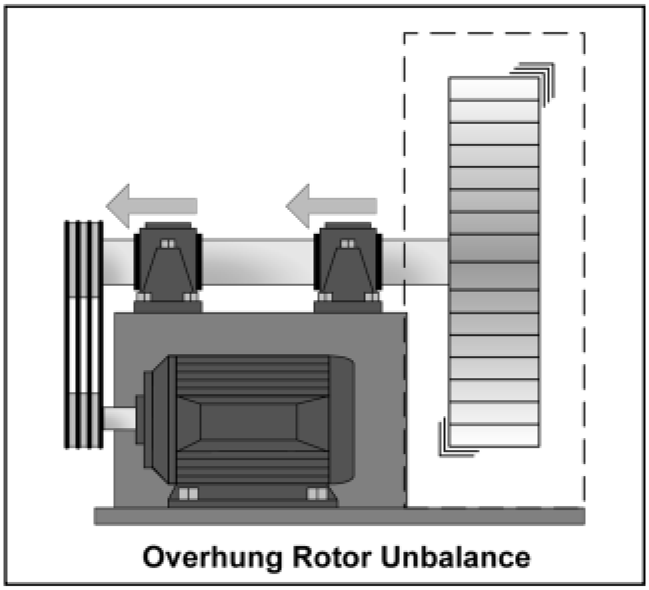



**Figure 5.** Overhung Rotor unbalance.

Overhung fans exhibit special characteristics. High axial readings as well as high radial readings are common, on both bearings. The axial phase readings should be in phase. The horizontal phase readings can be unsteady.

## 2.0 METHODOLOGY

### 2.1 Balancing methods

An imbalance condition can be corrected in essentially two different ways.

#### 2.1.1 Shop balancing

a. The equipment component is sent to a machine shop and typically, a balancing machine is used to correct the imbalance condition

b. Needed for parts like pump impellers and motor rotors where field balancing is impractical

c. Balance is performed in conditions that differ from final installation

i. Different load

ii. Different bearings

iii. Different speed

d. Trim run is often needed once installed

#### 2.1.2 Field balancing

a. Balancing is performed on the equipment while it is in place

b. Balance is performed in same conditions as running condition

c. No machine teardown is required reducing the risk of initial

d. failure upon restart

e. No trim run is needed

**We are going to focus on field balancing.**

### 2.2 Balancing procedure

For the purpose of our discussion, we will not use any specific method or brand but rather discuss the common steps needed to perform a balance job. For information on how to use a particular manufacturer's balancing program refer to the owner's manual.

#### 2.2.1 Step 1 (Attach Equipment)

When attaching the transducers and the tach to be used it is prudent to take a little care to reduce the chance of errors later. Place the transducer and the tach in the same measurement orientation when possible.

This will make your reflective tape location your zero reference and no phase shifts will be needed eliminating some confusion.

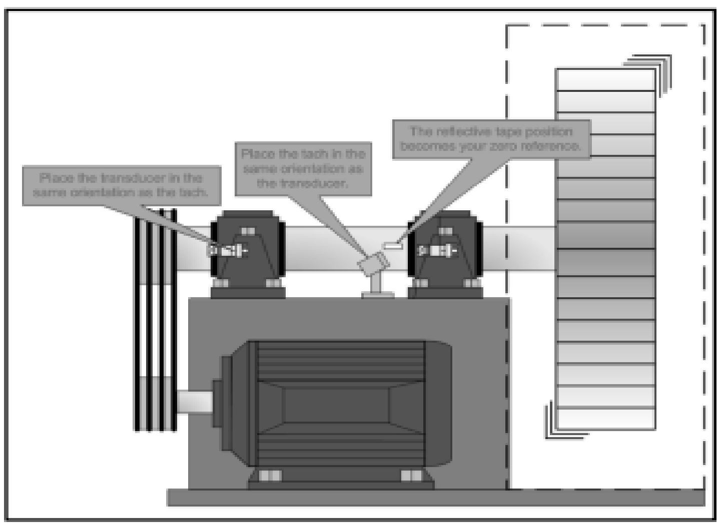



**Figure 6.** Attach Equipment.

#### 2.2.2 Step 2 (Perform the reference run)

This will establish the as-found condition of the equipment. On occasion you will find that after cleaning the rotor of all the buildup that the vibration may be within tolerances and no further action is required.

Compare the reference run to our standard to determine if further work is required.

### 2.2.3 Step 3 (Determine Trial Weight)

If further reduction in vibration is needed, we will now need to perform a trial run.

