Design of Auto Drilling Mechanism For Dynamic Balancing of Rotors Used In Generators

Puneeth H V[1], Sujeeth Swamy[2], Aswin J[3], Abrar[4], Adil A[5], Mahesh M[6]
[1, 2]Assistant Professor, Dept of Mechanical Engineering
[1, 2, 3, 4, 5, 6]New Horizon College of Engineering, Bengaluru, India,

Abstract- *Unbalance is the most common source of vibration in machines with rotating parts. Unbalance exists in a rotor when the mass centre axis is different to its running centre axis. Practically all newly machined parts are non-symmetrical due to blow holes in castings, parts fitted off-centre, machined diameters eccentric to the bearing locations etc. An unbalanced rotor, when rotating, wants to revolve around its mass centre axis. Because the bearings restrict this movement, the centrifugal force due to the unbalance causes the rotor to vibrate. This vibration cause's wear to the bearings creates unnecessary noise and in extreme cases disintegration of the rotor itself can be experienced. It is therefore necessary to reduce the unbalance to an acceptable limit. The aim of rotor balancing is to achieve satisfactory running when installed on site. To identify the position and amount of unbalance, balancing machines are used to correct any unbalance that exists. To correct the unbalance material removal by drilling is preferred. After measuring the unbalance, the software calculates the depth of cut that the machine must drill in order to compensate the unbalance. The balancing machine indicates the operator how much material to remove from each lobe (claw) of the rotor. The operator does not have to calculate or vector this amount himself. Based on the specifications, the balancing machine will display the amount to be removed from each lobe of the rotor. The main objective of the present work is to develop and implement a mechanism to drill the holes automatically by using limit switches and timer pulley arrangement so that the drill depth is accurate and the operator can successively operate three machines instead of one thereby reducing the cycle time for balancing operation. This increases the production rate, reduces rework and increases the profit to the company. In the current scenario, the operator manually places the rotor on to the drilling machine and adjusts the depth of cut as specified on the balancing machine using the scale provided on the drilling machine operated by a timer pulley arrangement. A hole is drilled on the lobe where unbalance exists and the operator continues the same until the required depth is achieved. Therefore by automating the drilling operation, an accurate drilling is obtained in addition to the benefits of reduced rework and cycle time for each operation, which ultimately leads to an increase in the production rate.*

Keywords- Unbalance, drilling, production rate, automation, cycle time

I. INTRODUCTION

Unbalance is the most common source of vibration in machines with rotating parts. It is a very important factor to be considered in modern machine design, especially where high speed and reliability are significant considerations. Balancing of rotors prevents excessive loading of bearings and avoid fatigue failure, thus increasing the useful life of machinery. Unbalance in a rotor is the result of an uneven distribution of mass, which causes the rotors to vibrate. The vibration is produced by the interaction of an unbalanced mass component with the radial acceleration due to rotation, which together generate a centrifugal force. Since the mass component rotates, the force also rotates and tries to move the rotor along the line of action of the force. The vibration will be transmitted to the rotor's bearings, and any point on the bearing will experience this force once per revolution. Balancing is the process of attempting to improve the mass distribution of a rotor, so that it rotates in its bearings without uncompensated centrifugal forces. This is usually done by adding compensating masses to the rotor at prescribed locations. It can also be done by removing specific quantities of material, for example by drilling. Rotating machinery is commonly used in mechanical and electromechanical systems that include rotors of motors and engines, machining tools, industrial turbo machinery, etc. In case of unbalanced distribution of rotating masses around an axis of rotation the rotor unbalance arises. This presents a serious engineering problem because it is a major cause of excessive vibrations, especially at higher speeds. Arising large centrifugal unbalanced forces can lead to damage of bearings and finally to destruction of machines. This is the reason why solving of the unbalance is a basic concern in design and operation of the machinery. Vibration of the rotating machinery is suppressed by eliminating the root cause of vibration-the system unbalance. Practically, vibrations cannot reach zero values but usually it is acceptable to decrease them to a value lower than that one prescribed for a certain quality class of the machinery. Balancing of the rotor increases the bearing life, minimizes

vibrations, audible noise, power losses, and finally it results in increased quality of products.

II. METHODOLOGY

A. Existing Methodology

1. Place the rotor on the balancing machine and identify the position where the unbalance exists.
2. Look at the monitor on the balancing machine and locate the rotor on the drilling station such that the drill head is above the claw number at which the material has to be removed.
3. Drill the hole manually according to depth shown on the balancing machine.

