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Design and Fabrication of Automated Angle and Height Measuring Fixture for Blade Mounting Brackets

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Abstract:- **Blade mounting brackets play a vital role in successful operation of fans. In order to get a rigid joint between rotor and blades, the blade mounting brackets are used. The lift and inclination of these brackets are the major parameters to be monitored. The existing system involves manual inspection and requires trained personnel. This work involves designing and fabricating an automating angle and height measuring fixture for blade mounting brackets to overcome the issues with the current system which will lead to reduction in the overall operating . The automated machine achieved the goalof a decreased overall measurement and inspection time.**

Keywords: **Blade mounting brackets, automated inspection, Work measurement, Sampling Plan.**

I. INTRODUCTION

Blade mounting brackets for fans are made of mild steel and are used to hold the blades. It forms a rigid joint between the rotor and the blade. Both lift and the angle of the bracket should be precisely monitored as it determines the flow of air from the fan. Lift accounts for the area over which the air will be circulated and angle determines the amount of air which will be sheared and pushed towards the area of application. Hence the lift and the inclination of the blade mounting brackets are the major parameters to be monitored before putting it into operation. Also proper inspection of the bracket is very important. Industries usually incorporate a manual mode of inspection which is time consuming and requires a skilled labour to perform the job. Manual mode of inspection faces a lot of draw backs during peak seasons when brackets undergo mass production. These limitations unfortunately cannot be ignored and hence there is a need for automated inspection. There is no proper system to carry out all the measurements and inspection effectively. Presently a standard block is being used to hold the bracket for measurements which is supposed to be changed every time as the design of the bracket changes. Two different types of instrument are used for the measurement purpose and a standard chart is being referred to check if the component is acceptableor not,accordinglythecomponentsareinspected. Ourresearch workfocuses on three types of brackets which are under mass production.

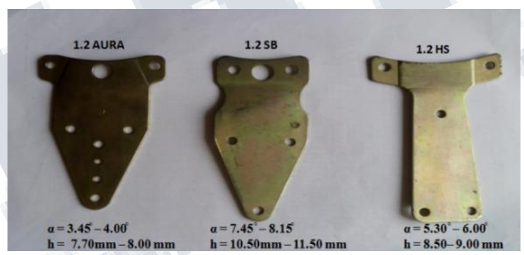

Fig 1.1: Components under study

These components are mainly inspected for lift (h) and the angle which they make with the reference .

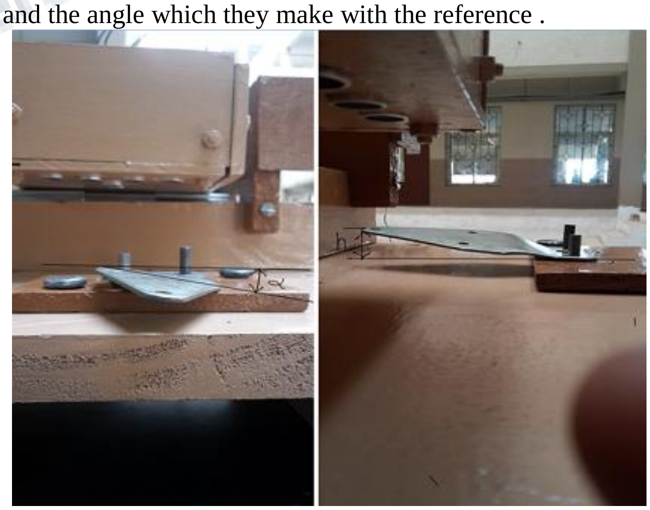

Fig 1.2: Component Detail

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II. LITERATURE REVIEW

On reviewing of literature, it was found that most of the researchers prefer using manual mode for evaluating the dimensions of various components. But this method of evaluating the dimensions is time consuming. This involves monotony and hence increases the worker's fatigue. With the advent of mass production, it has become a necessity to maintain good quality practices which in turn demands a reduction in overall production and inspection time.

[8**] R. Hunter Alarcon** demonstrated the fixture knowledge model development and implementation based on a functional design approach. Knowledge based systems have evolved from computer programs that partially automate the creation of a specific solutions for design problems, commonly known as expert systems, to the development of integrated systems that support d signer's decisions along the product life cycle. Finally the research concluded that three main issues demand for the research that is the complete implementation of machining process model, the implementation of fixture commercial catalogues and the implementation of algorithms to evaluate constraints imposedtothefixturesolution,accessibility,interference and cost.

