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Damage Analysis of Centrifugal Exhaust Fan in Air Arrangement in Room Painting

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***Abstract*: The Centrifugal Exhaust Fan is one of the supporting tools in Line Drawing that works to remove air from the drawing space so that the drawing space is protected from air and dust to produce paintings on painted paintings during the production process. From a field survey, it is known that the centrifugal exhaust fan is damaged due to impeller pressure on housing. In general, if this damage occurs, the replacement of the bearing or propeller is made faster than the scheduled replacement. This study is conducted to determine the cause of damage and improve the life span by maintaining the reliability of the exhaust fan. To find a solution to this problem, use the Root Disruption Failure Analysis (RCFA) to determine the location, cause and effect of the damage. RCFA methods used are vibration checks and visual checks, so the cause analysis of the damage is done using the Ishikawa diagram or fishbone concept. After the cause of the damage is known, the Failure Mode and Impact Analysis (FMEA) is made for centrifugal exhaust fans. The results obtained from the RCFA and Ishikawa diagrams are the consequences and the main causes. Damages include thirst on booster, bearing, shaft, alignment, and imbalance. Symptoms of unbalanced damage and structural weaknesses appear to be the most dominant damage with the vibration value of 10.87 mm/s. The improvement strategy to sustain the Fourth-Fans's lifetime is given in the form of FMEA on every faulty component as a solution to the problem.**

***Keywords*: Exhaust Fan Centrifugal, Root Cause Failure Analysis (RCFA), Ishikawa diagram, Failure Modes and Effect Analysis (FMEA).**

1. Introduction

Exhaust fan is one of the most widely used tools in the industrial world. Almost every industry uses exhaust fan as a way to support existing production processes. Exhaust fan works to absorb air in the room to be released outdoors, while at the same time pulling fresh air out into the room. In addition, the exhaust fan can also adjust the amount of air that will be distributed in the room. To stay healthy, the room needs air circulation so that there is always room for change in the room with fresh air from the outside ... Given the importance of exhaust fan role, maintenance should also be considered carefully. Properly prepared maintenance strategies are implemented so that exhaust fans are protected from hazardous damage that may occur such as cavitation, ignorance, unbalance, coocked bearings, and other damage to the exhaust fan's performance uninterrupted. From the above picture, it can be seen that the centrifugal exhaust fan on the line of paintings is often subjected to problems because the impels are bricks with housing causing the cause of the impeller. In general, if this happens, the replacement of the bearing frequency is made faster than the maintenance schedule of the centrifugal exhaust fan. This study is conducted to improve centrifugal exhaust fan lifetime by maintaining the reliability of the centrifugal exhaust fan from possible damage. The problem discussed in this study is to determine the type of damage that occurs in the centrifugal exhaust fan, analyzing how this damage can occur and provide an accurate solution to the damage.

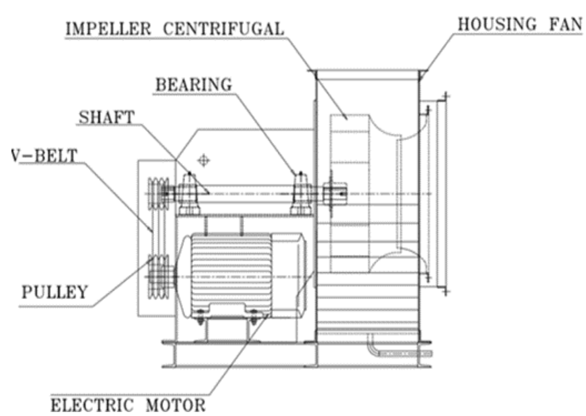


Fig. 1. Components on centrifugal exhaust fan
(Source: Data Of Drawing Koba Multi Indonesia, PT)

2. Methodology

This research begins with conducting field studies to determine the current state of the centrifugal exhaust fans and the historical analysis of the damage that has taken place so far as well as the refinement efforts have been made. Methods used are visual methods or direct observations to exhaust fan units and direct interviews. From the check carried out, find out what the problem is in the centrifugal exhaust fan. One of the preventative maintenance efforts carried out by the parties is to analyze the condition of the motor and pump (state monitoring) using visual vibration monitoring and cleaning at the impeller. Visual observation is performed on an exhaust fan or a faulty motor component when the disassembly occurs. As for vibration data capture, it is done on 2 parts, one side of the measurement on bearing 1 (one) bearing 2 (two) and one side once again the measurement is made on the electric motor. On each side data is collected 3 times, ie on the vertical, horizontal and axial sides. Location and direction of vibration data capture as shown in Figure 2. The results obtained from vibration checks are in the form of vibration magnitude values, but data must first be processed into a vibration spectrum to analyze the symptoms of the damage. The vibrating value will be read by the sensors in the mm / s unit using the acceleration interpreted in the accelerometer graph every time. Then the result is modified by using Fast Fourier Transformation (FFT) method to get the velocity graph spectrum shape to vibration frequency.

