AUTOMATIC CONDITION MONITORING TO DETECT CRACKS IN ROTATING SHAFTS

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ABSTRACT

The aim of organization is to improve the productivity of assets with higher rate by following some certain standards or procedures. In this regard the present work is carried out in leading auto manufacturing industry located in Tamil Nadu .They face certain issues in the roll brake tester while doing some tests like friction and braking torque of vehicle tires. The roll brake tester consists of rotating shafts which makes the tire of vehicle to roll on the shafts by which we can estimate the amount of torque produced in the vehicle tire. The major problem addressed in this work is frequent wear and tear of roller shafts due to sudden parking of tire on shaft surface these results in wear over a period of time followed by cracks. In this paper attempt has been made to develop some methods like eddy current testing, Thermo imaging etc to find out the cracks over shaft surface.

Keyword: Eddy current Testing, Thermo imaging, Rolling shafts, Braking torque, Roll brake tester.

1. INTRODUCTION:

As organizations return underneath increasing pressure to vie in today's quick charging business surroundings, the businesses hunt for the one issue to provides the competitive advantage. This issue is usually to hunt the way to market the continual productivity with none insulating material. This continuous productivity is achieved by the right maintenance. Inspection, maintenance, repair and different services are key to the performance of method equipment at industrial plants. Having progressive instrumentation is not any guarantee of optimum practicality and economical processes. it's even as necessary to possess a replacement product properly put in and assembled on have your product inspected and to urge repairs or maintenance activities done at the proper time. The standard and conjointly safety of your processes will be controlled by having a program for review and maintenance services. Additional and additional customers ar ti ght that manufactures quickly reply to their needs and desires, deliver good quality product on time. This trend, which is able to continue, has junction rectifier firms to focus additional attention on review and maintenance to market productivity. In this paper the machine-controlled maintenance system is enforced to find the cracks.

2. OBJECTIVE OF THE STUDY:

To think about the reasons for the disappointment of the pivoting shaft in the dynamic move brake analyzer and recommend the fitting strategies to identify the blunders as a piece of preventive support.

3. NEED FOR THE STUDY:

If the failure happens it'll get daily to induce fastened and causes a lag within the productivity rate. Here the causes for the failure are studied and recommended the ways that to induce scale back the failures while not poignant the work friendly atmosphere. And additionally to that, the

appropriate ways are planned to modify observation o f the shafts to notice the cracks as a component of preventive maintenance. So, if the processes are standardized then it'll promote the effective and continuous productivity rate.

4. LITERATURE REVIEW:

R. Peretz et al [1] Shafts are usually subjected to troublesome operative conditions in superior rotating instrumentation like compressors, steam and gas turbines, generators and pumps. As a result, shafts are liable to fatigue failures because of thwart wise cracks. During this study, vibration observance and orbital ways observation were wont to discover the presence of a flaw in a very shaft. 2 styles of flaws were tested: a straight slot, and a crevice. For each flaw sorts, specimens of various depths were examined so as to assess the detection capability. a replacement approach to look at vibrations at the important speed is proposed; this speed is chosen due to the sturdy association to the fundamentals of the physical downside. Orbital ways are advised as suggests that for fault detection moreover. The presence of a straight makes time for the shaft was found to be associated with a decrease within the natural frequency and to a decrease in amplitude of the primary order at important speed. For the crevice, a regular trend in important speed and in amplitude wasn't seen as crack depth grew. a replacement methodology to discover the amendment within the shaft natural frequency is planned. the mixture of 2 indicators, amendment in important spee d and alter in amplitude at important speed, are advised for classification of flaw size. For the straight slot case, the strategy planned was able to distinguish between totally different fault depths.