[7]**Geetanjali Sharma** demonstrated that an electromagnetic undulator can be used for free electron laser experiment of infinite permeability of the lamination core. The removal of the infinite permeability approximately leads to an alternate design similar to four blocks per period as the case of pure permanent magnet undulator.

[5] **Dirk Rueter** demonstrated that an induction coil can be used as non contacting ultrasound transmitter and detector. Conventional electromagnetic acoustic transducers consist of radiofrequency inductor coil and a permanent magnet. The analysis and straight forward calculations of magnetic field topologies with a simplified computer model reasonably described the acoustic intensity of the ultra sound transducers. The experiment concluded that for lower energies and lower field intensity, the use of ferromagnetic materials is more advantageous.

There is no proper system to carry out measurement and inspection of the lift and the angle of blading mounting brackets of the fan effectively. A standard block is being used to hold the bracket for measurements which is supposed to be changed every time as the design of the bracket changes. Two different types of instrument is used for the measurement purpose and a ready reckoner is being referred to check if the component is acceptable or not, accordingly the components are inspected. The two instruments used are the vernier height gauge and the bevel angle protractor. Use of these instruments, standard blocks, and a ready reckoner accounts for manual mode of measurement which generally involves monotony. This makes measurement and inspection a tedious task and also requires a skilled worker to perform the task. All small scale industries use manual mode of inspection. However we found that there were many shortcomings in this method of inspection. Some of those were:

1. Time consuming
2. Requirement of a skilled operator
3. Inaccuracies in measurement.

All these short comings can be considerably avoided and hence it is possible to overcome the resulting drawbacks by using automated systems such as Coordinate Measuring Machine (CMM), Machine Vision, etc. But these systems are highly expensive and demands for a huge initial investments which involves maintenance and operating costs. It is impossible for most of the small scale industries to opt for such automated systems.

After carrying out detailed study on the industrial scenario and understanding the current trend , it was concluded that a system was required which is cost effective and capable of reducing time and amount of labour required from the operator. These inferences formed the basis of this work and it lays focuses on the design of setup and components that will aid in achieving the objective of reducing the overall measurement and inspection time.

III. COMPONENTS USED

3.1 Fixture

Fixture is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool. It provides only a reference surface or a device. What makes a fixture unique is that each one is built to fit a particular part or shape. The main purpose of a fixture is to locate and in some cases hold a workpiece during either a machining operation or some other industrial process.

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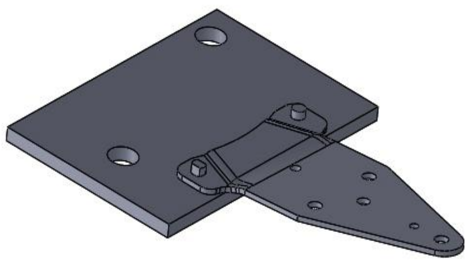

Fig 3.1 : Fixture

3.2 Design of Locating Pins

Location of work piece on fixture is done using two pins. To prevent the work piece from getting over constrained one pin used is cylindrical while the other is a diamond pin.The Diamond Shape is a critical feature that helps in taking care of machining inaccuracies and offers smoother locating operation. When two round head pins are installed onto one plate, the distance between two mounting holes must be extremely precise and even then, the work piece will not be placed on the base as easily as it would with the use of a diamond shaped pin.

3.2.1Cylindrical Pin

- Positional tolerance = 57.2 ± 0.15 mm
- Allowed dimensions of holes = 5.5 + 0.1
- Taking the diameter of hole = 5.5 mm

From Taylors Principle –
Tolerance of locating pin is 0.1 times the hole tolerance
Tolerance of locating pin = 0.1 * 0.1 = 0.01 mm
Diameter of cylindrical pin = 5.5+0.01
Since manufacturing the pins to the above dimension is difficult,
Diameter of pin =**5.4mm**

3.2.2 Diamond Pin

The diameter of the diamond pin is given by :

$d = \sqrt{D^2 - 4V^2 - 4VW}$

Where,
d= diameter of diamond pin (maximum)
D = work piece hole diameter (minimum) = 5.5 mm
V = variation in center distance = 0.15 mm
W = engagement width = (0.5* D) = 2.75 mm

$d = \sqrt{(5.5)^2 - 4(0.15)^2 - 4(0.15 \times 2.75\ )}$
= **5.3mm**

iii) Length of Locating Pin

The length of the locating pin is given by:

$L = \frac{L_1 + L_2 + 0.5D}{L_2 + D} \times \sqrt{2C(L_2 + D)}$

Where;
L = length of locating pin
L_1= distance of nearest edge from hole = 31.25 mm
L_2 = center distance between two locating pins = 57.5mm
D = diameter of the hole in the work-piece =5.5 mm
C = minimum clearance between the locator and the hole
Therefore,

