Acceleration Analysis of Transversely Vibrated Cracked Shafts

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Abstract

The output of the rotating shaft vigorously depends on the condition of a shaft. While deeming the perfection of a shaft, crack can be one of the major factors that need to emphasize on. Because of the mechanical design the shaft undergoes continuous stress while the engine is running. As the power of the engine escalated the stress on the shaft started increasing and perpetual running of engine in this condition causes failure resulting crack in the shaft. However, crack may propagate into 2 stages, at the beginning there is rising stress, change in the cross section or some other factors, for instance-fretting, porosity, inclusion etc generates the crack. Afterwards, if the machine left running with the first condition the discontinuity started increasing because of repeated stress imposed on the rotating shaft. Crack present in the shaft can obstruct the performances of the shaft enormously and at a certain stage it causes failure or loss of efficiency. Thus, it's important to identify the crack within the shaft at the beginning of its generation. In this paper the cracked behavior of a shaft is identified by vibrating the shaft transversely. Different types of cracked specimen are examined, and data are compared with the behavior of specimen without having crack.

Keywords: Shaft, Crack, Transverse vibration, Acceleration.

1. Introduction

The key to maintain the smooth running condition of a machine is the proper maintenance and careful inspection of the mechanical arrangements; therefore, it is very crucial to conduct the right inspection method and the right maintenance strategy in order to keep the mechanical instruments safe and away from any sort of damage [1]. Regarding this, a suitable monitoring of the machine condition plays a significant role to provide the necessary safety and quick detection of any possible faults in the machine elements [2]. Since rotating shafts are the most common machine elements used in heavy industrial and other machines or engines, the interest of this study goes to detection of any damage within a rotating shaft by means of acceleration analysis. Due to natural fatigue during rotation, any shaft may experience repeated bending and develop cracks which can cause a major break-down of a machine component. That is why, detection of any development of crack within the rotor shaft is vital for the safe operation. Though there have been conducted some experimental, numerical and analytical studies on cracked shaft [3,4,5] still investigations are going on for establishing the most suitable method for crack identification.

2. Research Methodology

2.1 Equipment used: The following equipment are used for the experiment:

a. Specimen: The material of the specimen was standard mild steel shaft material. The length of the material was 900mm and the length and diameter of the testing section was 800mm and 20mm respectively. The ends are rectangular shaped (width 12) with lengths right-70mm and left-40mm. The cracked specimens are created using the hacksaw where position of the crack is varied in 7 different specimens.
b. Milling Machine: The specimens ends are rectangular in shape which are generated by the milling machine.
c. Lath machine: The test section which is cylindrical was obtained from the lathe machine.
d. Device: The experiment was carried out by the vibration apparatus named TM16.

2.2 Experiment procedure

Figure 1 shows the experimental set up where trunnion blocks support the specimen at the both ends. The pivots are supported by right-hand in the bearings, whereas, two roller bearings are present in the left-hand support that can move freely within the guide block. A motor is placed at the middle of the specimen. First the experiment was done with the specimen without any crack. The specimen was placed and tightened the screw of the trunnion block. The servo motor with control unit was placed at the center to make the specimen vibrate in transverse manner. The acceleration of the vibrated specimen was gained by the vibration meter.