Zyad Nawaf Haji [2] the property, swish operation and operational lifetime of rotating machinery considerably depend upon the techniques that discover the symptoms of inchoate faults. Among the faults in rotating systems, the presence of a crack is one in every of the foremost dangerous faults that dramatically decreases the protection and operational lifetime ofthe rotating systems, thereby resulting in ruinous failure and potential injury to personnel if it's unseen. though several valuable techniques and models are developed to spo ta crack (or cracks) in stationary and rotating systems, finding associate economical technique (or model) that may establish a singular vibration signature of the cracked rotor remains a good challenge during this field. this can be thanks to the unceasing necessity to develop high performance rotating machines and driving towards vital reduction of the time and price of maintenance.

Vaibhav J Suryawanshi et al [3] many rotor dynamic systems incorporates shaft/rotor components that are extremely at risk of cross cross sectional cracks because of fatigue. the first detection which will be provided by economical (a good} vibration observation and analysis technique is efficient. 2 theoretical analyses, international and native spatial property crack models, are utilized to spot characteristics of the system response that will be directly attributed to the presence of a cross crack during a shaft. The work according to this paper element of an in progress analysis on the experimental investigations of the results of cracks and damages on the integrity of structures, with a read to discover, quantify with the study of some parameter like essential speed, RMS rate. As crack initiates and propagates, essential speed and RMS rate changes consequently which will be monitored with condition observation technique. Thus the amendmen t in essential speed and RMS rate is effective thanks to establish the crack .In this paper review of those two parameters disbursed for effective identification of crack during a Rotor-shaft system.

Hariom et al [4] this survey paper gives the experiences of different investigation completed to discover shaft deformation. Roller Shaft deformation can be improved by preventive mechanical support methods and utilizing safe plan with appropriate assembling forms. The different writings has been deliberately contrasted and assessed with get an appropriate shaft deformation examination. Each strategy has its upsides and downsides and utilized by explicit modern portions. Shaft deformation makes the superfluous shutdowns and leads overwhelming creation misfortune. The target of this paper is to consider different shafts disappointment investigation and select the best technique to discover the root since disappointment of overwhelming nip roller shaft utilized in material industry

Kiran P. Patil et al [5] Turning shafts which are exposed to the hardest conditions in superior pivoting types of gear utilized simultaneously and utility plants like rapid blowers, steam and gas turbines, generators and siphons and in modern machines and so on. Despite the fact that when shafts are worked in various kind of conditions then genuine deformities can show up, yet these are tremendously associated to weakness splits on the grounds that with the quickly

fluctuating nature of bowing anxieties. In view of assembling blemishes or cyclic stacking, breaks as often as possible show up in turning shaft, different deformities in shafts incorporate bowed shaft, misalignment and so forth. The ductile pressure fixation coming about because of shear slip causes the new splits that spread far from the previous blame. Because of split on shaft calamitous disappointment, machine can be harm, it is perils to person, mishap will be happen and so on. A deformity on shaft can be analyzed by numerous techniques, e.g., ultrasonic identification, electromagnetic strategy, acoustic outflow, vibration examination. We utilize vibration investigation strategy since when shaft pivots then because of deformity the vibration reaction of the turning shaft will pretty much change. By utilizing the extra vibration separated from the pole reaction because of imperfection, an on-line condition checking framework for deformity location may be created for rotor frameworks. Different strategies for split location are tedious and it doesn't give appropriate outcome that is the reason we utilize vibration investigation technique.

Navnath Hegade et al [6] Shafts are the segments which are exposed to the hardest conditions in elite pivoting supplies utilized all the while and utility plants like fast blowers, steam and gas turbines, generators and siphons and so on. In spite of the fact that when shafts are worked in various kind of conditions then genuine imperfections can show up, however these are greatly associated to breaks on the grounds that with the quickly fluctuating nature of stresses. The advancement of break changes dynamic conduct of rotor framework. It diminishes the quality of protest or material. At the point when shaft pivots then because of imperfection the vibration reaction of the turning shaft will pretty much change. By utilizing the extra vibration extricated from the pole because of deformity, an on-line condition checking framework for break identification may be produced for rotor frameworks. Notwithstanding for littler split, pivoting shaft makes the vibrations. Along these lines, the vibration checking is more valuable for distinguishing split in turning shaft. This paper gives the vibration investigation of turning shaft with various break area and with various shaft speeds.