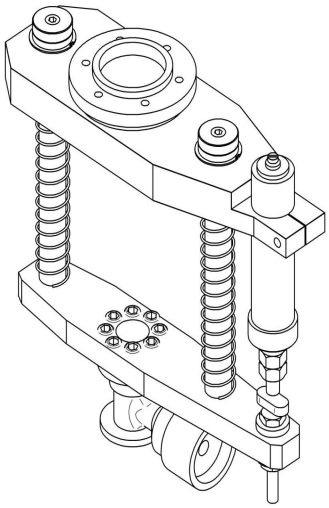
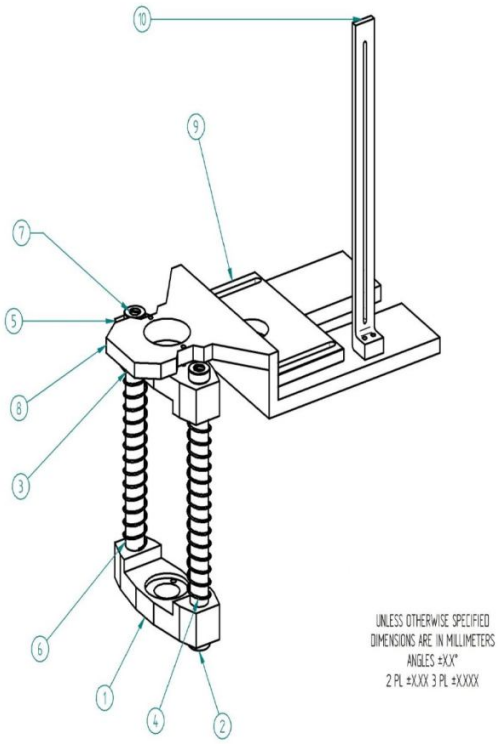


Fig 1: Existing design of fixture

B. Proposed Methodology

1. Place the rotor on the balancing machine and identify the position where the unbalance exists.
2. Look at the monitor on the balancing machine and locate the rotor on the drilling station such that the drill head is above the claw number at which the material has to be removed.
3. Adjust the drill depth using timer pulley arrangement driven by means of a brake motor. The drilling depth is controlled by means of a limit switch to prevent over drilling from taking place.
4. Now in this process, the drill depth drilled on the rotor will be accurate as to what specified by the operator and over drilling or under drilling is avoided.



Part	Part name
1	Bottom plate
2	Spacer
3	Spring
4	Guide rod
5	M6 screw
6	Fixture mounting plate
7	Sensor mounting plate
8	Cylinder mounting plate

Fig 2: Proposed design of Fixture

III. MATERIAL

EN8 is the material used to fabricate the newly designed fixture. EN8 is unalloyed medium carbon steel (BS 970 080M40) has high strength levels compared to normal bright mild steel, due to thermo mechanical rolling. EN8 is suitable for all round engineering purposes that may require a steel of greater strength. EN8 or 080m40 can be tempered at a heat of between 550°C to 660°C (1022°F-1220°F), heating for about 1 hour for every inch of thickness, then cool in oil or water. Normalizing of EN8 bright mild steel takes place at 830-860°C (1526°F-1580°F) then it is cooled in air. Quenching in oil or water after heating to this temperature will harden the steel.

Table 1: Chemical Composition of EN8 Steel

	C	Mn	Si	P	S
Min	0.35%	0.60%	0.05%	0.015%	0.015%
Max	0.45%	1.00%	0.35%	0.06%	0.6%

Table 2: Mechanical Properties of EN8 Steel

Condition	Yield Stress × 10^6 Pa	Tensile Stress MPa	Elongation %
Normalized	280	550	16
Cold drawn (thin)	530	660	7

IV. BENEFITS OF AUTOMATED ROTOR BALANCING

A. Drawback of conventional system:

In earlier era, drilling technology could not meet the needs of smart drilling system. Generally, manual and semi-automatic systems had serious reliability problems, did a poor job. Some problems regarding existing system are as follows-

1) Manual operation.
2) Discontinuous operation because of manual working less speed of operation.
3) Startup time is more.
4) Less production rate.
5) It cannot detect metal pieces in object.
6) Unsafe working due to more manual efforts.

B. Automatic vs. manual drilling operation

Automatic armature balancing is the most cost effective means of producing higher quality products, in less time and for less money. There are many reasons to automate your balancing process, some of which include; higher production rates, the use of less floor space, the reduction of skilled labor, better quality control, a higher quality final product, the elimination of multiple shifts, and the ability to take on more business with increased capacity.

In addition, automatic balancing can increase the marketability of your products with the ability to showcase your "state of the art" equipment for the production of their "state of the art" products. Thus, automatic armature balancing can give your company a competitive edge by increasing your production and lowering your costs while producing higher quality products. As balance tolerances continue to tighten, manual balancing will become increasingly more difficult, and less practical. Although a manual machine has the capability of measuring unbalance as well as an automatic machine, an operator cannot consistently balance as quickly or as accurately as an automatic machine.