$L = \frac{31.25+57.5+(0.5 \times 5.5)}{57.5+5.5} \times \sqrt{(2 \times 0.1)(57.5 + 5.5)}$

L = 5.13 mm
Taking length, L= 6mm (approx.)
Assuming a 2mm of chamfer,
Therefore, L=8mm

3.3 Electromagnet

Electromagnets are magnets that are generated when there is electric current flow ing in a wire. The magnetic field disappears when the current is turned off. Electromagnets usually consist of a large number of closely spaced turns of wire that create the magnetic field. The wire turns are often wound around a magnetic core made from a ferromagnetic or ferrimagnetic material such as iron. The magnetic core concentrates the magnetic flux and makes a more powerful magnet. For our research project we have used a horseshoe magnet (refer fig 1.4). Advantage of this type of electromagnet over bar type is that the both north and south poles are obtained close to each other thus it is more stronger for the clamping of the workpiece than a bar type electromagnet.

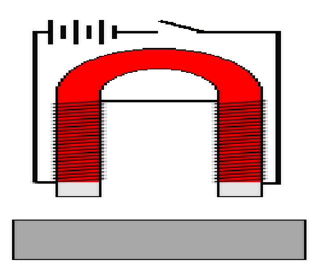

Fig 3.2 : Horseshoe magnet

3.3.1Magnetic Field

$B = \frac{\mu \times N \times I}{L}$

Where,
B = Magnetic Field.
N = Number of turns of the wire.
I = Current through the wire.
L = Length for which the wires are wound.
μ = Permeability of mild steel

$B = \frac{K \times \mu \times N \times I}{L}$

$= \frac{2000 \times 4 \times \pi \times 10^{-7} \times 180 \times 0.6}{0.035}$

= **7.755T**

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3.3.2Magnetic Force

F =B × I × L

Where,

B = Magnetic Field

I = Current

L = Length of wire used

F =7.755 × 0.6 × 20

=93.06N

3.4 Ultrasonic Sensor

Ultrasonic sensors(fig 1.4) use ultrasonic sound waves. Ultrasonic sound waves are those sound waves which cannot be heard by humans and have frequencies above 20kHz. The ultrasound module has a separate transmitter and a receiver.

Fig 3.3 : Ultrasonic sensor

***Specifications**:*

- Working Voltage- DC 5 V
- Working Current- 15mA
- Max Range- 4m
- Min Range- 2cm
- Measuring Angle- 15 degree

3.5 AURDINO

Arduino is an open source prototyping platform based on easy to use hardware and software. This micro controller was used for automation part of our work.

Fig 3.4: Ardino Uno

Specifications:

- Microcontroller - ATmega32
- Operating Voltage - 5V
- Digital I/O Pins–14
- PWM Digital I/O Pins- 6
- DC Current per I/O Pin–20mA

IV. DESIGN OF THE INSPECTION MECHANISM

The final assembly including all the above mentioned components is as shown below

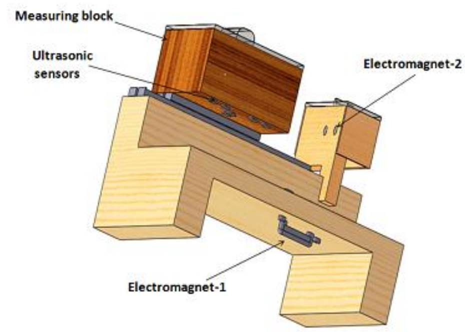


Fig 4: Final Assembly of Inspection Setup

V. OVERVIEW OF AUTOMATED MEASURING SETUP

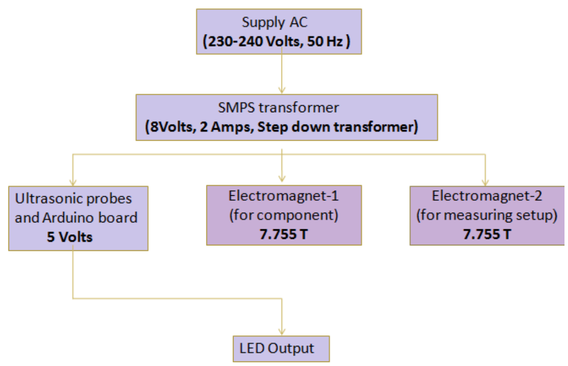
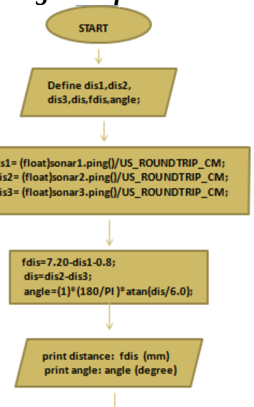