Saleem Riaz [7] security, dependability, effectiveness and execution of pivoting apparatus in every modern application are the primary concerns. Pivoting machines are broadly utilized in different modern applications. Condition observing and blame determination of turning apparatus deficiencies are critical and frequently intricate and work escalated. Highlight extraction procedures assume a crucial job for a solid, viable and effective component extraction for the determination of turning apparatus. In this manner, creating successful bearing flaw symptomatic technique utilizing distinctive blame highlights at various advances turns out to be more appealing. Heading are generally utilized in medicinal applications, sustenance handling enterprises, semi-conductor ventures, and paper making businesses and airplane segments. This paper survey has shown that the most recent audits connected to turning apparatus on the accessible an assortment of vibration include extraction. By and large writing is ordered into two fundamental gatherings: recurrence area, time recurrence investigation. In any case, blame identification and analysis of pivoting machine vibration flag handling techniques to introduce their very own restrictions.

Adrian D. NEMBHARD et al [8] Obtaining and resulting preparing of vibration information for blame analysis of turning apparatus with numerous course, for example, Turbo-generator (TG) sets, can be very required, as information are normally required in three commonly opposite bearings for solid finding. Subsequently, the errand of diagnosing issues on such frameworks might dismay for even an accomplished examiner. Consequently, the present examination intends to build up an improved blame determination (FD) strategy that utilizes only a solitary vibration and a solitary temperature sensor on each bearing. Starting preliminaries on a trial pivoting rig show that enhancing vibration information with temperature estimations gave enhanced FD when contrasted and FD utilizing vibration information alone. Perceptions produced using the underlying preliminaries are introduced in this paper.

These are the couple of writing studies directed by different writers in every writing writers have told the effect of utilizing apparatuses like mark examination, on line vibration investigation to distinguish the split in pivoting shafts.

5. DETAILED ANALYSIS OF DYNAMIC ROLL BRAKE TESTING MACHINE

DESCRIPTION

The Burke E. Watchman dynamic move brake test machine is intended for superior generation lines. The Burke E. Watchman is a hand crafted blend of six wheel move test and brake test machine used to precisely test a vehicle's drive train segments and braking execution. The machine can test the capacity of front wheel, raise wheel, all wheel, and multi pivot

drive vehicles alongside electronically monitored slowing mechanism frameworks (ABS) and essentially some other unique framework.

Fig .1 Burke E. Porter Dynamic Roll Brake Tester Machine

MACHINE FUNCTION

Some of the main functions that are tested include

- Brakes and ABS
- Transmission
- Parking PAWL and parking brake
- Speed control
- Traction control and electronic stability programs (ESP)
- Supplemental restraints (air bag systems)
- Emission
- Vibration analysis
- Speedometer accuracy
- Body/ chassis/ electrical controllers
- Vehicle electronic control unit (ECU)
- Tire pressure

SPECIFICATIONS

- Roller Diameter :20 inches / 0.508 m
- Roller Length :74 inches / 1.87 m
- Maximum Roll Speed :120 Km/h
- Wheel Base Range :customer-defined
- Machine Height :3.5 m
- Other Features :Automatictiresize adjustment