The purpose of the trial run is to establish the balancing coefficient for the correction calculations. All further correction calculations will use this value; therefore, it is important to use a trial weight that will provide the desired effect. As a rule of thumb, we want to achieve a 30% change in amplitude and a 30-degree shift in phase. Refer to the trial weight calculation discussed previously.

### 2.2.4 Step 4 (Apply trial weight and record result)

Once we have determined the appropriate trial weight amount, we need to determine where on the rotor we will place the weight.

Let us say we took our initial measurements, and the measured amplitude was 4 mils at 45 degrees. When we apply our trial weight, we want to place it opposite the heavy spot to achieve a reduction in vibration.

In the case of a two-plane balance we will need to determine which correction plane will be plane 1 and which will be plane 2. Then apply the weight to plane one.

Verify that a 30% decrease in amplitude and a 30-degree phase shift was achieved.

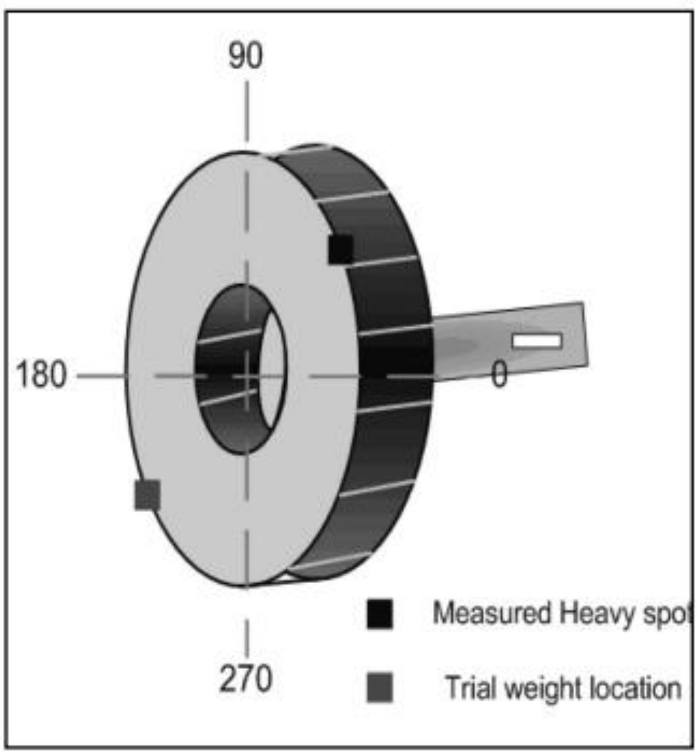


**Figure 7.** Trial weight location.

### 2.2.5Step 5 (Apply second trial weight)

If performing a single plane balance move to the next step. When performing a two-plane balance it is necessary to perform a second trial run on the second correction plane. Generally, it is simplest to place the weight in the same location on the second weight plane. Re-measure and record the results.

### 2.2.6 Step 6 (Calculate corrections)

If using a computer assisted program this step will be done for you. In this case simply apply the designated amount of weight to the designated location.

If the vector plotting method is being used, then you will need to plot the measurements and derive the correction weights and locations.

### 2.2.7 Step 7 (Apply the correction)

Add the designated amount of weight to the designated location indicated in the previous step.

If you are using pre-defined weight amounts, it is likely that you will be asked to apply weights that do not exactly match your available denominations. In this case you will either want to adjust the weight size by removing some of the weight material or use a combination of weights to get the desired amount.

It is important to try to get as close to the designated amount as possible.When using degrees instead of discrete weight locations you may find that the weight to be applied is between two blade locations. In this case it will be necessary to do a split weight calculation to determine the appropriate amount of weight to be applied to each adjacent blade.

It is not acceptable to simply apply the designated amount of weight to the closest blade.

### 2.2.8 Step 8 (Confirm the results)

Take a new set of vibration measurements to confirm the results of the applied weight.

Compare the results to our balancing standard to determine if further action is needed .

If we are not yet within tolerances a trim run will be necessary. Continue until the measured vibration is within tolerances. Document the results if a correction report is needed.

## 3.0 THE CASE STUDY:

In cement plants, there is a very important fan (CENTRIFUGAL BLOWER OF AIR-SLID) in the packing system of cement factories, and it will serve as case study in which the unbalance case will be addressed.