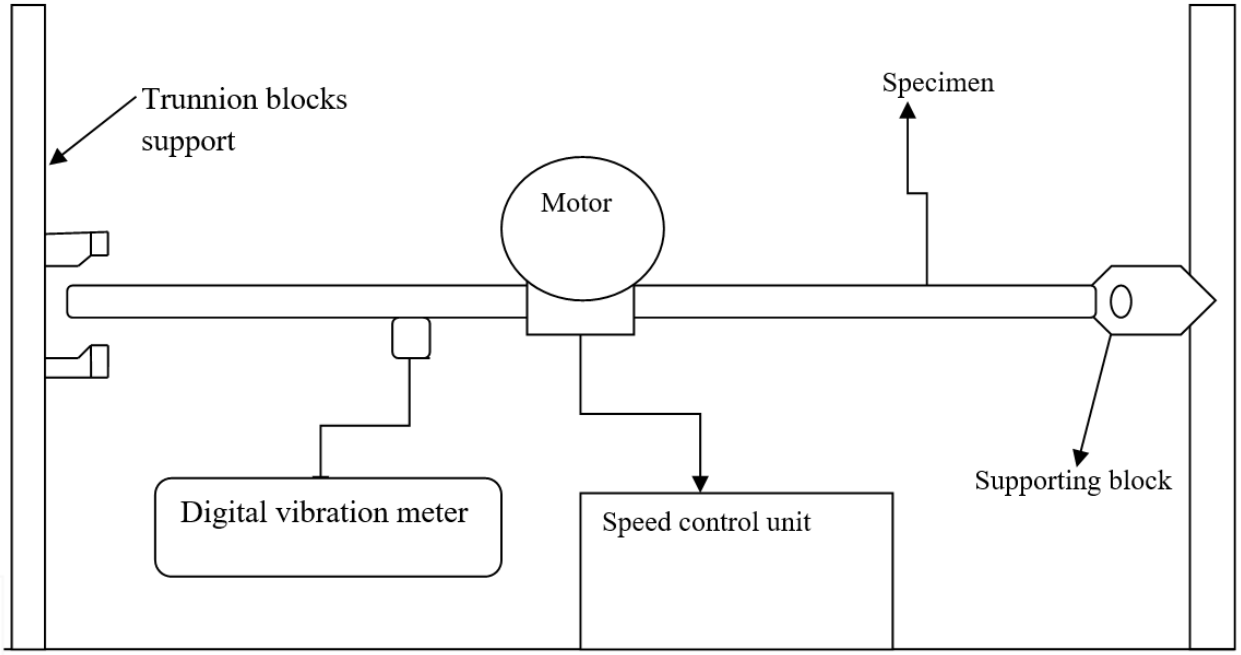

Figure 1. Arrangement of the experimental set up.

3. Results and Discussion

The experiment was carried out for each of the specimen and the acceleration of the vibration are noted. Table 1 shows the acceleration of specimen during transverse vibration and from this table, figure 2 and figure 3 can be depicted where the deviation is easily visible from different categories of cracked shaft.

Table 1. Acceleration of specimen during transverse vibration.

Time (s)	Intact shaft acceleration	acceleration for 3mm depth crack, from left 25cm	acceleration for 3mm depth crack at center	acceleration for 3mm depth crack from right 25cm	acceleration for 6mm depth crack, from left 25cm	acceleration for 6mm depth crack at center	acceleration for 6mm depth crack from right 25cm
10	0.3	1.6	0.3	0.2	0.3	0.2	0.7
30	0.5	2.5	0.7	0.6	0.7	0.5	0.9
60	1.2	2.1	1	0.7	0.8	0.8	1
90	1.3	2.3	1.7	0.9	1.2	1.7	0.9
120	1.5	1.8	1.8	1	1.4	1.3	1.2
150	2.1	1.7	3.8	1.5	1.2	1.6	1.4
180	2	6.5	2.5	2.1	1.7	1.8	1.6
210	2.5	5	38.7	5.3	2	17.5	10.5
250	46	4.9	1.9	1.6	3.5	2.3	1.2
280	1.5	3.9	1.6	0.8	3.2	0.8	1.3
310	0.4	7.5	0.3	0.5	1.5	0.2	1.7

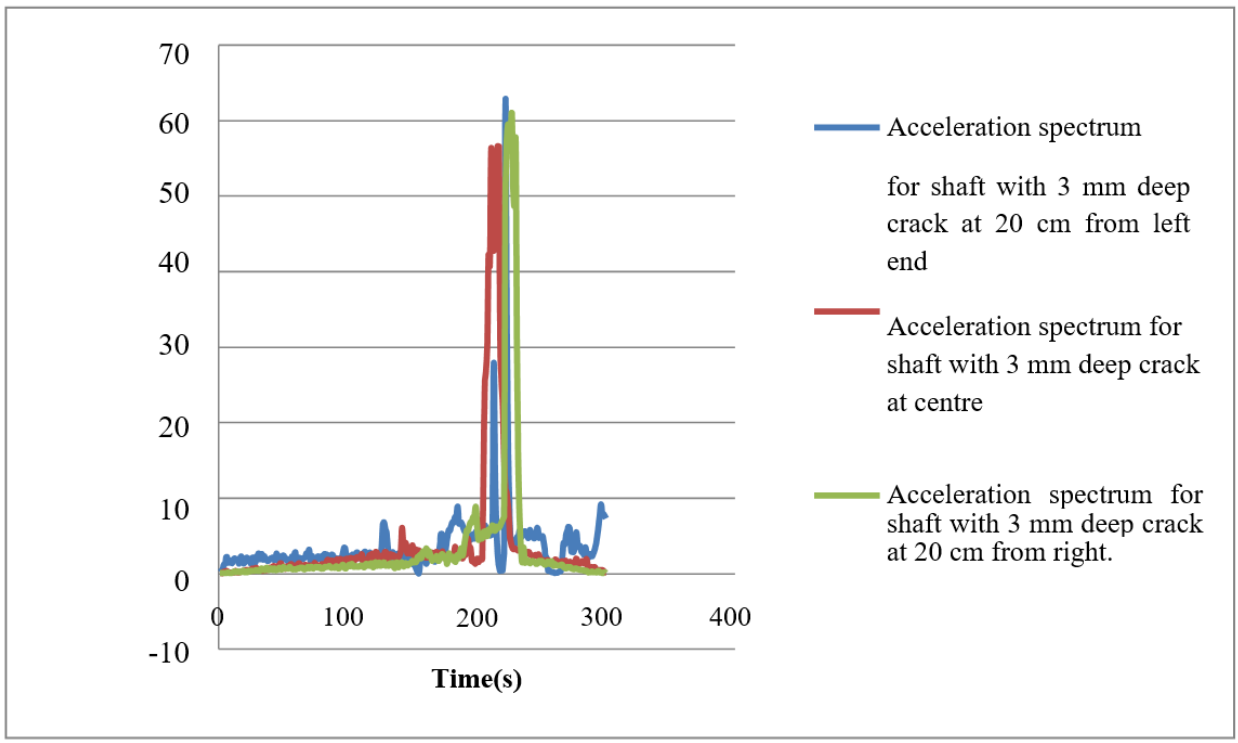

Figure 2.Spectrums of acceleration for the shafts having 3 mm depth crack depth in various positions