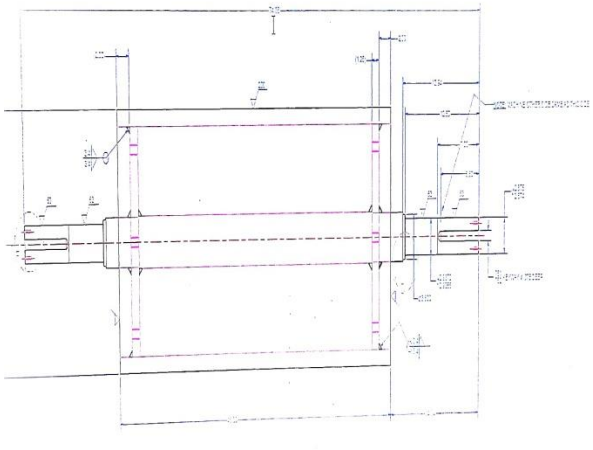

Fig2. Roller diagram

6. PROBLEMS IDENTIFIED:

Fig 3. Workers fixing the damaged rollers

From the primary day of usage, the deformation happens multiple times from the execution. Both the disappointments are on a similar side and on a similar shaft. The first is actually on the welded surface which joints the pole with the roller and the second is on where the poles which bolsters the handyman square. Be that as it may, both the disappointments happen with the moderate development of splits and abruptly crumple with the fragile harm.

Fig.4. Failure due to brittle effect

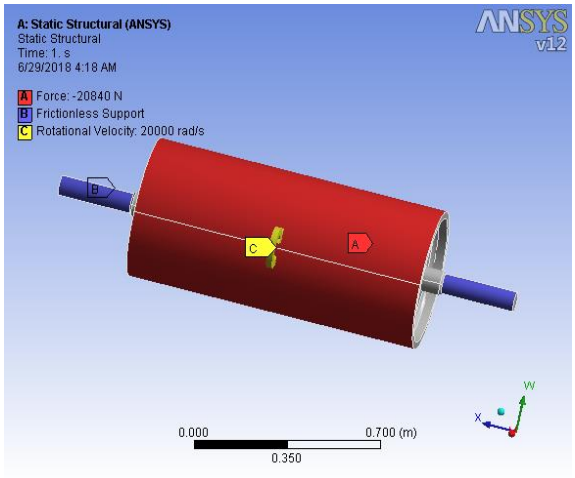

Fig.5. loads acting on the roller

7. PROBLEM DEFINITION

7.1. SEQUENCE OF OPERATIONS

The vehicle that is to be tested is placed in between the front 2 rollers that is lively on the stationary plate when the machine gets switched on the front guard can rise and also the stationary plate can get captive down and also the tire is adjusted mechanically and placed between the two rollers. First method is to test the brake power that the front shaft tires are given the ability by the rollers and also the brake is applied to test the ABS and to live the brake power is within the vary or not. Then the vehicle is captive forward and also the rear shaft is brought into the position to test the drive train. Currently the transmission is in reverse direction and also the brake is applied to gauge the reverse traction force. After the most throttle is given to test the meter and also the speed is reduced to the conventional and brake is applied to gauge the forward traction of the vehicle. Finally the emission check is meted out and also the vehicle is continuing to the following stage if it satisfies all the requirements.

7.2. CALCULATION OF THE LOADS

The maximum load vehicle which is to be tested in the roller brake tester is 3718 model tipper truck. The gross vehicle weight is 37 tons. This is separated by the axles as front three axles as 6 tons and the rear two axles as 9.5 tons. So the maximum load experience on the rear axle testing and each roller shares the load as 2.125 ton as each. In addition to this, although the plumber block has a bearing it too contributes some load at the shafts. In order to this the maximum revolutions reached by the roller while testing is calculates as 2100 rpm.

8. CAUSE AND EFFECT ANALYSIS:

A cause and effect diagram was created after interviews with shift leads and operating persons and first person observations (see fig .5). Many factors contribute towards the failure of the roller shaft such as measurement, methods, machines, materials, manpower being most prevalent categories.

First person observations, interviews, and time studies were used to develop the ideas for the roller failure. This thesis proposes a means to achieve the causes and preventive maintenance for the failure occurs without the production rate and work friendly environment.

From the analysis the proposed results are based on the two phases. Phase I gives the solutions for the problem faced by the man and machine. And the phase II is for the methods which give effective preventive maintenance for the inspection of the cracks and flaw occurred on the rollers

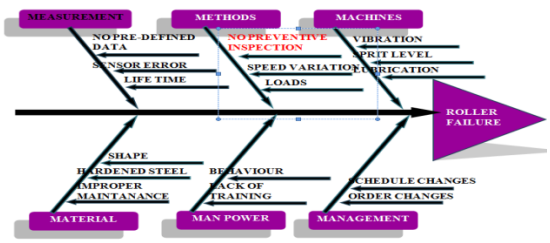

Fig 6. Fishbone Diagram for Roller Failure

8.1. APPROACH TO THE CAUSES

The phase I includes the results to minimize the failures due to the shape, behavior of the labor, changes in the quantity, life time, vibration & spirit level, lubrication, etc.,.