In this case we will discuss one of the most important fans (CENTRIFUGAL BLOWER OF AIR-SLID) in the packing system of cement factories, and this machine is critical machinery as it has sudden and immediate cost losses and therefore should not be suddenly stopped, so we are always planning by preventive maintenance before the failure happened, which is unbalancing case in this case.
In this thesis, we will review how balancing step-by-step action to benefit from this case as a practical way to do a balancing by help a special device we will remind it later.

### 3.1 EQUIPMENT DETAILS.

Equipment name (CENTRIFUGAL BLOWER OF AIR-SLID) motor details KW: 7.5, RPM:2970, 10 Vanes; Overhang Fan NORMAL VIBRATION 4.5 mm/s CRITICAL VIBRATION 11.1 mm/s.

**Figure 8.** Centrifugal Blower OF AIR-SLID in the packing system of cement factories

## 3.2 MEASUREMENT AND ANALYSIS FOR DE AND NDE BEARING:

Vibration Readings at 1x (2970 rpm) taken by Analyzer: SKF MICROLG ANALYZER AX-80

| Direction | Phase Reading at 1x (2970 rpm) Before Balancing |
|---|---|
| FAN DE: Horizontal | 9.5 mm/s @ 305° |
| FAN DE: Vertical | 14.8mm/s @ 38° |
| FAN NDE: Horizontal | 13.7 mm/s @ 288° |
| FAN NDE: Vertical | 27.1 mm/s @ 358° |

**Table 1.** The Reading of vibration for FAN before balancing.

## 3.3 THE PRACTICAL DETECTIONS:

As shown in above table 3. vibration reading in horizontal and vertical direction before balancing for both fan bearings in phase where this indicated unbalance of impeller of fan is found. So must do balancing for this fan impeller.

## 3.4 DATA COLLECTION FOR SKF ANALYZER WHICH WILL USE IN BALANCING PROCESS:

1- Overall vibration of fan DE & NDE bearings (27.1 mm/s).
2- Fan radius (337.5mm).
3- No. of fan blades (10 Nos.).
4- Amplitude and phase of un-accepted vibration reading (A=27.1mm/s, Ph=357°⁼360°⁼0°).

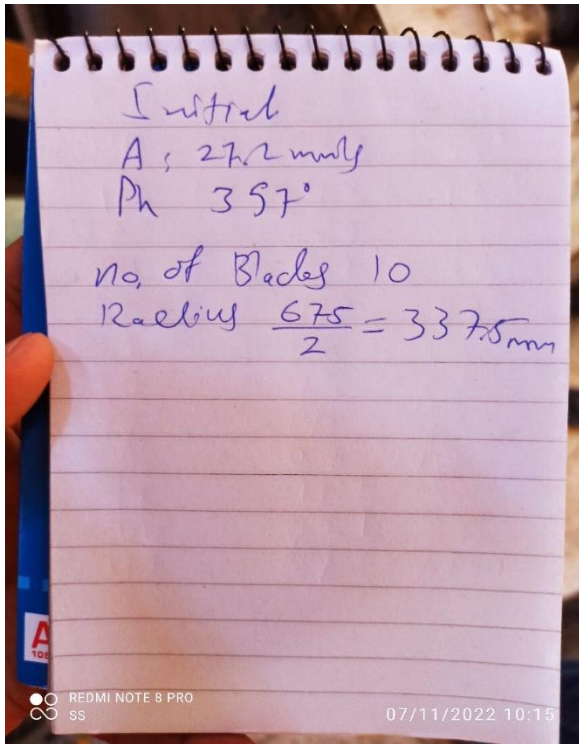




**Figure 9.** During take measurements

**Figure 10.** Amplitude, phase, fan blades No. and radius.

### 3.5 THE PRACTICAL BALANCING PROCESS FOR UN-BALANCED FAN

In the most important part of the thesis, which is the practical balancing process of the unbalanced fan, we will try to list it in a simplified, practical, and applicable as follows:

1- Clean the fan from any dust or stuck material.


**Figure 11.** Fan after cleaning

2- Arrange all tools will use in balancing such as SKF analyzer, Tachometer, welding Machine, Grinding Machine, welding rod, several weights, Marker pen, Measuring tape, Pen, and Notebook.


3- Numbering the fan as per blades from one to 10.

**Figure 13.** Numbered fan

4- Select the reference point means phase 0° to fix a tachometer connected to SKF analyzer with its shifted 30° after blade no.1 of fan, because as it is known in balancing process the weight gives response by the effect of vibration after about 30° of the actual effect of weight.

**Figure 14.** Selected reference point (0°)

**Figure 15.** Selected reference point

5- Start by previous data to determine the position of the trail weight and after adding will take vibration readings.

