Fatigue Failure of Pan Mixer Shaft

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Abstract

The primary aim of the present study was to find out the cause of failure of concrete pan mixer shaft. This shaft under various loading may failed like, overloading, bending, fatigue, vibration, etc. By this study, the main cause of Failure of shaft is fatigue. "Fatigue failure is defined as the tendency of material to fracture by means of progressive brittle cracking under repeated altering or cyclic stresses". This paper only describes the investigation of fatigue failure of pan mixer shaft on the basis of literature survey and extensive study of the existing pan mixer. In this paper we will see the cause of failure of shaft by using various methodologies and various literature papers which are added in this review paper.

Keywords- Concrete Pan Mixer, Shaft, Fatigue Failure

I. INTRODUCTION

A. Types of Concrete Mixer

There are mainly two types of concrete mixers available, they are

- Batch mixer
- Continuous mixer

Batch type mixer produce concrete one batch at a time. Continuous mixer can produce concrete at constant rate. Batch type mixers needs to be clean after each cycle of concrete production and reloaded with raw material for the next batch of concrete. In continuous, the raw materials are continuously entered into one end of mixer and fresh concrete exit from other end of mixer.

1) Batch Mixers

According to orientation of axis of rotation this batch mixer again distinguished in two main types

- Drum mixer (horizontal)
- Pan mixer (vertical)

a) Drum Mixer (Horizontal)

The drum mixers have a drum, with fixed blades, rotating around its axis.

Every drum mixers have a container with a similar cross section as shown in Fig. 1. Inside the movable drum, there are blades attached. In this type of mixer parameter like rotational speed of the drum and the angle of inclination of rotation axis can be controlled.

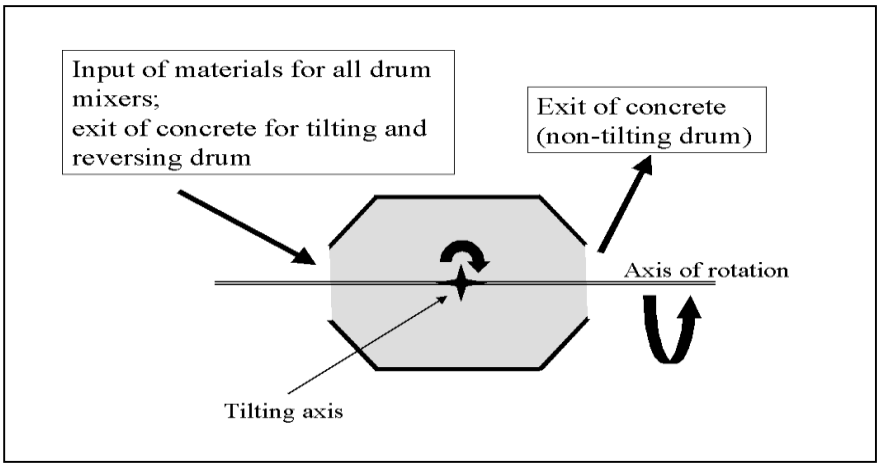

Fig. 1: Cross section of drum mixers

There are again three types of drum mixers,

- Non-tilting drum
- Reversing drum

– Tilting drum

b) Pan Mixer (Vertical)

The pan mixers may have either the pan rotating around the axis or the blades. A cylindrical pan (fixed or movable) required for the concrete mixing, also pan mixer have one or two sets of blades which are rotates inside the pan, blades are used for mixing the concrete inside the pan. Axes of rotation and the shape of blade may vary. Figure 2 shows the different combinations of blade configurations and pan.

