Alignment Supplies, Inc.

National Distributor For EASY-LASER®

Precision Alignment in Wind Turbines

By Paul Berberian

Of all the mechanical maintenance problems you will encounter in a wind turbine, shaft alignment is probably the easiest to understand. The high speed shaft between the gearbox and the generator is a critical point of failure and misalignment a leading cause of failure.

Precision shaft alignment is the process of aligning the center line of the shafts of one or more rotating machines. One machine is the driving machine and the other is driven. When the shaft center lines are co-linear, the can turn freely and the external forces that destroy key components of the system (bearings, seals, couplings) will be mitigated. Misalignment will most affect the main bearings in the gearbox and generator. Left unattended for too long, it will destroy the bearings and then go to work on other components down the line on the shaft – seals, rotors, etc. Precision alignment at install and periodic checks can help prevent component failure, up tower repairs and catastrophic failure. A bearing failure up tower can cost $10,000 to $15,000 to fix. Catastrophic failure can cost an estimated $260,000.00. A good alignment program can stop these problems before they even start.

There are various tools for alignment, some better than others. Consider these options:

- Straight-edge mechanical tools
  - Not a precision alignment
  - Subject to gross interpretation of the user
- Dial indicators
  - Difficult to learn proper alignment method
  - Time consuming process for the inexperienced
  - Dials must be mounted on the shafts
  - Shafts have to be able to turn to align with dials
  - Can be subject to interpretation by user
- Laser alignment tool
  - Learning curve is short
  - Very precise, even for an inexperienced user
  - Many mounting options for different turbines
  - Shafts do not necessarily have to turn
  - No interpretation by the user – the data is the data

Precision alignment means you are using a laser alignment kit or dial indicators. A straight edge is not a precision alignment tool. Lasers have many advantages over dial indicators. Dials are hard to teach and learn. Until you have mastered the art of dial indicators, they can be very frustrating and time consuming. Lasers are a fast, easy and accurate method of alignment.

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A good laser alignment solution will give you options for mounting in wind turbines. Different brands of turbines present different challenges. The position of the brake calipers and discs can prevent mounting with a chain and bracket on the shaft. When the shaft turns for alignment measurement the measuring units (laser & detectors) need to be able to turn without obstruction, so mounting options need to take those clearances into consideration. A proper alignment job is not complete without a good electronic method for documentation. Owners and operators must have a means to verify alignment other than a hand written report.

Easy-Laser® solutions include our Easy-Turn™ program, requiring a minimum of 40^0 turn. This gives the operator more choices where to stop the shaft, without having to stop precisely at 9:00, 12:00 or 3:00. Magnetic and offset brackets are available for difficult mounting solutions. Easy-Laser® has developed mounting solutions for many turbines and couplers. Electronic documentation, data base and hard copy is included with every Easy-Laser® shaft alignment tool to ensure alignments are done and done properly.

Condition monitoring can help detect alignment problems. Vibration monitoring tools look at the mechanical components – bearings, gears, etc – and they are very important to monitor, but they also help to identify the root cause of the existing problems and predict component failure. Condition monitoring can detect misalignment problems before there is damage to the mechanical components. Angular misalignment will show in the vibration spectrum in the axial direction and will typically show high vibration at 1X or 2X turning speed. Offset misalignment will more typically show up in a radial measurement when 2X turning speed is greater than 1X. The increase in vibration at two 2X running speed in the spectrum shows a misalignment condition that is worsening and causing damage over time. Using vibration to detect a misalignment problem and using a laser shaft alignment tool for correction will prevent serious mechanical issues in the future.

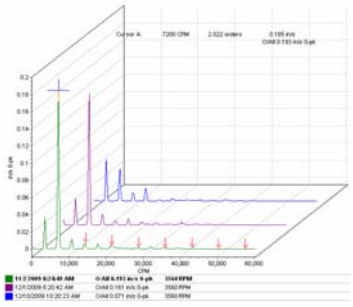
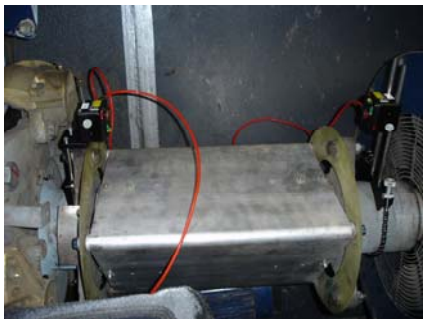


Figure 1 – Misalignment

When you are performing alignment in a wind turbine there are a number of issues to consider. First, and foremost, is safety. Laser alignment tools must be mounted in such a way that they will not be able to come in contact with techs if the turbine brakes give way. Turning the shafts is critical to performing a precision alignment and O&M teams have to be aware under what conditions they can work up tower when the blades will be turned. The requirement to perform a measurement without turning the shaft is becoming more predominant.

