

Wind Energ. Sci. Discuss., referee comment RC1  
<https://doi.org/10.5194/wes-2021-69-RC1>, 2021  
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## **Comment on wes-2021-69**

Jonathan Keller (Referee)

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Referee comment on "Input torque measurements for wind turbine gearboxes using fiber-optic strain sensors" by Unai Gutierrez Santiago et al., Wind Energ. Sci. Discuss., <https://doi.org/10.5194/wes-2021-69-RC1>, 2021

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### General comments:

The article discusses an interesting and useful application of fiber bragg grating sensors for torque-measurement and planetary load-sharing characteristics in wind turbine gearboxes, including full—scale verification testing. In general, I like the article and idea and have made some specific comments. The following comments may be personal preference, but I think some of the detailed descriptions could be shortened, especially in sections 3 and 4, and figures omitted to produce a more succinct article. In a similar fashion, I'd recommend a greater focus or structuring on the two uses and results of this technology (torque measurement and load-sharing) rather than the two methods (peak-to-peak and coordinate transformation). The Conclusions I think could be better written to reflect some of the same things in the Abstract, which is well written. After having read the paper, I am wondering if the title should reflect a greater focus on "Methods", like "Methods for Measuring Input Torque of Wind Turbine Gearboxes Using Fiber Optical Strain Sensors"?

### Specific comments:

#### In 1 Introduction:

- The discussion of gearbox dynamics (p. 2 lines 36-43) feels a bit incomplete. The lack of understanding and the importance of gearbox dynamics are indeed described, but what I think is implied (but left out) is the ability of this particular sensor to measure the dynamic characteristics of the torque at the frequencies necessary for such investigations – especially as described by the "second signal processing procedure" described in the Abstract and elsewhere. An easy way to improve this might be as easy as adding "dynamic" on to the sentence "It is, therefore, highly desirable to be able to

measure the dynamic torque from the rotor acting on the gearbox accurately and reliably.”

- It might be worth referencing recent work by Winergy on their Digital Gearbox (<https://www.winergy-group.com/en/DigitalGearboxUseCase>). If I understand correctly, this system is envisioned to be installed on operational wind turbines, rather than the more “one-off” systems (Guo and Rosinski) currently referenced. Maybe it is also important to state in the first sentence that “The traditional method to measure gearbox input torque...”
- I think the sentence describing the main contributions of the paper could be rewritten – the existing sentence is a bit “mixed” I think. In summarizing what this paper is, I wrote the following 2 sentences. They are even a more condensed version of what appears in the Abstract, which I think it already well written: “This paper develops a method to measure input torque on wind turbine gearboxes from ring gear strain measured with optical fiber bragg grating sensors and demonstrates it through full-scale dynamometer testing. The applicability of this method to also determine planet load-sharing characteristics is also explored.”

#### In 2 Background:

- In the first sentence of the Background, I think it would be better to say “The primary function of the gearbox is to transfer the power generated...”
- I think it might be worthwhile to say “The radial and tangential components of the mesh force, resulting from the helix angle in most gears, acting from the planets to...”
- Figures 4 through 7 are all interesting but might be hard to see and don’t necessarily add much to the paper. If any changes for brevity were needed, I believe any of these could be omitted. This is just an opinion, though. Maybe others find them very valuable. There are 23 total figures in the paper, which does seem like a large amount.
- I think the sentence in 2.4 should be “First, tests with a linearly increasing torque command.”
- It feels like a better title of section 2.5 might be “Data acquisition and vetting” more so than signal processing, as it feels like sections 3 and 4 are the “real” signal processing steps. This could just be a matter of opinion.

#### In 3 Torque Estimation:

- There are mis-spelled “toque” at 2 places in 3.2.
- I think some condensing of figures between 11 – 15 could occur. This relates to my general comment that the results and discussion are a bit “method heavy” rather than “results focused”.

#### In 4 Torque Estimation using a coordinate transformation

- Figures 17 – 20 are barely discussed. This relates to my general comment that the results and discussion are a bit “method heavy” rather than “results focused”.

#### In 5 Discussion:

- Figure 21 mis-spells “Weigth” in the upper portion.
- In terms of reducing figures as commented earlier, Figures 22 and 23 (right) are not discussed (or barely mentioned) in the text and are probably not needed.
- I am left with the impression that the coordinate transformation consistently yields better results than the peak-to-peak method. Is this correct, or are there pros and cons to each? If the coordinate transfer method is indeed “better”, then I have to wonder the value (in a journal article) of even discussing the peak-to-peak method any more than very briefly. This could be a matter of opinion as it really only relates to the overall length of the paper. Then again, having looked at things more – can load-sharing only be estimated with the peak-to-peak method?

#### In 6 Conclusions:

- Fully summarizing key points I think could be very helpful. For example, instead of “...optical fiber strain sensors were used because of their advantages over more conventional electrical strain gauges”, I would suggest to say something like “...optical fiber strain sensors were used because of their higher signal-to-noise ratio, immunity to electromagnetic interference, and faster installation compared to conventional electrical strain gauges” (or whatever the authors feel appropriate). I mention this because by the time I read the Conclusions I couldn’t remember what the advantages are, so I had to search back through the document to find the explanation. In a similar fashion, I suggest better summarizing “The key findings obtained during the development of the proposed method to measure input torque have been discussed...together with recommendations for future work.” Please state them here!