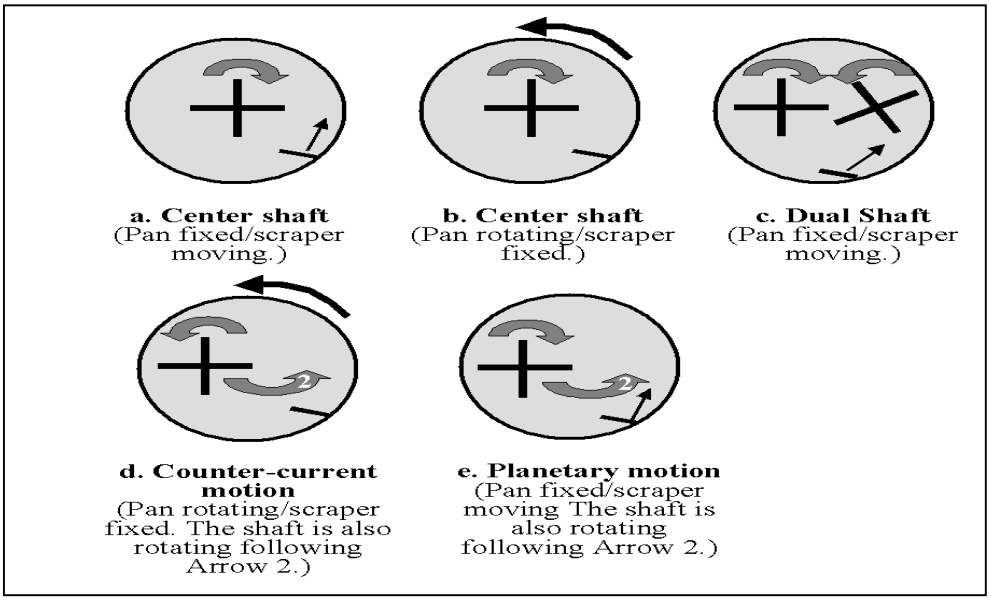

Fig. 2: Different combination of blade

Pan mixer, it is a concrete mixer used in pre mixing of concrete in various batch plants. This concrete mixer has different application like in cement tiles and paving manufacturing plant it used for mixing concrete and also mixing of paints and chemicals. Pan mixer, it is a common form of mixture having vertical mixing unit. It contains various components like pan, blades, motor, gear box, transmission shaft, etc.

In this study the existing Pan mixer have 7.5 Hp motor, RPM of motor is 2800.All the raw materials are placed in a concrete mixer and the mixture is rotated for 15 minutes. The prepared mix is discharged from the mixer and consumed in the next 30 minutes. Vibrating table may be used for compacting, the concrete mix in the moulds of desired sizes and shapes. After compacting the blocks are remolded and kept for 24 hours in a shelter away from direct sun and winds.

The mixing procedure includes the various types of mixers, thus for the tiles and paving blocks manufacturing, the mixing of concrete should be appropriate hence, the study of various mixer and mixer parts is necessary.

Fig. 3: Mixing of cement concrete

Fig. 4: Existing shaft assembly

Mixing of raw material in pan mixer carried out in two layers, i.e. in first layer 67.5 kg floor BFS, 75 kg Acc Cement, 112.5 kg gravels are added in pan mixer drum and this raw material continue to mix till 45 minute in mixer. The second layer the raw material are added in different proportion like 100 kg floor BFS, 75 kg Acc Cement, 200 kg gravels and this mixture continue to mix in pan mixer till 15 minute. First layer require more time for mixing of raw material than the second layer.

B. Continuous Mixers

It is second type of mixer. As the name indicate, the raw material continuously fed into the one end of mixer and at the same rate concrete discharge from the other end of the mixer. These are usually having screw type blades which are rotating at the middle of the drum, this type of mixer basically used non-tilting drum. These mixers are used for applications that require long unloading time, short working time, remote sites (not suitable for ready-mix) and/or small deliveries.

1) Frequency of Failure

From the extensive survey and research of pan mixer, this is found that failure of shaft occurs in three month. Thus failure of shaft occurs three or four times in year and average cost of shaft is Rs 6000.

2) Probable Modes of Failure

There are various probable modes of failure of shaft, these are listed below

- Vibration
- Misalignment
- Overloading
- Fatigue failure
- Torsional fatigue failure
- Material properties
- Angle of loading
- Corrosion
- Manufacturing defect

3) Pattern of Failure of Shaft

Fig. 5

Fig. 6

II. LITERATURE REVIEW

In this chapter, effort done by other researcher or authors involves, also there methodology, techniques and analysis is reviewed. As this topic is about the fatigue failure thus this chapter also included review about fatigue failure.

