CMVA 40 Dual-Channel SKF Microlog Used in Balancing Machine Retrofit

By John Harrell

Abstract

Precision field balancing with the family of SKF Microlog portable data collectors is easy using the step-by-step procedures found in the "built-in" Balancing Wizard programs. Recently, several older soft bearing shop balancing machines have been retrofitted using the SKF Microlog with outstanding results. This paper describes one shop balancing application using the CMVA 40 dual-channel SKF Microlog to replace the original 40 year old electronics.

Background

A large aerospace manufacturer of small (7 to 11 kg, *15 to 25 lbs.*), high speed (8 000 to 12 000 RPM) machines purchased a 40 year old soft bearing balancing machine after locating the machine during a web search for used balancing equipment. Previously, balancing was performed by an outside contractor, and the manufacturer decided that balancing in-house would be more economical as well as improve the balance quality.

After several months of trying to make the old electronics work, it was determined that the reliability of the old instrument and sensors was poor and the cost of repair was as much as a new instrument. The balancing stand, which included the supports, drive motor and bearings, had been well maintained and was in excellent shape.

After evaluating a number of alternatives, the decision was made to purchase a CMVA 40 dual-channel SKF Microlog as the new balancing instrument to retrofit the balancing machine. The field balancing and vibration analysis capabilities were additional features that were weighed in the decision to purchase the CMVA 40 SKF Microlog rather than a dedicated shop balancing instrument.

Fig. 1. The SKF CMVA 40 dual-channel SKF Microlog.

Retrofitting the balancing machine

After disconnecting the electronic instrument and velocity transducers, and removing the strobe light from its mounting arm, two small aluminum mounting blocks were attached to the moveable bearing supports on the balancing machine. The bearings are attached to the supports by small, flexible leaf springs, which give the suspension a low natural frequency, in the range of 150 to 300 CPM, which is a characteristic of soft bearing balancing machines. Standard SKF accelerometers were then stud mounted to these blocks to measure the motion (unbalance) in the horizontal direction.

The SKF photo tach was attached to the mounting (swivel) arm that held the strobe light, using the same clamp that was used for the strobe. This method of mounting the photo tach made it very easy to add and remove trial weights, because the mounting arm could be pivoted out of the way (between runs) and then repositioned to accurately measure speed and phase. The entire retrofit operation took less than an hour, and the first rotor was balanced in two planes to the manufacturer's balance tolerance of 0.02 oz. in./plane in less than 30 minutes. Although this rotor, when assembled and installed, will run at 10 000 RPM, successful low speed balancing was performed at 815 RPM.

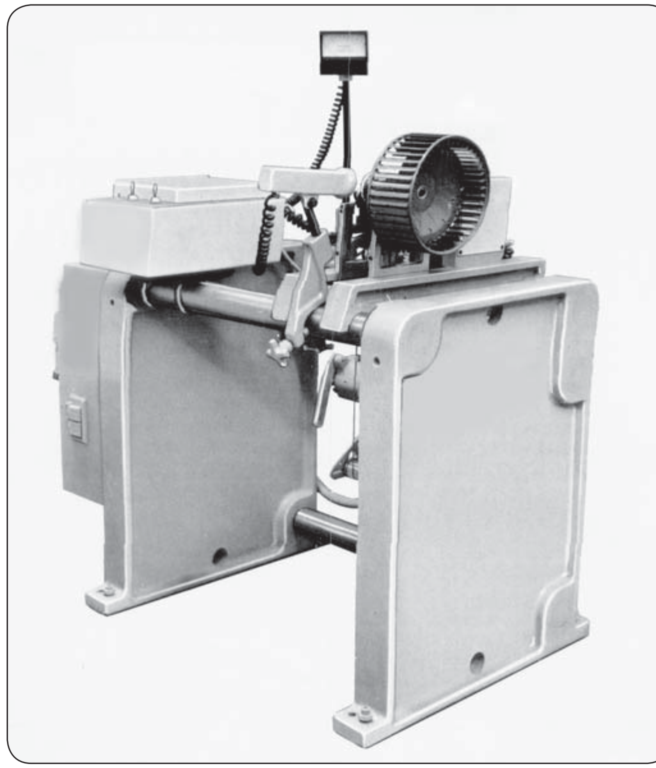


Fig. 2. Balancing machine. (Photograph courtesy of Gilman, a division of Giddings & Lewis, Inc.)