Fig. 2. The vibration data retrieval position

After the spectral graph is obtained, the vibration value is analyzed and compared with the ISO 2371 standard shown in Figure 3. Analysis is carried out according to the centrifugal safety limit values and motor categories used. Identification of the problem and the selection of suitable treatment for problems in the motor and pump is obtained from data analysis of vibration test data graphs.

Rank of machine Vibration (ISO 2371)

VIBRATION RATION AMPLITUDE	MACHINE SORT			
VIBRATION VELOCITY V rms (mm/sec)	I	II	III	IV
0 – 0,28	A	A	A	A
0,28 – 0,45	A	A	A	A
0,45 – 0,71	A	A	A	A
0,71 – 1,12	B	A	A	A
1,12 – 1,8	B	B	A	A
1,8 – 2,8	C	B	B	A
2,8 – 4,5	C	C	B	B
4,5 – 7,1	D	C	C	B
7,1 – 11,2	D	D	C	C
11,2 – 18	D	D	D	C
18 – 28	D	D	D	D
28 – 45	D	D	D	D
> 45	D	D	D	D

Note :
Class I is small motor (power less than 15 kw).
Class II is medium motor (power between 15 - 75 kw).
Class III is hight motor
Class IV is hight motor

A	MEANS GOOD
B	MEANS SATISFYING
C	MEANS NOT SATISFYING
D	MEANS FORBIDDEN

Fig. 3. Rank Of Machine Vibration (ISO 2371)

After the damage to the centrifugal exhaust fan is known, then Root Cause Faure Analysis (RCFA) is carried out using the Ishikawa diagram concept. The concept of Ishikawa is used to determine the cause of the occurrence of damage as shown in Fig. 4.

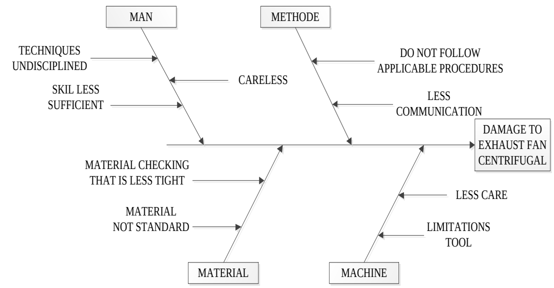


Fig. 4. Ishikawa diagram

Ishikawa diagram is made on all components in the centrifugal exhaust fan and analyzed on damaged components. The damaged components will be further analyzed using the Ishikawa diagram which is more in depth about the kind of damage that occurs. Such steps are carried out continuously until the cause of damage and the symptoms of damage are the most dominant. After the root damage and damage location is known, then the next step is to formulate a repair and maintenance strategy using the FMEA's Failure and Impact Analysis concept. In the FMEA object formulation, there are several steps that must be taken, including:

- Determine the object or system to analyze.
- Create a hierarchical tool for the selected object.
- Designing mods and causes of failure.
- Analyze the damage effect.
- Define targets for protection.
- Set the value of severity.
- Determine the probability of damage.
- Determine the risk code by using the risk matrix.
- Formulate corrective measures of each failure mode

3. Results and discussion

A. Damage to exhauast fan centrifugal

In order to know the centrifugal exhaust fan damage, it is necessary to perform an inspection when the exhaust fan has a disturbance in the form of noise, high vibration. Examinations using vibration inspection methods on bearings and motors are performed when the exhaust fan is operating, while visual inspection is performed by unpacking the exhaust parts, including by unloading the bearings and bearings by looking directly at the damage. From checks that have been carried out, some damage has occurred, including the following:

- Impeller damage is usually caused by friction with housing fans and impeller corrosion due to air containing chemicals. This is the flow of noise and vibration on the exhaust fan becomes larger. As can be seen in Fig. 5.