Fig 5 Block Diagram of Automation System



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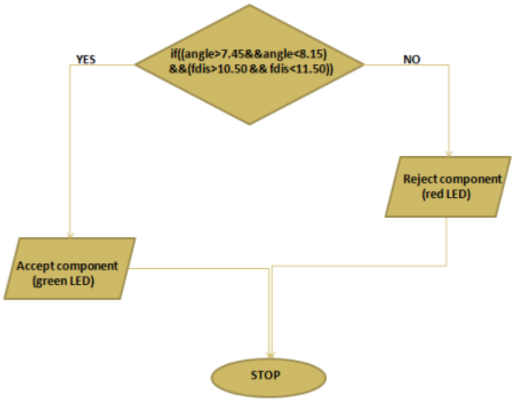


Fig 5.2 Flowchart of the Program

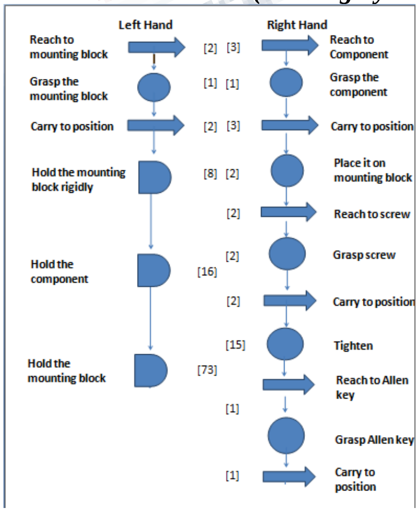
VI. WORK STUDY

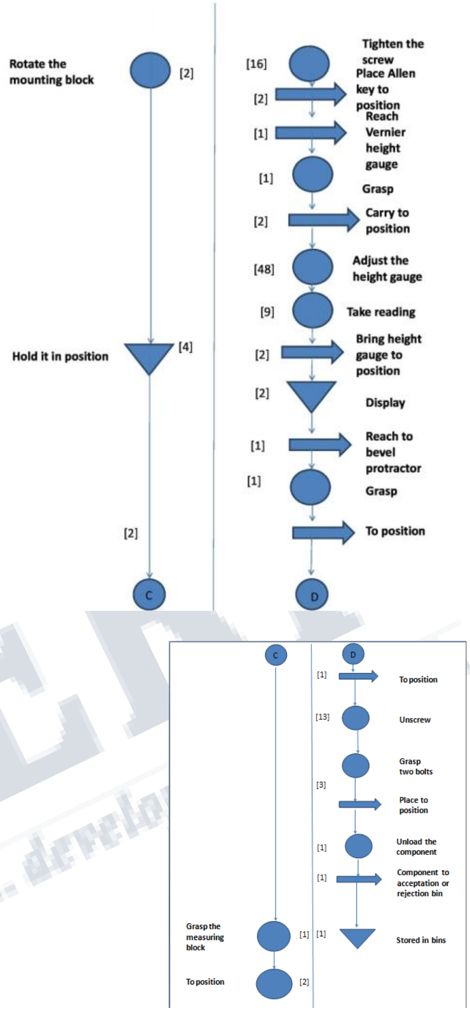
Work study is a generic term for those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contexts, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.

6.1 Two Handed Process Chart

The two-handed process chart is a process chart in which the activities of a worker's hands are recorded in their relationship to one another. The two-handed process chart is a specialized form of process chart because it shows the two hands of the operator moving or static in relation to one another, usually in relation to a time scale.

6.1.1 Two Handed Process Chart (Existing System)





Summary (Existing System):

SYMBOL	METHOD	LEFT HAND	RIGHT HAND
O	Operation	21	105
→	Transportation	4	25
D	Delay	138	18
□	Inspection	0	15

Calculation of Standard Time (Existing System)

OPERATION	CYCLE TIME (SECONDS)				PERFORMANCE RATING	NORMAL TIME (SECONDS)
	T_1	T_2	T3	T_{AVG}		
Reach and carry component to position	28.5	27	30.5	28.66	1	28.66
Grasp the component	11.5	12	11	11.16	1	11.16
Place the component on the block	2	2	2	2	1	2
Tighten the cap screw	31	29	30	30	1	30
Adjust height gauge	48	46	45	46.33	1	46.33
Take height reading	9	8	7	8	1	8
Rotation of measuring block	2	3	2	2.33	1	2.33
Adjust the bevel protractor	13	14	14	13.66	1	13.66
Take angle reading	6	7	6	6.33	1	6.33
Unscrew	13	15	14	14	1	14
Total Normal Time						162.47

