XXI IMEKO World Congress „Measurement in Research and Industry“
August 30 – September 4, 2015, Prague, Czech Republic

EXPERIMENTAL ANALYSIS OF POSITIONING THE TURBINE AND THE GEARBOX USING STRAIN GAUGE

Martin Dub [1], Ondřej Berka [2], František Starý [3], František Lopot [4], Martin Janda [5], Vojtěch Dynybyl [6]

[1] CTU in Prague, Department of Designing and Machine Components, Technická 4, 166 07 Prague 6, Czech Republic, Martin.Dub@fs.cvut.cz
[2] CTU in Prague, Department of Designing and Machine Components, Technická 4, 166 07 Prague 6, Czech Republic, Ondrej.Berka@fs.cvut.cz
[3] CTU in Prague, Department of Designing and Machine Components, Technická 4, 166 07 Prague 6, Czech Republic, Frantisek.Stary@fs.cvut.cz
[4] CTU in Prague, Department of Designing and Machine Components, Technická 4, 166 07 Prague 6, Czech Republic, Frantisek.Lopot@fs.cvut.cz
[5] CTU in Prague, Department of Designing and Machine Components, Technická 4, 166 07 Prague 6, Czech Republic, Martin.Janda@fs.cvut.cz
[6] CTU in Prague, Department of Designing and Machine Components, Technická 4, 166 07 Prague 6, Czech Republic, Vojtech.Dynybyl@fs.cvut.cz

Abstract – In this work, the positioning the turbine and the gearbox has been investigated. The standard methods of position measurement were at the limit of measurability so the measurement of relative position of the turbine and the gearbox was based on the measurement of shaft deformation respectively shaft bending moment using standard 120ohm strain gauge.

Keywords: Position, Strain gauge, Bending moment

1. INTRODUCTION

Because during operation of the turbine and the gearbox were occurred vibrations so the main aim of this measurement was to determine if the vibrations are caused by the incorrect relative position of the turbine and the gearbox or by the own weight of the turbine. The standard methods of the position measurement were at their limits of measurability therefor the relative position was evaluated on the basis of measurement the turbine shaft bending moment and the gearbox input shaft bending moment.

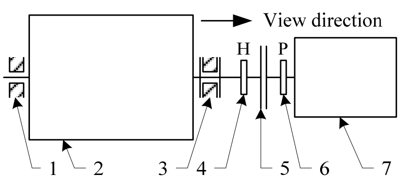

Fig. 1. Scheme of the measurement. 1. Turbine bearing, 2. Turbine, 3. Turbine bearing, 4. Turbine shaft strain gauge placement “H”, 5. Fixed coupling, 6. Gearbox input shaft strain gauge placement “P”, 7. Gearbox.

Other goals of the measurement were to determine the gearbox inlet shaft bending moment without load and the change of the gearbox inlet shaft bending moment with load of 400kW and 500kW.

The arrangement of the measurement can be seen in Fig. 1.

2. METHODS

The measurement was carried out using standard 120ohm strain gauges. The placement of the strain gauges can be seen in Fig. 1. Both places were equipped with two half-bridge circuits rotated by 90°. So the four channels connected to measurement unit equipped with amplifiers, converters and Wi-Fi module for connecting with the data acquisition computer were used [1]. The placement of the strain gauges can be seen in Fig. 2.

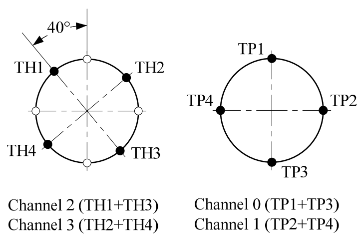

Fig. 2. Strain gauge placement – view in direction from turbine shown in Fig. 1.

3. MEASUREMENT

With respect to the objectives the data were obtained by the following measurements: manually rotating, operation at 400kW and 500kW.

3.1. Manually rotating

In Fig. 3 are presented data from channel 2 (turbine shaft) obtained by manually rotating. In the figure can be seen maximal reached value of the turbine shaft bending moment.

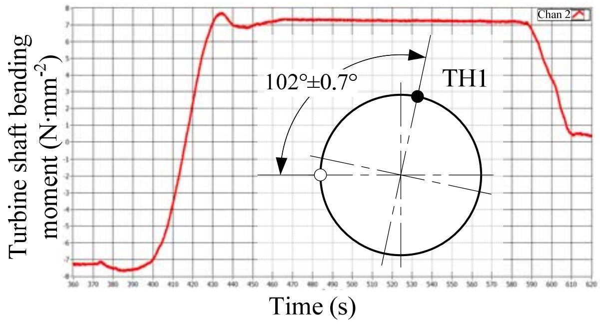

Fig. 3. Data from channel 2 obtained by manually rotating and the position of the strain gauge TH1.