Balancing tolerances (for low speed balancing)

Because there may be some confusion concerning low speed balancing, the following discussion is a brief summary covering the balancing of rigid rotors in a balancing stand like the soft bearing machine described in this paper.

Most rotors can be successfully balanced at low speed (200 to 1 000 RPM) even though they may run at speeds of 1 800 RPM, 3 600 RPM or higher.

From the following formula, it can be seen that the centrifugal force at the bearings of a machine is dependent on two things: machine speed (RPM) and the amount of unbalance weight (w) multiplied by the radius (distance = r) of this weight from the center of the shaft.

- Centrifugal force at bearings = Fc = 1,77 [RPM/1 000] 2 [w × r]

Note that:

- The force Fc increases as the square of the speed
- The force Fc increases if weight [w] or radius [r] is increased
- Unbalance is defined as weight multiplied by radius = [w × r] = ounces × inches (or gram × inches)

Note: All balance tolerances are stated in ounce inches (or gram inches or gram millimeters). If 0.1 oz. is added to a perfectly balanced rotor at a 2 in. radius, the unbalance is 0.2 oz. in. (0.1 oz. × 2 in.). Although the force produced by this unbalance increases as the square of the speed, the unbalance (0.2 oz. in.) is the same. In other words, no matter what speed this rotor turns, the unbalance is always 0.2 oz. in. In fact, if the rotor is at rest (0 RPM), the unbalance is still 0.2 oz. in. The force changes with speed; the unbalance does not!

Because the unbalance is the same at every speed, low speed balancing tolerances are stated in terms of the amount of unbalance that can remain after balancing. Balancing reduces the force at the bearings by removing weight (grinding or drilling) at the heavy spot or adding (bolting or welding) correction weights to the light spot. The operator of a balancing machine must think in unbalance terms rather than vibration terms in order to know if the rotor is really balanced.

This particular manufacturer specified that the rotors being balanced in the balancing machine would be balanced to a tolerance of 0.02 oz. in./plane, which converts to:

- 0,567 g in./plane (0.02 oz. in. × 28,35 g/oz.)

Since the CMVA 40 SKF Microlog reads in vibration units (mils, displacement, in./sec, velocity or g's, acceleration) and not unbalance units (ounce inches, gram inches), a simple conversion is required. Therefore, an understanding of unbalance terms is necessary.

To achieve a low level of balance in a balancing machine using the CMVA 40 SKF Microlog, and to prove the rotor is balanced, the following steps should be followed.

Procedure for balancing using the CMVA 40 SKF Microlog

The two-plane balancing procedure is as follows:

- From the **Main Menu**, select:
  - **Analyzer**
  - **Balance**
  - **Set up** (select two planes, simultaneously)

Take data:

- Reference run:
  - Spin rotor in the original unbalanced condition with no weights and store readings (**Enter**) when readings stabilize.
- Trial run 1:
  - Select plane 1 nearest bearing A, and add a trial weight.
  - Spin rotor and store readings.
- Trial run 2:
  - Remove weight from plane 1.
  - Add trial weight to plane 2, nearest bearing B.
  - Spin rotor and store readings.
- Remove trial weight from Plane 2.
- Go to **Balance Menu 4**.
  - Trial weight set up.
  - Enter the amount and angle of both trial weights (remember, the angle convention is against rotation).
- Go to **Menu 5**.
  - Correction weight
  - Compute the initial correct weights for both planes (these initial weights are not removed during any additional trim runs), angles measured against rotation.
- Trim run:
  - Read vibration in both planes and compute trim corrections (trim correction weights are added to the rotor in addition to the original correction weights).