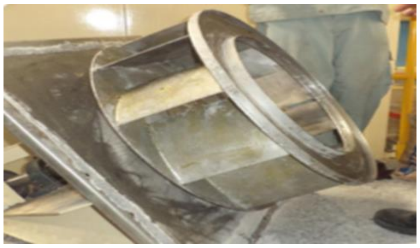
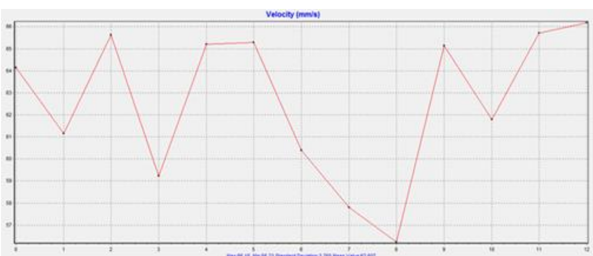


Fig. 5. Centrifugal impeller

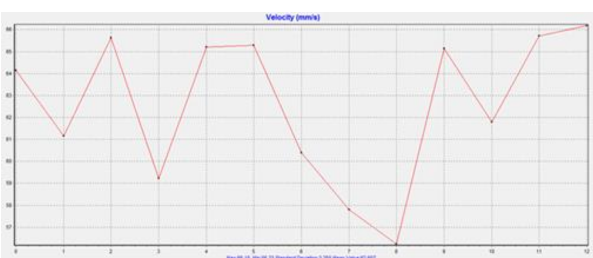
- Damage to the bearing in the form of lubrication in the interior, damage in the form of longitudinal cracks towards the center of the outer bearing, scratches and deformation on the surface due to friction and effect can be seen in Fig. 6.

Fig. 6. Fillow block bearing

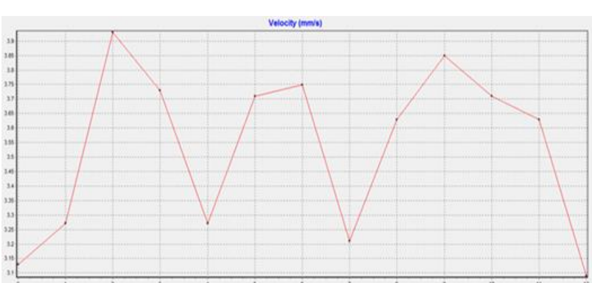
B. *Analis vibration*



(a) Vertical position



(b) Horizontal position



(c) Axial position

Fig. 7. Vibration chart measurement results

The vibration spectrum graphs on the bearings and motors as shown in Fig. 6 show that the position of the vertical velocity vibration is still in the red column with a value of 55.395 mm / s. While in horizontal position also exceeded the permissible safe limit or red column based on ISO 2371 with value 62.607 mm / s. Although the axial velocity vibration position is still in a safe limit with a value of 3,532 mm/s. From the trend chart shows the breakdown of the bearing on the bearings where the large amplitude appears in the vertical position then increases the horizontal position and decreases in the axis. This indicates that there is damage to the bearing and impeller disconscience. Spectrum analysis of vibrations is performed on all parts of the centrifugal exhaust fan, obtaining the symptoms of damage obtained. And can be seen in Table 1 as follows,

Table 1
Velocity Vibration Exhaust Fan Centrifugal Fan

No.	Section Checked Items	Type Of Damage
1	Bearing - Vertical	Danger
2	Bearing - Horizontal	Danger
3	Bearing - Axial	Permitted
4	Motor - Vertical	Good
5	Motor - Horizontal	Permitted
6	Motor - Axial	Good

From the above table it can be seen that the exhaust fan has some indication of damage, but the most dominant damage symptom is the bearing that causes vibration and unbalance, where the damage symptoms are seen in the horizontal and vertical position of the bearing exhaust fan that has the highest vibration value compared to axial position, which is 62.607 mm/s. In addition, the signs of damage are damage to the rusty impeller.

C. *Root damage analysis*

From the analysis of vibration that has been done, it is known that any damage occurred in the centrifugal exhaust fan, then the next step was to diagram Ishikawa to facilitate the analysis of the damage. To analyze the cause of the damage, the exhaust fan Ishikawa diagram as a whole is made more detailed about the faulty exhaust fan components to get the cause of the damage.