S.K. Bhaumik [1] in review paper authors have identified a small crack on a small speed, hollow shaft of helical gearbox of single stage during examination. They come to know that, the shaft was introverted from service because of leakage of oil. They have carried out fractography, metallography and visual inspection for identification of failure. Their consequent examination revealed that at keyway portion, the crack occurred due to fatigue and propagated in a helical manner on shaft periphery but the shaft not given grow to final fracture. They fôund out that fatigue crack initiation started from a depression mark at the keyway end surface due to stress concentration. At the last part of paper they have given recommendation for performance improvement and safety of shaft. Yong Liang [2] this research paper gives the knowledge about analysis of failure of shaft. The authors have considered research object as a wind turbine main shaft bearing. There is involvement of ANSYS software for the analysis purpose. They determine the unsafe region because of contact stress under different working conditions, also they have analyzed the stress position on the main shaft bearing. They have used S-N curve for the interpretation of results of stress analysis, by changing the material's S-N curve they have obtained the main shaft bearing's S-N curve. Paper used Goodman formula to correct the average stress as they have considered the influence of average stress to fatigue damage. By using the nominal stress loom and the fatigue damage collective rule, they have predicted fatigue life of the wind turbine main shaft under dissimilar working surroundings. D. N. Walker [3] basically this paper involves the transmission system events and operations for eliminating major fatigue life from turbine-generator shafts with detail description. This paper offered the factors which bound the fatigue competence of turbine generator shaft systems, next to argument of systematic models and their boundaries for estimating the shaft fatigue duty. This paper is from electrical side in which numerical examples are mentioned. Gautam Das [4] this paper gives the idea about the failure investigation techniques and methods. This paper involves detailed failure examination of rotor shaft of pump in thermal power plant which is used in boiler. Authors investigate the failure using compound analysis, microscopy, fractography, hardness measurement and stress measurement. They come to diagnose by analysis that the metallization processes is main reason for the failure. In this paper they have given the photograph of different tests for the reference purpose. At the boundary to near the fillet portion large no of defects are identified due to metallization procedure. The crack due to defect area are initiated from and then additional propagated by fatigue. Authors come to the conclusion that the style of fracture is fatigue and the occurrence of oxides at the base where the interface regions observed. Y.A. Khalid [5] in research paper, bending fatigue analysis has done by the authors. For this study they have used hybrid shafts which were made-upby help of filament winding procedure. External composite cover finished with glass fiber and epoxy resin as a matrix and hardener. They predict four cases and these are studied using aluminum tube surrounded by dissimilar layers of composite configuration and combination of resin and matrix part. Failure modes of hybrid shaft have identified using microscopic level of tests which were show crack initiation region and pattern of crack initiating in the outer film of resin and not from the fiber part. The cracks are enlarging with rising number of cycles up to the failure of hybrid shaft specimen. They came to on the termination that, no fiber fracture from the rotating bending fatigue test. In this repot they discussed about fatigue strength of compound material. A. A. Mohamed [6] Area of the research of this paper is fatigue crack beginning and transmission in a pre-cracked high carbon steel shaft because of vibration. Thus in this article they used experimentally find out and monitored with a vibration based situation health monitoring method. This broadside examines vibration uniqueness and experimental test in two dissimilar types of crack initiation. Along the notch profundity fatigue fracture cracks are observed from test results. The outcome of the tests and examination clearly reveal the possibility of using vibration to sense the alteration in frequency of a shaft because of the variation in stiffness of shaft. Xinjie Shao [7] this review is totally numerical based which evaluate the reliability of low and high cycle fatigue. Fatigue growth damage theory and nominal stress procedure are combined by the authors for high-rotation fatigue. To gain the high-cycle and low-cycle stochastic fatigue reliability, arbitrary reaction surface method is implemented to fit the life distribution function. In this literature various concepts are employed to analyze the composite damage of high-cycle and low-cycle to achieve the stochastic fatigue dependability of torsion shaft of complex equipment. Probability function also the parameter used in it. M. da Fonte [8] this research paper discussed about the fatigue crack intensification, stress strength factor and mixed mode crack growth under multi-axial loading. When the crack growth is the major area of study then on the endurance curve and limit safe life design is being created by considering suitable tolerance.

