EFFECT OF VARYING MACHINING POINT ON DEFORMATION OF CRANKSHAFT PIN IN ORBITAL GRINDING SYSTEM

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Abstract- In this study, the influence of varying machining point on the deformation of a crankshaft pin is investigated. The model is simplified with the stock and vibration dampeners replaced by stiffnesses. While the grinding wheel machines the pin part, the force acting on the work piece changes continuously. Analysis was done for 24 positions: 360 degrees was divided with 15 degree interval. The deformations are toward the center when the pin position is under the wheel center, but slightly outward the center when the pin position is over the wheel center. This is because the gravitation affects the deformation significantly. In addition, while the machined pin position and force direction change, the vibration dampener positions were fixed. This affects the deformation.

IndexTerms- Deformation, FEM, Orbital Grinding.

I. INTRODUCTION

The demand on precision parts has been continuously increasing. Small parts as well as large parts are needed. For example, crankshafts used in engines are of various sizes depending on engine types. The length of a crankshaft can be 30cm for a 2 cylinder engine, and can be up to 8m for a large ship engine. Since it is an essential part in an engine and is a driving shaft, the quality of the crankshaft affects the lifetime of the engine [1].

A crankshaft consists of a pin part and a journal part. The journal has the same center as the crankshaft, and a general machining can be used to machine it. However, the pin part has an eccentric center to the centerline of the crankshaft, and a general machining cannot be used to machine it. Orbital grinding can be used to machine the pin part. In orbital grinding, the pin rotates following a certain trajectory while the crankshaft rotates, and a grinding wheel moves back and forth along the horizontal axis according to the pin motion. In orbital grinding, the machined part of the pin (or the machining point) contacting the grinding wheel changes continuously, and the direction of the force does as well. In this study, the deformation of the pin will be investigated for the continuously changing machining point.

II. STUDY BACKGROUND

The supported parts of the crankshaft in an orbital grinding system in shown in Fig. 1. Both ends of crankshaft are supported by head and tail stocks, and 5 vibration dampeners support the crankshaft. The crankshaft machined is 5m long, and the 3D model is shown in Fig. 2. The 5 positions were selected to cause the least deformation of the crankshaft. In order to simplify analysis, vibration dampeners, head and tail stocks were replaced by equivalent stiffnesses. The force applied during machining was calculated using chip formation theory: cutting force of 900N and radial normal force of 450N [2]-[3].

When the crankshaft revolves one turn, the pin also rotates following a certain trajectory, being machined by a grinding wheel. The grinding wheel moves along a horizontal axis. While the grinding wheel machines the pin part, the force acting on the wheel changes continuously. The machined positions are shown in Fig. 3. Analysis was done for 24 positions: 360 degrees was divided with 15 degree interval. The closest position was assigned 0 degree, and the angle increases in clockwise direction as shown in Fig. 4.

In the analysis, the deformation was obtained in the direction to the pin center. In order to investigate the effect of the gravitational force, analysis was done with and without grinding force.