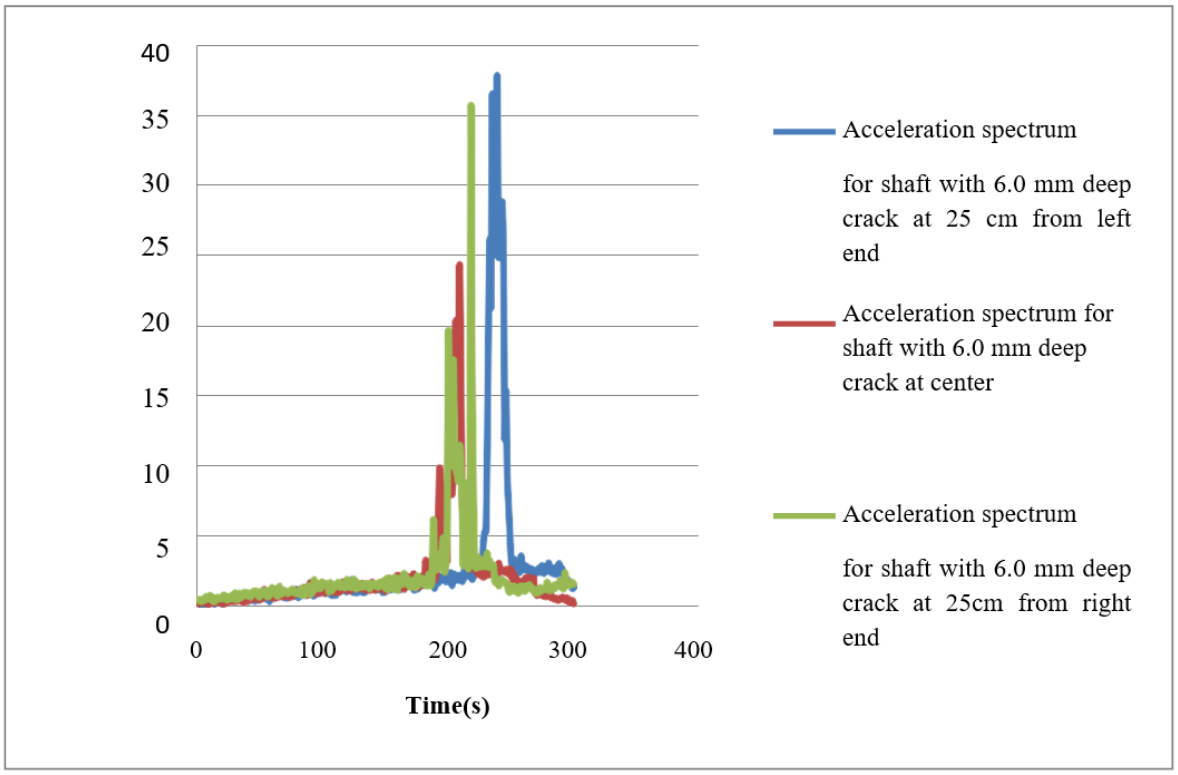

Figure 3. Spectrums of acceleration for the shafts having 6 mm depth crack depth in various positions

It was found that the highest acceleration spectrum came from the intact shaft. The values started reducing according to crack introduction. When the crack width remained constant, the depth of the crack and peak acceleration showed a correlation. When the cracks were of same depth, but they put in different position of the specimen and when there were various peak accelerations, the cracks which were in the center showed less acceleration then the cracks near to the supporter.

4. Conclusion

The experiment informs the acceleration characteristics of different types of cracked shaft under transverse vibration. The crack shaft has deviation from the normal and peak frequency. Itwas found that the behavior of the cracked shaft depended on the position of the crack in the shaft and for the same size of crack,thecenter crack-shaft has the greatest reduction in acceleration whereas, the severity in the changes of acceleration decreased by the distance of the crack from the center. However, the study needs to carry out more elaborately for comprehending the nature and detection of crack for several types of crack present at a time in the shaft.

5. References

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Biography

Md Mohaimeen-Ul Islam is a marine engineer who is an ex-cadet of Bangladesh marine academy (BMA), Chittagong, Bangladesh. Afterwards, he earned his Bachelor of maritime science (engineering) degree from Bangabadhu Sheikh Mujibur Rahman Maritime University (BSMRMU). In 2019, he designated as merchant 3rd Engineer .While completing his sea time (degree requirements) as an Engine Cadet in VLCC (very large crude carrier) at NITC, he gathered some valuable experiences. The experience which was something like starting from zero and an unknown position to something greater and reaching to the desired destination. His realization brought him to the intersection of his future plan and that was performing something new with desired destination which is only possible by stepping to the world of research. His research interest includes- Fuel cell, combustion, propulsion system and heat transfer.