It uses the knowledge of fatigue crack expansion under loading for the application of damage tolerance concept, mainly for maintenance and failure analysis purposes. In this paper the effect of torsion on fatigue crack enlargement under bending is focused. Based on stress strength factor for bending and torsion, fractography approach is used to explore the outcome. Using fatigue crack escalation path the results are compared for the same stress ratio. Gustavo De-Deus[9] This paper evaluated the bending opposition and the dynamic and static recurring fatigue life of Reciproc R40.Basic research and technology for this paper explained material and methods, bending resistance test, cyclic fatigue test, dynamic test, static test with the statistics. For the evaluation and assessment, methods are used nickel-titanium equipment for use under reciprocation displacement. 10 specimens were experienced under bending resistance for every system with the help of universal testing instrument. They used custom made machine for dynamic and static product to perform the cyclic fatigue test. For determination of mode of fracture they have performed SEM analysis. Statistical analysis, Tukey test carried out for analysis of inconsistency and post hoc couple wise evaluation. E. J. Williams [10] In this research hollow shaft is under the combined axial loading and torsional loading. The investigations came to conclusion that the failure cause from fatigue. Thus they performed fatigue crack expansion test on the specimen which is hollow shaft under mutual torsional loading and axial loading. After the examination on the specimen authors investigated other parameter like shaft geometry, stress ratiosandpre-cracks shapes. From the tests and experimental results indicated four cracks in the region of the holes, the sites of the highest tensile stress, have shown. Analysis data and crack progress data were well interpreted in this paper. Fatigue crack increment rates were characterized. Vahid Mortezavi1 [11] this paper fully fits to theoretical and testing background. Thus it contains various theoretical explanations towards the damping parameters. Authors from this paper have tested specimen with different test like tension-compression test, fully-reversed bending tests. From material damping constraint they have evaluated fatigue life of component for low and high cycles. From this paper series results of tryouts have reported to show how the damped parameter varies during fatigue test. They have discussed how to modify damping measurements to study the property of inhomogeneity of the component constitute and the crack instigation due to cyclic fatigue damage. A. Tjernberg [12] In this study, heat treated hardened shafts under torsional load have fatigue tested. The tests accompanied both with torque variety and with stable amplitude with dissimilar torque ratios. In this description, he has investigated fatigue failures, cracks under the hardened layer interior material are observed. They found, tensile stresses are high in the center material from the measurement of stress and from the hardening process. Using different parameters, they have performed simulations of the heat treated hardening process. Fatigue test carried out on core material of small specimen. Jafar Albinmousa [13] the author has used polar diagrams to show the variation of stresses and strains. Critical plane theory is broadly used as the fundamental for formulating fatigue harm models. Sympathetic of fatigue crack actions, introduction and early enlargement, under cyclic multi axial loading is necessary for fatigue damage analysis and fatigue life predictions. Polar diagrams represent the loci of upper limit stresses respect to plane direction. To comprehend the crack augmentation pattern on basis of stress-strain fields, crack path were measured onto polar diagrams. From the study they found that cracks are initiated from shear strain plane and maximum normal plane. It was found like chances for a crack to begin and grow at unlike paths. Polar diagrams used to find out the probability areas where crack could probably initiate and develop. J. Bris [14] this paper involves the fatigue corrosion failure offered by a duplex stainless steel shaft from an agrochemical plant atomization system. Whole section gets fracture near a surface bearing of shaft. In this study some techniques were employed like, naked eye observation and electronic scanning microscopy to find a fractographical description. They have done emission spectrometry for element analysis of the steel and Brinell hardness test. Energy utilization at the instant of the failure is used to approximate the stress level. To determine microstructure of steel they have performed optical microscopy. The study gives the most imaginable cause of failure was fatigue. Failure was caused and increased by the occurrence of the corrosive and harsh lubricating substance surrounded by the defected area and the high temperature. Laukik P. Raut[15] This review is identical essential for the investigation. In this article author have listed and explained the different methodology used for failure analysis of the shaft which is used in different purpose. This paper showed the comparison between unlike methodologies used and their application and limitation. The persistence of paper was to study the variety of methodologies used for the shaft failure investigation and to choose best methodology proper for the failure analysis of shaft used in gear box. R.W. Fuller[16] Using conventional 14- steps failure analysis approach they have investigate the failure cause structural component and also they explained their methodology on 14 conventional steps. In their methodology they have done necessary steps like, observation, information gathering, preliminary visual examination and record keeping, nondestructive testing, mechanical testing, preservation of fracture surfaces, microscopic study, and metallographic, failure mechanism evaluation, and compound analysis, mechanical failure analysis, testing under replicated service conditions, and last analysis and statement. Their main area of failure analysis is mixer unit shaft composed of AISI 304 stainless steel. Using various approaches, they analyzed the principal mode of failure. At the closing stages of the paper they come to the conclusion that the failure of mixer shaft is due to the inter-granular stress increase which cause crack initiation at the heat effected region. Chiara F. Ferraris [17] this article describes about diversity of concrete mixers their uses, application, criteria where to uses. Thus detail explanation has given in this paper. This paper tells that microstructure decides the performance of concrete for all material. Performance of concrete also determines from its compositions, curing condition, mixing process, mixing conditions and from its microstructure. This paper gives general idea about variety of mixing methods and concrete mixers. The factors for the mixing methods are considered that includes place of construction site, mass of concrete needed, the construction agenda and the cost. These articles show how to get better efficiency of the concrete. Eventually, superiority of concrete produced evaluates its performance after situation. This paper review about procedures to evaluates the mixing of concrete.

III. CONCLUSION

With the help of failure identification technique and methods, it is easy to identify the failure occurred in shaft under various condition. Modeling software and analysis software required for design and analysis purpose. Using this analysis software we can analyze stress and deformation on shaft. This study involves improvement in shaft performance by improving shaft parameters using analysis software we can find all results. Literature gives idea about failure, fracture of shaft, identification of failure, experimental analysis.

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