C. Advantages of automatic balancing and auto drilling

As discussed, there are many types of operator errors and inaccuracies typically associated with manual balancing. These errors combined, cost time and money, as well as the possible reduction of overall generator performance. As production rates increase and balance tolerances continue to tighten; manual balancing will become increasing more difficult and impractical.

There are vast opportunities for automation in different manufacturing operations whether the operations are related to machining or assembling of component. The main advantages of Auto Drilling are:

a) It increase the productivity
b) It reduce the manpower
c) It reduce the processing time
d) It reduce the overall manufacturing cost
e) To improve quality
f) An accurate drill depth can be achieved on the rotor
g) Now the operator can operate three machines one after the other on the balancing machine when compared to earlier scenario where the operator can operate only one machine.

Automatic rotor balancing will become a necessity for the consistent production of high quality rotors. Automatic rotor balancing is a good investment in your company's future.

The present system is superior in both performance and is more flexible in operation. Moreover, the running time has got shortened. Thus, desired requirement of company has been fulfilled by this automation.

V. CONCLUSION

High Production quality and low production cost are essential for the success of manufacturers in today's competitive market. Automation is essential for producing large quantities of high quality products at low costs. High accuracy, uniform quality, and large production quantities are important characteristics of automation. In addition, the system developed minimizes the level of expertise required to perform the analysis and eliminates possible human errors.

The current system focuses on balancing and drilling related operations.

1. The dynamic balancing of generator rotor was earlier done by manual drilling operation. By automating the drilling operation it was able to save labor and greatly reduce the task intensity.
2. The introduction of dedicated automation equipment greatly reduced the potential for safety accidents from tasks.
3. By incorporating dedicated automation equipment it resulted in improved productivity, reduced defect rate, and increased quality of rotor by proper balancing.

REFERENCES

[1] Shiyu Zhou and Jianjun Shi, "Active Balancing and Vibration Control of Rotating Machinery". Beijing University, Volume 13, 2014

[2] Viliam Fedak, Pave Zaskalicky and Zoltan Gelvanic , "Analysis of Balancing of Unbalanced Rotors and Long Shafts using GUI MATLAB" ,MATLAB Applications for the Practical Engineers, Chapter 19, Volume 1, 2009.

[3] Sanjay Taneja, "Effect of Unbalance on performance of centrifugal pump", International Journal of Scientific and Technology research Volume 2, Issue 8, August 2013

[4] Md. Abdul Saleem, G. Diwakar and Dr. M.R.S. Satyanarayana, "Detection of Unbalance in Rotating Machines Using Shaft Deflection Measurement during Its Operation", Published in Journal of Mechanical and Civil Engineering (IOSRJMCE) ISSN: 2278-1684 Volume 3, Issue 3 (Sep-Oct. 2012), Pg 08-20.

[5] Pan Xin, Wu Hai-Qi, Gao Jin-Ji, Mu Yu-Zhe, "Study on online active balancing system of rotating machinery and target control method". Beijing Key Laboratory of Health Monitoring and Self-recovery for High-end Mechanical Equipment Beijing University of Chemical Technology. E-ISSN: 2224-2678, Volume 13, 2014.

[6] Zhao Qing-Liang Wang Hua-Qing Yao Jian-Fei, "A Novel Method of Dynamic Balance Weighting for Single-Disk Rotor System", Diagnosis and Self-Recovery Engineering Research Center, Beijing University of Chemical Technology, E-ISSN: 2224-2678, Issue 1, Volume 11, January 2012

[7] P.A Mehta, A.ASagare, V.S. Samseand Dr. A.D. Rahulkar, "Automatic Drilling System Using PLC", Department of Instrumentation and Control Engineering AISSMS Institute of Information Technology, University of Pune, published in International Journal for Technological Research in Engineering Volume 1, Issue 7, March-2014.

[8] M. Tolouei-Rad, "An intelligent approach to high quantity automated machining", School of Engineering, Edith Cowan University, Perth, Australia, published in Journal of Achievements in Materials and Manufacturing Engineering, Volume 47, Issue 2, August 2011.

[9] S.Y. Yoon et al, "Control of Surge in Centrifugal Compressors by Active Magnetic Bearings" Volume 3, January 2012.

[10] Sung Hoon Oh and Byung- moon, "A Study on Automatic Drilling Machine for Manufacturing the Truck Cargo Box", Division of Mechanical system engineering, Chonbuk National University, Republic of Korea, International Journal of Control and Automation, Vol.7, No.2 (2014), Pg.33-40

[11] M.I. Friswell, J.E.T. Penny, S.D. Garvey and A.W. Lees," Rotor dynamics Software Manual-Dynamics of Rotating Machines", Cambridge University Press, 2010

[12] J.S.Rao, R. Sreenivas and C.V.Veeresh. "Solid Rotor Dynamics", Quality Engineering and Software Technologies Pvt Ltd, Bangalore, Advances In Vibration Engineering, 2(4) 2003.