TABLE: Calculation of economic life of an asset

End of month	Maintenance cost at end of month	p/f, 5% n	Present worth as of beginning of month of maintenance cost	Summation of present worth of maintenance cost through month given	Present worth of cumulative maintenance cost & first cost	A/P, 5%	Annual equivalent total cost through month given
A	B	C	B*C=D	E	F	G	F*G=H
1	0	0.9524	0	0	80000	1.05	84000
2	600	0.907	544.2	544.2	80544.2	0.5378	43316.67076
3	1200	0.8638	1036.56	1580.76	81580.76	0.3672	29956.45507
4	1800	0.8227	1480.86	3061.62	83061.62	0.282	23423.37684
5	2400	0.7835	1880.4	4942.02	84842.02	0.231	19598.50662
6	3000	0.7462	2238.6	7180.62	87180.62	0.197	17174.58214
7	3600	0.7107	2558.52	9739.14	89737.14	0.1728	15506.57779
8	4200	0.6768	2842.56	12581.7	92581.7	0.1547	14322.38899
9	4800	0.6446	3094.08	15675.78	95675.78	0.1407	13461.58225
10	5400	0.6139	3315.06	18990.84	98990.84	0.1295	12819.31378
11	6000	0.5847	3508.2	22499.04	102499.04	0.1204	12340.88442
12	6600	0.5568	3674.88	26173.92	106173.92	0.1128	11976.41818
13	7200	0.5303	3818.16	29992.08	109992.08	0.1065	11714.15652
14	7800	0.5051	3939.78	33931.86	113931.86	0.101	11507.11786
15	8400	0.481	4040.4	37972.26	117972.26	0.0963	11360.72864
16	9000	0.4581	4122.9	42095.16	122095.16	0.0923	11269.38327
17	9600	0.4363	4188.48	46283.64	126283.64	0.0887	11201.35887
18	10200	0.4155	4238.1	50521.74	130521.74	0.0855	11159.60877
19	10800	0.3957	4273.56	54795.3	134795.3	0.0827	11147.57131
20	11400	0.3769	4296.66	59091.96	139091.96	0.0802	11155.17519
21	12000	0.3586	4303.2	63395.16	143395.16	0.078	11184.82248
22	12600	0.3419	4307.94	67703.1	147703.1	0.076	11225.4356

8.2. **SHAPE**

The shape of the roller is tested to find the stress distribution and strain distribution while working. The results shown by the soft tools clearly portraits that the strain and strain are concentrated on the welded joint which is exactly on the joining of the shaft and roller.

In order to reduce the stress and strain concentrated on a single point the sudden reduction of the size of the diameter of the roller to the shaft is minimized and it is gradually reduced such as tapered joint. The labors who drive the vehicles for the testing must follow the instructions to dirve it smoothly on the testing machine. Sometimes the brake power they applied on false speed will bring the bending thrust to the roller. As a result the roller gets deformed and experience more wear and tear than normal conditions.

This is lowered by fixing the speed breakers on fron and back side of the machine setup to get smooth driving of the vehicles irrespective of the drivers.

9.1. **CHANGE IN QUANTITY**

The production rate is not uniform at all the times, sometimes it is high and sometimes low. So the roller will experience the different loads and the load gets changed suddenly based upon the model tested. Due to this conditioning the roller life time will gets decreased. If sometimes the quantity will increased this will result in formation of the fatigue deformation due to this effect. This is lowered by proper scheduling of the vehicle testing.

9.2. **LIFE TIME**

The roller tester can test 120 trucks a day, so that the lifetime of the roller is around to test 50,000 trucks. After that the roller will be monitored very closely for the formation of any flaws and change in dimensions can occur. So that the roller can be changed to prevent the sudden breakage.