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Standard Time Calculation (Existing System)

Normal Time = 162.47 seconds

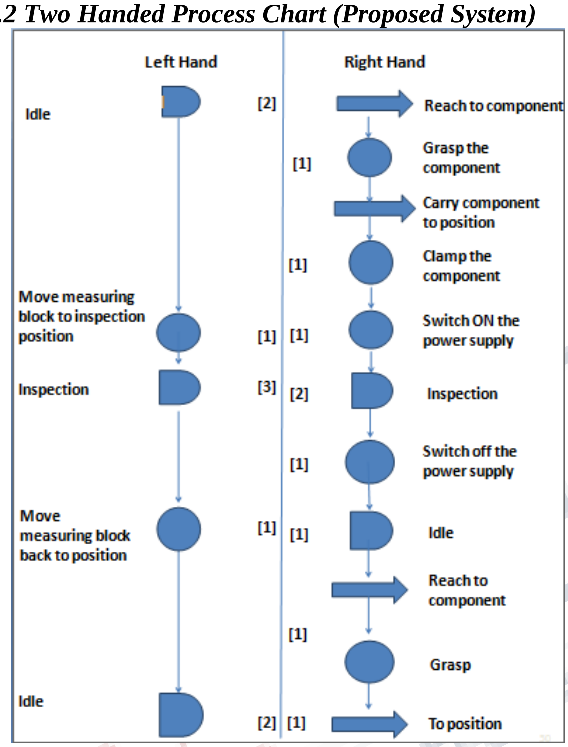
According to International Labour Organization (ILO),

Standard Time = Normal Time + (Relaxation allowance * Normal Time)

=162.47+(0.15* 162.47)

=186.84seconds

6.2.2 Two Handed Process Chart (Proposed System)



Summary (Proposed System):

SYMBOL	METHOD	LEFT HAND	RIGHT HAND
O	Operation	2	4
→	Transportation	0	2
D	Delay	7	3

Calculation of Standard Time (Proposed System)

OPERATION	CYCLE TIME (SECONDS)				PERFORMANCE RATING	NORMAL TIME (SECONDS)
	T_1	T_2	T3	T_{AVG}		
Reach and carry component to position	3	4	3	3.333	1	3.333
Clamping of the component	1	2	3	2	1	2
Switch power supply ON/OFF	2	2	2	2	1	2
Inspection	2	3	3	2.666	1	2.666
Idle	1	1	2	1.33	1	1.33
Total Normal Time						11.332

Standard Time Calculation (Proposed System)

Normal Time = 11.332 seconds

According to International Labour Organization(ILO),

Standard Time = Normal Time + (Relaxation allowance * Normal Time)

=11.332+(0.15* 11.332)

=13.03seconds

Overall reduction in standard time

Standard time for measurement and inspection on existing system = 186.84 seconds

Standard time for measurement and inspection on proposed system = 13.03 seconds

Reduction in standard time per component = T manual mode – T automatic mode

= 186.84 seconds – 13.03 seconds

=173.81seconds

% reduction in standard time per component = ((186.84 - 13.03)/ 186.84) x 100

=93.02%

Overall reduction in labourcost

According to the Ministry of Labour and Employment, Government of India,

Minimum wage for a skilled labourer per month = Rs. 14040

Minimum wage for an unskilled labourer per month =Rs. 11700

Reduction in labour cost per labourer per month = 14040 - 11700

=Rs. 2340.

VII. CONCLUSION

The prototype for design and fabrication of automated angle and height measuring fixture for blade mounting brackets of fans was successfully designed and fabricated and the following objectives were met:

.• Proper locating elements i.e cylindrical pin and diamond pin were successfully designed for the blade bracket.

• A clamping mechanism using electromagnet was designed to clamp the blade mounting bracket on the fixture.

• A system for automatic measurement and inspection of blade mounting brackets for fans was fabricated.

• Workstudyonthe existing system and proposedsystemwascarriedoutandthe standard time for measurement and inspection of blade mounting brackets on proposed system showed a reduction of 93.02% (i.e. time saving per component of 173.81 seconds) as compared to existing system.

• Monthly labor cost reduction of Rs.2340 per laborer was observed.

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