Biasing for Tooling Errors

Balancing tooling is often necessary to adapting a rotor to a balancing machine. When this is the case, careful consideration should be given to the unbalance that can be introduced by its use and, how to compensate for it. One method is called biasing.

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Whenever balancing tooling is used to interface a rotor to the balancing machine, the unbalance of the tooling needs to be considered and, it's influence eliminated from the operation. On a vertical balancer for instance, where the spindle and interface adapter would be viewed as tooling, error can come from several sources; the residual unbalance of the spindle, the tool's unbalance and, the unbalance caused by the fit error between the tool and the spindle.

There are several ways to go about eliminating tooling's influence. Today most, if not all, PC based instrumentations are supplied with software that allows one to compensate for tooling error by going through an indexing method (typically 180^{o}, and often referred to as "180 degree indexing). There are, however, many older machines still in use that don't have the luxury of indexing software. The reader should therefore, at least, know of the options.

The first thing that comes to most people's mind when talking about reducing tooling error is to just balance the tool by itself. This method has one flaw though. It assumes that the tooling's datums (interface and rotor mounting surfaces) are all concentric, perfectly round and, correctly define the rotor's spin axis. Unfortunately, this is to varying degrees never true. Just balancing the tool will not account for unbalance introduced by the mounting surface errors. It could be, for instance, that the arbor's mounting surface is slightly eccentric to the spin axis. Balancing the arbor by itself would not then account for the rotor being balanced somewhat off center of the spin axis. It would also build an unbalance into the rotor which would not become apparent until after the rotor is removed from the tool and in its service installation. This is where biasing comes in. The procedure is as follows:

1. Mount the rotor to the tool and make an initial run.
   Note: In the special case where two new aerospace simulators (a.k.a. "dummy rotors" or "PMI rotors") are involved, such as a turbine simulator and a compressor simulator, they are mounted and biased to one another.
2. Make a temporary (clay, wax, tape) correction to the assembly but, add half to the arbor and the other half to the rotor.
3. Now carefully index the rotor to the arbor by 180^0 and make another run.
4. Again, balance the assembly and split the correction 50/50.
5. Index the rotor on the arbor by 180°, back to its first run position.
6. Replace the temporary corrections made to the tool with permanent corrections.
7. Finally, check that the arbor has been biased adequately by again indexing 180° and, comparing this reading with the prior.
8. If the required tolerance has not been achieved, begin from Step 2.

What variation in readings is acceptable depends largely on the application and tolerance of the rotor. The aerospace industry (SAE ARP 4163) states that the change should not exceed 20% of the rotor's tolerance. This is easy to say but not always easy to achieve. Sometimes this 20% requirement exceeds what the machine, or any machine suited to the rotor, can deliver. If the 20% requirement cannot be met the decision of what is acceptable is left to the manufacturer of the rotor and the customer.

The importance of repeatability in the successful completion of a biasing operation, especially with the tolerance requirements of today's aerospace industry, requires meticulous attention to detail. The procedures involved when heating, cooling and, handling rotors and tools with an interference fit, must be performed identically during each index, i.e., heating and cooling rates, temperatures, orientation in the cooling container, the quantity of dry ice, heating uniformity, and so forth, must be repeatable.

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10/2/16