9.3. VIBRATION, SPRIT LEVEL & LUBRICATION

While setting the machine the vibration, sprit level is tested to work smoothly. After the implementation the lubrication is checked for the weekly/ monthly maintenance or this will even create such collapse of the rollers.

10. METHODOLOGY:

Ultrasonic testing (UT) is a family of non-destructive testing techniques based on the propagation of ultrasonic waves in the object or material tested. In most common UT applications, very short ultrasonic pulse-waves with center frequencies ranging from 0.1-15 MHz, and occasionally up to 50 MHz, are transmitted into materials to detect internal flaws or to characterize materials. A common example is ultrasonic thickness measurement, which tests the thickness of the test object, for example, to monitor pipe work corrosion.

Ultrasonic testing is often performed on steel and other metals and alloys, though it can also be used on concrete, wood and composites, albeit with less resolution. It is used in many industries including steel and aluminum construction, metallurgy, manufacturing, aerospace, automotive and other transportation sectors.

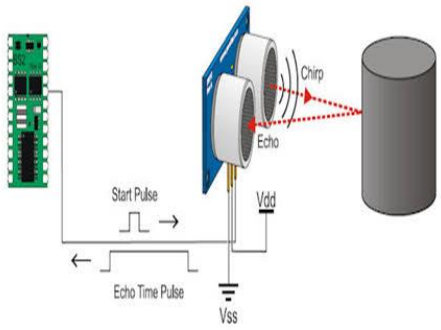

Fig9. Working principle of Ultrasonic testing

In ultrasonic sensor there are major two parts, the transmitter and the receiver. The transmitter propagates the ultrasonic waves and the waves should travel some distance and return back after striking the object. The receiver receives the signal and calculates the distance of the object. When it is passed through the object to be monitored, when the cracks occurred on the object there should be deflection in the receiving signal. So the cracks are easily identified.

10.1. POSSIBILITIES OF IMPLEMENTATION

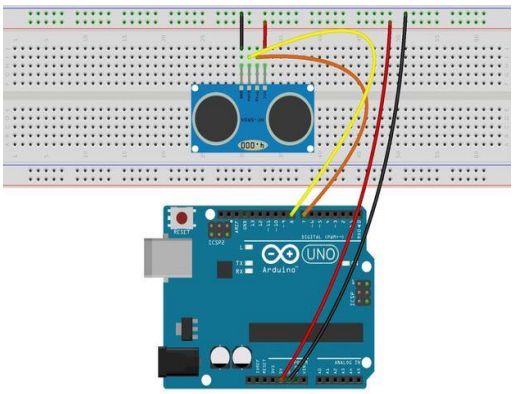

Fig 10. Fixing Of Ultrasonic Sensor Using Arduino Board

Among all the methods in NDT the ultrasonic is the cheapest method to detect the cracks in the rotating shafts but the only drawbacks of using this method is there will be a limitation for the sensors range some ultrasonic sensors will not detect the cracks which are lesser than 2mm in width. So for higher accuracy go for the advanced ultrasonic sensors.

10.2. EDDY CURRENT TESTING

Eddy-current testing (also commonly seen as eddy current testing and ECT) is one of many electromagnetic testing methods used in nondestructive testing (NDT) making use of electromagnetic induction to detect and characterize surface and sub-surface flaws in conductive materials

10.3. WORKING PRINCIPLE

In its most basic form — the single-element ECT probe — a coil of conductive wire is excited with an alternating electrical current. This wire coil produces an alternating magnetic field around itself. The magnetic field oscillates at the same frequency as the current running through the coil. When the coil approaches a conductive material, currents opposed to the ones in the coil are induced in the material — eddy currents.

Variations in the electrical conductivity and magnetic permeability of the test object, and the presence of defects causes a change in eddy current and a corresponding change in phase and amplitude that can be detected by measuring the impedance changes in the coil, which is a telltale sign of the presence of defects. This is the basis of standard (pancake coil) ECT. NDT kits can be used in the eddy current testing process.

