Dynamlc, high-speed rotor balancing and electrical testing

Newly built or repaired/renovated rotors require dynamic balancing to ensure their safe and reliable running. Balancing minimizes the vibration transmitted from the rotor to its stator and other surrounding equipment, thereby increasing the lifetime, reliability and efficiency of the rotating machinery. For generator rotors in particular, electrical testing of rotor function has also become standard practice.

VG Power Turbo operates two specialized machines that combine high-speed balancing and testing to ISO 1940 and ISO 11342 quality standards. Using the experience acquired from more than 700 rotors, our engineers balance in cold and in heated runs and perform electrical tests at standstill as well as at operational speeds. Rotor weights range from 1,300 kg to 110,000 kg.

State-of-the-art equipment, experience and know-how

- Fully equipped facility for generator and motor rotors plus other applications
- More than 700 rotors balanced and tested during the past 20 years
- Common bearings and bearing seals kept in stock
- Adjoining workshop for part manufacture, repair or modification
- Expert assistance for rotor evaluation and trouble-shooting
Fully equipped balancing facility
VG Power Turbo’s two balancing units are located in one single facility in Västerås, Sweden. Originally commissioned to balance all newly built ASEA and ABB turbogenerator rotors produced in Västerås, it is now utilized to service new and repaired/refurbished rotors of any brand. Over the years, our skilled engineers have successfully balanced everything from the smallest exciter shaft to huge nuclear power turbogenerator rotors.

The smaller unit balances rotors from 1,300 kg to 30,000 kg and the larger from 30,000 kg to 110,000 kg. An adjoining workshop houses our spare part manufacture, repair and modification operations.

Complete range of balancing skills and services
We balance rigid and flexible rotors (see below and right for details) at low-speed as well as high-speed. We also perform over-speed tests at 120% of nominal speed to confirm structural integrity. For some rotors, particularly generator rotors, balance testing should be done in the low stable ‘cold state’ condition as well as during heat runs, the latter of which will help identify thermally-induced imbalance.

As long as they fulfill the requirements for the balancing units, we handle rotors for motors and generators as well as other applications. Further requirements include bearings, bearing oil seals and an adapter to the running motor. Our inventory includes stocks of these standard parts. In addition, our experienced machinists are on hand to make any adaptations necessary to fit your rotor; they design and manufacture whatever parts are required. We can also use operator-supplied bearings, which we fit to our pedestals with adaptation rings. Let’s discuss the best alternative with you.

Rigid vs. flexible rotors
Before a rotor can be balanced, it must first be designated as ‘rigid’ or ‘flexible’. Rigid rotors operate well below their first critical speed, while flexible rotors may have one or even two critical speeds below their operational speed. In this context, ‘critical speed’ is defined as a rotational speed that matches a natural frequency of the rotor.

Deciding whether the rotor is rigid or flexible (and for the latter, the number of critical speeds below operational speed) is essential for defining the balancing procedure and the requirements for declaring the rotor well balanced.

In addition, the rigid vs. flexible designation also affects the regulatory standard applicable for rotor balancing. For rigid rotors, the most common standards are based on ISO 1940-1, while ISO 11342 generally applies for flexible rotors. Oil & Gas industry requirements are usually API 541 or API 546, but others may also apply. These standards also define the balance quality grade to be achieved.

Low-speed vs. high-speed balancing
Low-speed balancing can be done (usually at speeds <900 rpm) for rigid rotors that do not require a high balance quality grade.

High-speed balancing is needed for all flexible rotors and rigid rotors that require a very fine grade of balance quality. Moreover, due to the very high inertia energy of a rotor turning at high-speed, the balancing machine has to be built into a bunker or a thick concrete housing. VG Power Turbo’s balancing units fulfill this requirement. Table 1 lists details of a balancing test program for a turbogenerator rotor.
Table 1. Example of a balancing program
- Adjusting bearing pedestals in the balancing room
- Fitting the rotor in the balancing machine
- Run-out check before balancing
- Determination of balancing speeds
- Test run for establishing influence coefficient matrix
- Balancing to nominal speed
- Over-speed test to 120% of nominal speed for 2 minutes
- Final trim balancing: G 2.5 quality according to ISO 11342
- Run-out check after balancing
- Securing balance weights
- Returning rotor to delivery box or cradle

Computer evaluation of imbalance
Our engineering staff helps operators evaluate the balancing test results and assists with trouble-shooting. Their long experience in vibration analysis, both in our balancing facility as well as on-site at operators, is at your disposal.