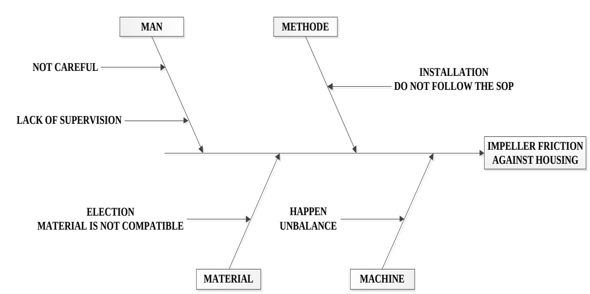


Fig. 8. Ishikawa Diagram Impeller with Housing

Analysis of the root causes of friction between impellers and housing using the Ishikawa diagram as shown in Figure 8, where friction can occur due to several things such as errors in installation, failure of the shaft, failure of the bearing, and unbalance. From the checks that have been done, it is known that friction between impellers and casings is caused by failure of the bearing. This can be seen when the disassembly of the exhaust fan turns out that the bearing is damaged and corroded due to lack of lubrication in the bearing .. Damage to this bearing causes the shaft to move forward at high speed and results in rotation of the impeller on the housing. Damage analysis is carried out continuously on each type of damage that appears until the root is obtained from the damage that occurs on the last ishikawa diagram as seen in Fig. 9.


Fig. 9. Damage to Bering

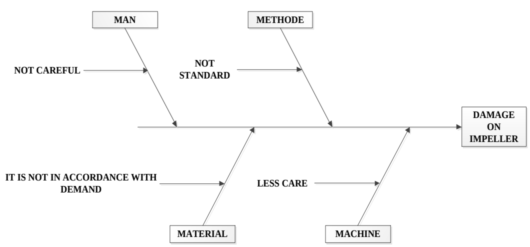


Fig. 10. Ishikawa Damage diagram on the impeller

From the inspection, it is known that impeller damage is caused by imbalance, this can be seen in the result of vibration checks where there is an indication of imbalance in the centrifugal exhaust fan that has the highest vibration value compared to other damage symptoms which causes the most dominant damage effect. An imbalance causes vibration and causes relaxation at the base, so that the bolt bolt is damaged and released.

D. Solutions and problems

Based on the type of damage that occurs and the source analysis of the damage, appropriate improvement strategies can be formulated using FMEA to prevent further damage. Preparation of FMEA is focused on faulty components, bearings and propellers. For unbalanced problems, it can be done after changing the bearings while damage to the impeller can still be fixed if the damage is not too severe. To determine the type of imbalance, you can check the value of the vibration when the motor is loaded. The vibration value is taken and recorded when the motor is controlled so that the motor load is stopped. If the vibration value decreases slowly then this indicates that the imbalance is mechanical imbalance, while electrical imbalances occur if the motor vibration value decreases dramatically as the load is stopped. From an unbalanced problem, the most important step to overcome this problem is to offset the rotor with mass repayment mass or reduce the rotor mass (drilling). If the problem is an electric unbalance due to the motor stator coil, the rewind is done. If the imbalance problem is solved, the next step is to repair the base, and tie the bolt. This is important because these components also work to make the rigid motors also function as vibration dampers.

4. Conclusion

The analysis and infections of the author can be concluded that the damage discussed in this final project includes:

- The breakdown of the centrifugal exhaust fan is a friction between the housing with impulse, unbalance, relaxation, absence, and vibration.
- Damage to exhaust fan caused by
- Damage to booster and bearings, where the damage is caused by the friction between the impeller and housing of the fans.
- The damage to the bearing causes the shaft to move forward when the pump works at high speed, so the impeller rubs it into the housing.
- The damage to the bearing is due to the crane imbalance, as well as due to improper installation and less lubrication.
- The pulley adjustment is caused by the relaxation of the relaxation which causes the alignment that has been done for not being wrong.
- Symptoms of relaxation damage caused by indiscriminate indication of damage to the fan and the base of motorcycles.
- Maintenance strategies implemented for each damaged component are as follows:

Table 2
Preventive Maintenance Strategy

No.	Part Item	Repair And Maintenance
1	Impeller	* Clean every 2 weeks
		* Fix the impeller if the condition is lightly damaged
		* Replace with the new impeller if the old impeller cannot be repaired
2	Bearing	* Lubricate the bearing periodically
		* Bearing installation follows the instructions
3	Motor	* Check the vibration on the motor regularly
4	Pulley	* Check the pulley condition if there is a crack immediately replaced
5	V-Belt	* Check the condition of V velt, if there is a crack and break immediately replace

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