∵ Fan radius (**337.5mm**)

∵ No. of fan blades (**10 Nos**.)

∵ Amplitude and phase of un-accepted vibration reading (A=**27.1mm/s**, Ph=357°≈360°≈**0°**).

∴ The trial weight will be adding in the opposite side of phase 0° (i.e., in **phase 180°**) and we will choose trial weight 20 grams plus weight of welding material in the four directions is estimated for each direction 1 gram means the total trail weight will be **24 grams**.

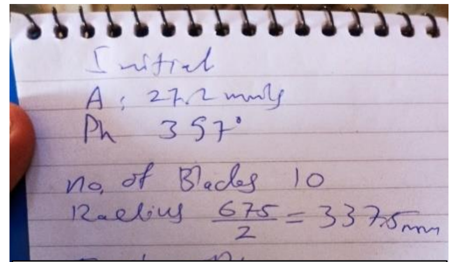



**Figure 16.** Initial data & trail weight

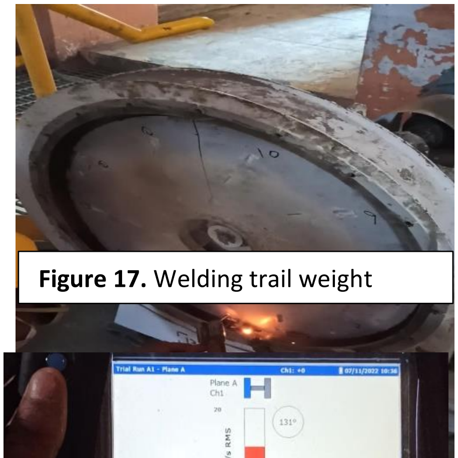


**Figure 17.** Welding trail weight

6- We take vibration reading after adding trail weight found the Amplitude and phase of vibration reading un-accepted yet (A=11.3mm/s, Ph=131°).

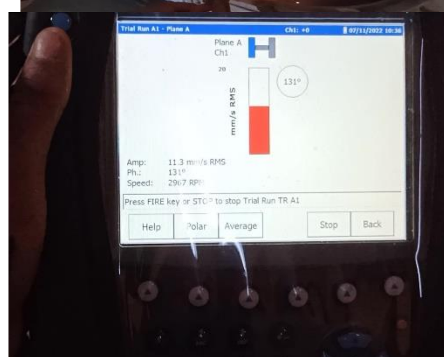
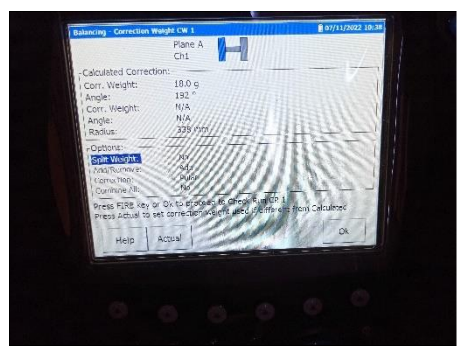



**Figure 18.** Vib. Reading after trail run

7- After trail run and previous data the SKF analyzer will calculate the corrected weight in correct phase **(correct weight: 18 grams, phase: 192°).**



8- Now will remove the trail weight (24 grams in phase 180°) by correct weight (18 grams in phase 192°). So, in accurate the correct weight will be one iron piece (14 grams) plus weight of welding material in the four directions is estimated for each direction 1 gram means the total trail weight will be **(18 grams in phase 192°)**.


**Figure 20.** Shifting trail weight

9- Now will run the fan as correct run and we will check by the SKF analyzer. We observed that the vibration reading decreased from un-accept reading (11.3 mm/s) to accept reading (0.866 mm/s) by corrected weight in correct phase **(correct weight: 18 grams, phase: 192°).**
Then, the result or summary of balancing as follows:
Initial reading - IR 27.1 mm/s ph: 356°
Trial weight (removed) - TR 24 gram ph: 180°
Trial response (selected) - TR 11.3 mm/s ph: 135°
Correct weight - CW18 gram ph: 192°
Correct response – CR 0.866 mm/s ph: 234°