From this measurement was calculated angular position 102°±0.7° of the strain gauge TH1. The strain gauge position shown in Fig. 3 was measured from horizontal plane clockwise by view in direction from turbine as shows Fig. 1. This position is very close to plane at 90° where can be expected effect of the own turbine weight.

3.2. Operation at 400kW and 500kW

Fig. 4 shows raw measured data obtained by channels 1, 2 and 3 and gives an idea of their stability. Data obtained by Channel 0 was not used because of its instability.

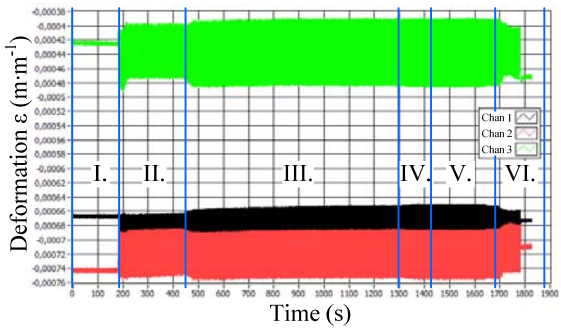

Fig. 4. The measurement at operation at 400kW and 500kW

In the measurement shown in the Fig. 4 can be seen six different areas marked with Roman numerals. Area "I." is non-operation state, area "II." is get in to operation state, area "III." is operation at 400kW, area "IV." is changing state from load 400kW to load 500kW at the same turbine speed, area "V." Is operation at 500kW and area "VI." is get in to non-operation state.

Table 1 shows average values of bending moment in measured areas. The values in areas I, II and VI are only for information. For further processing were used values in areas III and V with their standard deviation. For the better idea of the changing the average values of bending moment amplitudes are the data from Table 1 shown in Fig. 5.

The differences between turbine shaft values and gearbox input shaft values were caused by their different dimensions and geometrical properties.

Table 1. Average values of bending moment amplitudes in measured areas with their standard deviations

Chan 1	Area I.	Area II.	Area III.	Area V.	Area VI.
Avg. ($N\cdot mm^{-2}$)	0,0	2,0	3,5	3,6	1,76
St. Dev. ($N\cdot mm^{-2}$)	-	±0,2	±0,2	±0,1	-

Chan 2	Area I.	Area II.	Area III.	Area V.	Area VI.
Avg. ($N\cdot mm^{-2}$)	0,0	8,0	10,0	10,2	7,5
St. Dev. ($N\cdot mm^{-2}$)	-	±0,4	±0,4	±0,2	-

Chan 3	Area I.	Area II.	Area III.	Area V.	Area VI.
Avg. ($N\cdot mm^{-2}$)	0,0	7,8	9,7	9,8	7,0
St. Dev. ($N\cdot mm^{-2}$)	-	±0,4	±0,4	±0,2	-

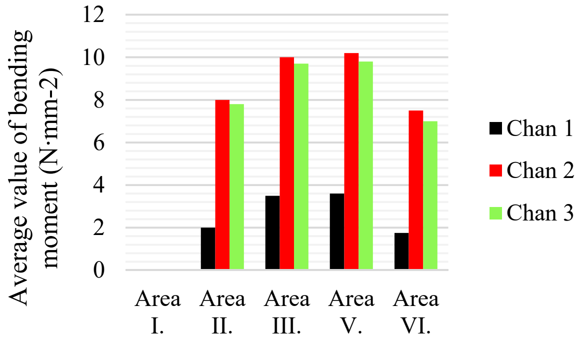

Fig. 5. Bending moment amplitudes in different areas.

4. CONCLUSIONS

Developing of the bending stress during the test operation cycle (see Fig. 5) shows the increasing bending moment under the load of 400kW and 500kW. This effect can be expected because of the turbine shaft bearing arrangement. Important are the gearbox input shaft bending moment value and turbine shaft bending moment value, which are very small and their position is very close to the plane where can be expected the turbine own weight effect.

ACKNOWLEGEMENTS

This work was supported by the industrial cooperation.

REFERENCES

[1] Berka, O., Lopot, F., Dub, M., *Experimental analysis of gear loading in planetary transmission,* 52nd International Conference on Experimental Stress Analysis, EAN 2014; Marianske Lazne; Czech Republic; 2 June 2014 through 5 June 2014; Code 107000.