We make special use of computer systems that quickly acquire data and evaluate rotor imbalance. All information gathered is analyzed so that balancing is completed in the shortest time possible. Should problems occur, e.g. sub-harmonic excitations, thermal deflections, etc., the software quickly analyses the vibration behavior and generates valuable data on which to base decision-making. In addition, data from the rotor’s previous balancing, or from a series of identical rotors, can be used to optimize the process even further.

Electrical testing of turbogenerator rotors
Our balancing facility is also fully equipped to simulate operating conditions and run a wide range of key electrical tests. Table 2 lists examples of such tests, which are performed at standstill as well as during rotation up to operational speed.

Table 2. Selected electrical tests
- Heat run with DC current (checks thermal stability of rotor)
- HV test and turn-to-turn insulation check performed with:
  - Impedance measurement at standstill and during rotation
  - Flux probe measurement during rotation
  - RSO measurement at standstill and during rotation

Balancing documentation
As with all VG Power Turbo programs, we fully document the work we carry out. This not only gives operators a written record of the current state of their equipment, but also simplifies future engineering and maintenance work. Table 3 lists examples.

Table 3. Balancing documentation
- Coast-down curves after balancing
- Over-speed test result with before and after residual imbalance
- Final balancing protocol of attached balancing weights and residual imbalance
- Electrical test protocols
Specifications and requirements for Balancing Unit #1 (max 30,000 kg)

Unit 1 has two bearing pedestals with built-in vibration velocity meters in horizontal, vertical and axial directions. Hydraulics allow the slide bearings to be varied between soft and stiff (soft pedestals are needed for low-speed balancing, stiff pedestals for high-speed balancing). Note that heat runs with current in the rotor can only be performed at low-speed.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max rotor weight</td>
<td>30,000 kg</td>
</tr>
<tr>
<td>Min rotor weight</td>
<td>1,250 kg</td>
</tr>
<tr>
<td>Min length between bearing (DE) and coupling flange</td>
<td>0.1 m</td>
</tr>
<tr>
<td>Min length between main bearings (NDE - DE)</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Max length between bearing (NDE) and coupling flange</td>
<td>7.46 m</td>
</tr>
<tr>
<td>Max bearing diameter</td>
<td>420 mm</td>
</tr>
<tr>
<td>Max rotor diameter (D)</td>
<td>2.5 m</td>
</tr>
<tr>
<td>Max speed</td>
<td>4,500 rpm</td>
</tr>
<tr>
<td>Max rotor current</td>
<td>445 amp</td>
</tr>
</tbody>
</table>

Specifications and requirements for Balancing Unit #2 (max 110,000 kg)

Unit 2 is for rotors above 30,000 kg that require two or three bearing pedestals. All pedestals have built-in vibration velocity meters in horizontal, vertical and axial directions. Journal bearings are mounted in stiff pedestals. Shaft movements can be measured. This balancing pit is equipped with a squirrel cage to allow heat run tests with full rotor excitation at operational speeds.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Max rotor weight</td>
<td>110,000 kg</td>
</tr>
<tr>
<td>Min rotor weight</td>
<td>30,000 kg</td>
</tr>
<tr>
<td>Min length between bearing (DE) and coupling flange</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Max length between bearing (DE) and coupling flange</td>
<td>1.4 m</td>
</tr>
<tr>
<td>Min length between bearing (NDE) and coupling flange</td>
<td>6.8 m (incl. adapter)</td>
</tr>
<tr>
<td>Max length between bearing (NDE) and coupling flange</td>
<td>15.3 m (incl. adapter)</td>
</tr>
<tr>
<td>Max bearing diameter</td>
<td>700 mm</td>
</tr>
<tr>
<td>Max rotor diameter (D)</td>
<td>3.7 m</td>
</tr>
<tr>
<td>Max speed</td>
<td>4,320 rpm</td>
</tr>
<tr>
<td>Max rotor current</td>
<td>3,600 amp</td>
</tr>
</tbody>
</table>
“Our skilled engineers have successfully balanced everything from the smallest exciter shaft to huge nuclear power turbogenerator rotors.”
Generating peace of mind – about VG Power Turbo

VG Power Turbo is a Swedish company focused on turbogenerator service and retrofit of air-cooled turbogenerators and auxiliary equipment irrespective of brand.

Our workforce possesses a complete range of in-house skills covering generator engineering, field service, workshop production, sales and project management. We also enjoy close cooperation with several strategic partners, including global turbine suppliers. Furthermore, we operate the only independent high-speed rotor balancing facility in the Nordic countries.