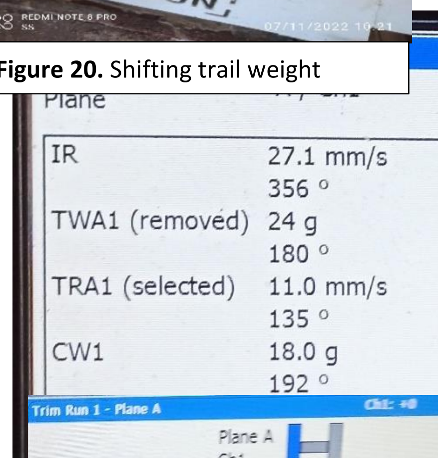



**Figure 21.** Trail & correction data

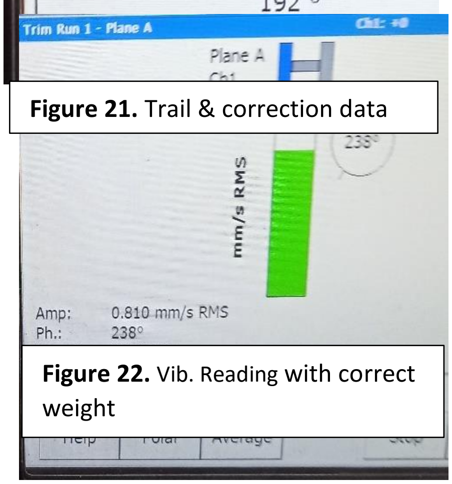



**Figure 22.** Vib. Reading with correct weight

## 3.6 THE RESULT AFTER CORRECTION:

Vibration Readings at 1x (2970 rpm) taken by Analyzer: SKF MICROLG ANALYZER AX-80

**Table 2.** Vibration Readings at 1x (2970 rpm)

| Direction | Phase Reading at 1x (2970 rpm) Before Balancing | Phase Reading at 1x (2970 rpm) After Balancing |
|---|---|---|
| FAN DE: Horizontal | 9.5 mm/s @ 305° | 1.3 mm/s @ 252° |
| FAN DE: Vertical | 14.8mm/s @ 38° | 3.1 mm/s @ 336° |
| FAN NDE: Horizontal | 13.7 mm/s @ 288° | 2.5 mm/s @ 248° |
| FAN NDE: Vertical | 27.1 mm/s @ 358° | 0.87 mm/s @ 235° |

Overall Vibration Readings (rms) of equipment at (2970 rpm) taken by Analyzer: SKF MICROLG ANALYZER AX-80

| Measuring Location | Direction | Before Balancing | After Balancing |
|---|---|---|---|
| Motor NDE | H | 10.7 | 2.9 |
| | V | 37.3 | 5.9 |
| | A | 8.3 | 2.6 |
| Motor DE | H | 7.5 | 2.1 |
| | V | 19.7 | 5.4 |
| | A | 5.9 | 2.8 |
| FAN DE | H | 11.1 | 2.9 |
| | V | 15.6 | 4.6 |
| | A | 15.7 | 5.6 |
| FAN NDE | H | 14.1 | 3.4 |
| | V | 28.5 | 3.6 |
| | A | 12.8 | 9.6 |

**Table 3:** Overall Vibration Reading (rms) of Equipment

## 4.0 THE DISCUSSION AND CONCLUSION:

- We conclude that when working on the balancing process by the analyzer the process was easy, fast, and accurate, this is what we need in maintenance, to avoid high costs and long stoppage.

- In short time we solved the problem (unbalanced case) and decrease vibration from 27.1mm/s @ 358° to 0.87mm/s @ 235°

- Might say that the analyzer is expensive, yes but this is in beginning, but when there is too much equipments. the working by the analyzer will be the right and even economical solution.

- This research aims to help understand condition monitoring. And to identify one of the most important methods of detecting faults, which is through the Spectrum Analysis and forecasting what the failure state may lead to from the vibration's readings data, and by referring to these data to develop the analysis so that you are aware that the multi-parameter monitoring program gives the greatest certainty.

- We conclude that when working on the balancing process by the analyzer the process was easy, fast, and accurate compared to traditional way, this is what we need in maintenance, to avoid high costs and long stoppage.

- In this research, we mentioned the practical steps for the balancing process in the field in 8 steps on pages 13 to 16.

- The common causes of imbalance in rotating equipment, were mentioned in page no. 4.

- In this research, we mentioned the SKF analyzer in the practical steps for the balancing process in the field in 8 steps on pages 13 to 16. The SKF analyzer, analyzes the reading taken and gives you the results that we follow to achieve the goal.

- Of course, in this research we referred to the spectrum analysis only as a matter of mention so as not to expand the research. Here we know that SKF devices analyze the spectrum and give you final results. We did not want to expand on this research because we will address it in my master's thesis.

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