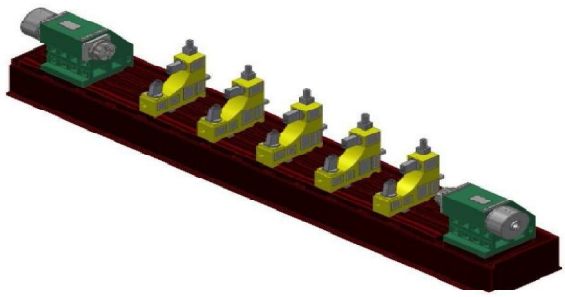


Fig. 1 Crankshaft supports

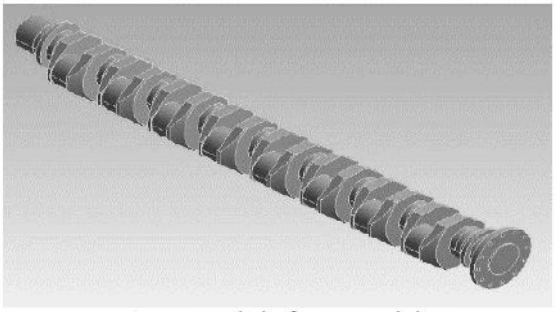


Fig. 2 Crankshaft 3D model

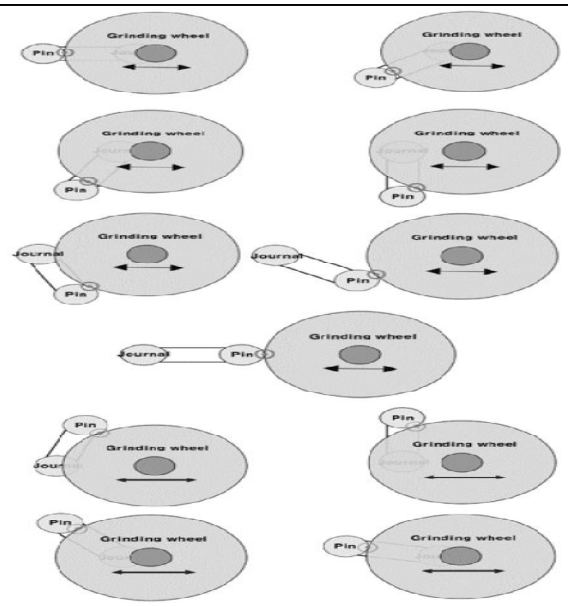


Fig. 3Positions of grinding wheel and crankshaft

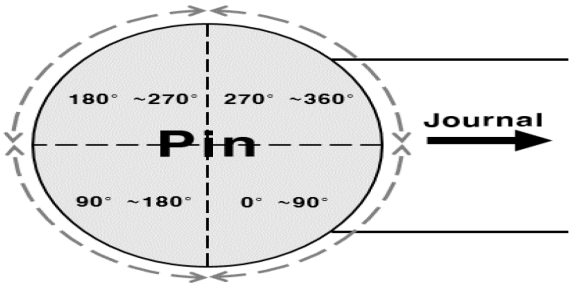


Fig. 4Angle of pin

III. RESULTS

1. Analysis with gravitational and grinding forces With gravitational and grinding forces applied, the result is shown if Fig. 5. In the figure, the direction toward the center is negative, and the outward direction is positive. The deformation is -14.34um at 30 degree, and 5.25um at 255 degree. The difference is 20um. The deformation is negative in the range of 0 and 180 degree, and positive in the range of 180 and 360 degree.
2. Analysis with gravitational force only In order to find the effect of gravitational force only, analysis was done with gravitational force, and the result is shown in Fig. 6. The deformation is -13.32um at 30 degree and, 6.05um at 255 degree. The deformation pattern is the same as that with gravitational and grinding forces.
3. Difference with the two results In order to find what difference the grinding force makes, the difference between the two results is shown in Fig. 7. The difference is -1.70um at 330 degree, and -0.43um at 210 degree. This means that this result is much less than the previous result. The pattern is not significantly different for the ranges of 0-180 and 180-360 degree.

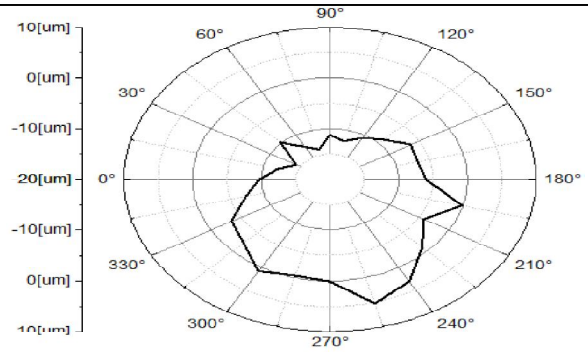


Fig. 5Deformation of pin with gravitational and grinding force

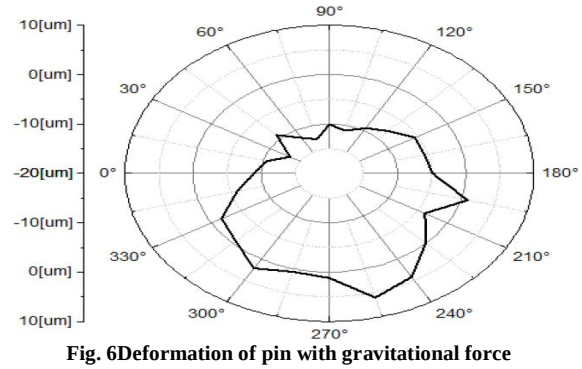


Fig. 6Deformation of pin with gravitational force

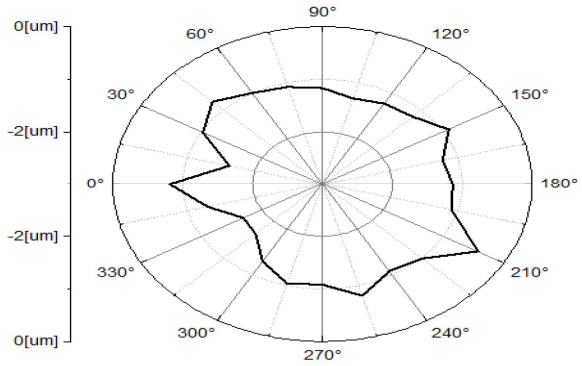


Fig. 7Deformation of pin with grinding force

IV. DISCUSSION

The analysis with and without the grinding force applied show that the deformations are toward the center in the range of 0-180 degree but almost the same or slightly outward the center in the range of 180-360 degree. In the range of 0-180, the pin position is under the center, and in the range of 180-360 the position is over the journal center. The result occurs because due to the gravitation, the crankshaft deforms downward. When the pin is under the wheel, the direction toward the center is toward the ground, and vise versa.

The deformation patterns are similar with and without grinding force. This means that the gravitation affects the deformation more than the grinding force. The grinding force affects the deformation by around 1um. In the three graphs, local variation in deformation occurs because while the force position and direction change the vibration dampener positions are fixed.

CONCLUSION

The pin deformation during orbital grinding was investigated for various machining points. In order to simplify the analysis, stocks and vibration dampeners were replaced by equivalent stiffnesses. The following conclusions are drawn in this study:

- When the pin is ground at over the wheel center, the deformation toward the pin center is large, and when the pin is under the wheel center, the deformation is small. This is because the gravitation affects the deformation significantly.
- The grinding force affects the deformation by 1um, and the effect dose not vary much for angular position.
- The fixed positions of the vibration dampeners affect the pin deformation.

The way to reduce the pin deformation will be investigated for various angular positions by adjusting the wheel position or the heights of vibration dampeners.

ACKNOWLEDGEMENT

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