Fig. 2 – Alignment with Coupler



A sudden strong gust of wind can catch the maintenance team off guard and cause the shaft to spin freely as the brakes are being released for the alignment process. Some turbine manufacturers have developed solutions with Easy-Laser® that do not require the gearbox to turn. This requires special fixtures and the coupling needs to be removed to perform the alignment. It is, however, the safest way to perform an alignment in a wind turbine. Know the guidelines that your turbine OEM has set for up tower alignment – maximum wind speed, direction the turbine should face, can the shaft covers be off or on, should the coupling be removed – make sure your maintenance teams are safety trained. The second consideration is deciding how often the turbine needs to be aligned. Many turbine OEM's have set requirements for turbine alignment intervals. Some OEM's only align prior to shipment from the manufacturing facility, some align when the turbine arrives "in-country" and some align when the turbine is installed on the tower. Some do all three. It is never a bad idea to check turbine alignment. A precision alignment check should be included in your intervals of preventative maintenance. A quick check when the alignment is not scheduled to be performed can be done fairly quickly. Once you have determined that alignment is required, you can schedule it in your maintenance plan.

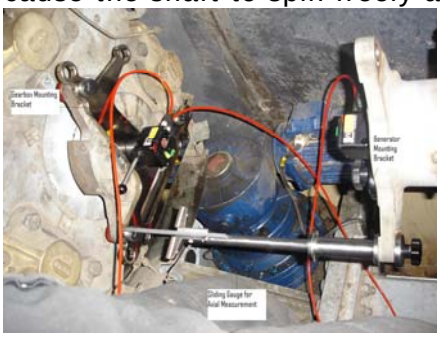


Fig. 3 – Alignment with coupler removed

Another important consideration is alignment tolerances. Alignment tolerances define how much misalignment is acceptable for a given model of turbine. Many turbine OEMs have established alignment tolerances for their equipment. If you don't know the manufacturer's tolerances, or they are not supplied, tolerance charts are available based on speed of rotation. Easy-Laser® tools include both speed based and have custom tolerance capability to ensure precision alignment.

The last consideration we will talk about in this article is dynamic movement. Dynamic movement is caused when the brake is released and the hub and blades turn freely. The weight and turning forces can cause the gearbox to move slightly – even imperceptibly to the human eye – and cause misalignment. You should consult your turbine manufacturer to find out if dynamic movement is present in their turbines, if they know how much it moves and whether or not it is critical. In some cases, the coupling can offset the movement when the shafts are aligned within tolerance. Once you know the amount of movement, you can add those calculations to your alignment tool. When compensating for dynamic movement, you will actually misalign the gearbox and generator at rest so that when it's running, the machines will move into alignment. The Easy-Laser® solutions have compensation programs built in to take the guesswork out of this requirement.

Easy-Laser® is a world leader in the wind industry with valuable tools for measuring flanges on wind tower and blade root flanges. Flatness and taper

measurements help ensure that these components will fit together properly during construction.

Precision alignment is a vital first step to prevent mechanical failure in wind turbines. Regardless of whether alignment is performed by the OEM, your O&M contractor or your own O&M team, good tools and training are not optional. Remember – an ounce of prevention equals a pound of cure – and lessens the chance for catastrophic machine failure up tower.

Paul Berberian is the National Sales Manager for Alignment Supplies, Inc, the authorized distributor for Easy-Laser® alignment tools. Paul has worked with turbine OEM's, Operations & Maintenance organizations, and wind tower manufacturers to develop alignment methods and processes focusing on safety and accuracy. Paul also functions as a field application engineer and trainer for the wind industry.