ECT has a very wide range of applications. Because ECT is electrical in nature, it is limited to conductive material. There are also physical limits to generating eddy currents and depth of penetration (skin depth).

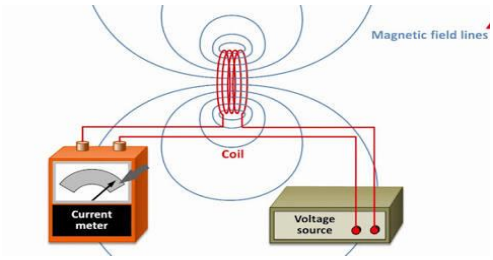

Fig 11. Eddy Current Testing Principle

10.4. POSSIBILITIES IN IMPLEMENTATION:

This method is easy to implement and monitor the cracks in circular objects such as shafts, pipe etc. And also the cost is also much equal to the previous method. But the drawback of this method is this method did not detect the cracks which are exactly parallel to the coil wounded on the shafts.

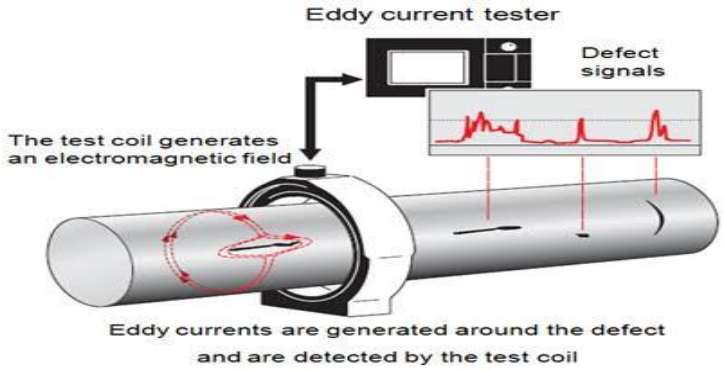

Fig .12. Eddy Current Testing in the Shafts

10.5. IR THERMOGRAPHY

An infrared thermographs scanning system can measure and view temperature patterns based upon temperature differences as small as a few hundredths of a degree Celsius. Infrared thermographs testing may be performed during day or night, depending on environmental conditions and the desired results.

Fig.13. IR Thermography Kit

10.6. POSSIBILITES FOR IMPLEMENTATION

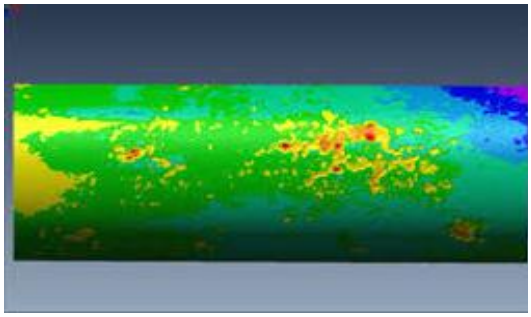

Fig 14. IR Thermographs Results

Among the above discussed two methods the results obtained from this method are accurate and it is easier to analyze the results. The cost is more expensive when compared to the two methods.

11. CONCLUSION

Based on the analysis done till date in the industry and the methods proposed the following results can be obtained in the automatic monitoring of the cracks in the rotating shafts

- The causes for the failure of the shafts are analyses detailed and the methods to rectify those factors are clearly mentioned.
- The preventive maintenance for the shafts is suggested and the possible ways for the implementation are given to the management to reduce the failures.
- By adopting the methods the continuous productivity is achieved without any lagging and without affecting the work friendly environment.

According to the plan of action, the above mentioned results and methods are suggested to the industry with their mentorship and the above said results will be achieved during the future implementation.

FUTURE SCOPE:

In this paper attempt has been made to detect the cracks occurring in rotating shafts using eddy current, ultrasonic testing. But we have not evaluated the life time for replacing the failure components due to cracks and that would be the next phase of work in future .

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