Prove rotor balance

As stated previously, balancing tolerance for this rotor was 0,567 g in./plane. For this small rotor, the radius for the correction weights was 2 in. Therefore, the proof of balance requires answering the following question: How much unbalance weight (grams) can be left in the rotor at a 2 in. radius so that the residual unbalance in the rotor is 0,567 g in. or less?

Divide the tolerance by the radius:

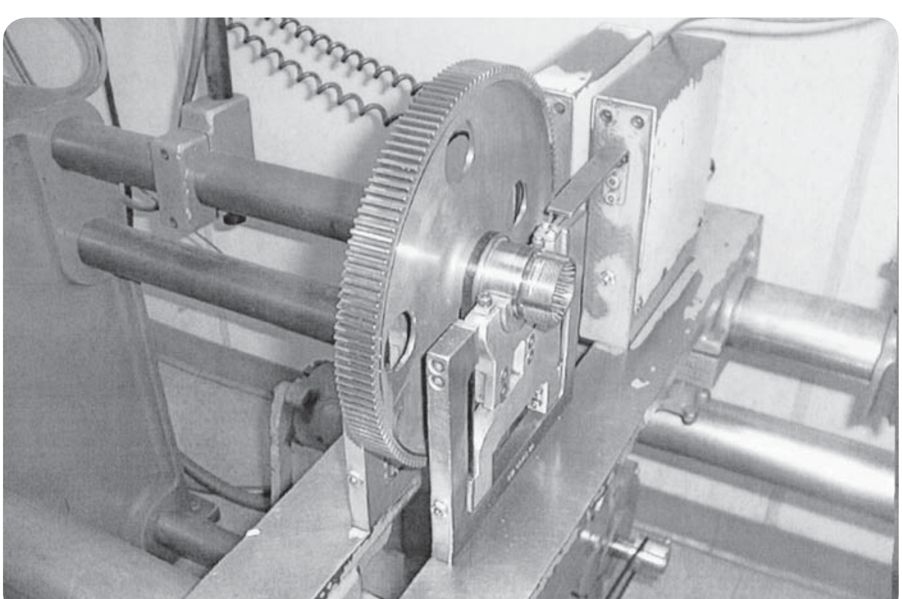
- 0,567 g in. / 2 in. = 0,284 g

Therefore, in order to meet the spec, the final trim weights computed by the CMVA 40 SKF Microlog must be less than 0,284 g. For example, if plane 1 computed trim weight is 0,15 g, the residual (remaining) unbalance is 0,15 g × 2 in. = 0,30 g in., which is less than the spec. To convert to ounce inches:

- 0,30 g in. / 28,35 g in. = 0.011 oz. in., which is the residual unbalance in plane 1

Plane 2 residual unbalance can be computed in the same way. To document balancing results, a report can be generated by connecting the CMVA 40 SKF Microlog to a printer using the printer adapter and selecting **Report** from the **Balance menu**.

Fig. 3. Example of a high speed gear in a slow speed balance stand.



Summary

Many outstanding condition monitoring programs include field balancing to correct unbalance problems that occur during operation due to wear or buildup on a rotor. Some programs also include shop balancing for new and rebuilt equipment to prevent vibration problems during start-up caused by unbalance. Shop balancing with a balancing machine also helps reduce the cost of sending equipment to an outside vendor for balancing. The manufacturer mentioned in this paper also felt that turnaround time and quality could be improved if they took control of the balancing operation.

The CMVA 40 dual-channel SKF Microlog was selected for this application as the most practical and cost effective solution for four reasons:

1. The CMVA 40 dual-channel SKF Microlog could be used primarily for precision balancing on the 40 year old soft bearing balancing machine, requiring only minor modifications to the machine.
2. Size, weight and battery operation made it attractive as a field balancer for fans and blowers.
3. The vibration analysis capability, not found in a dedicated shop balancing instrument, could be used for detailed analysis after the machines were assembled and tested.
4. The retrofit was cost effective, quick and easy to do.

Please contact:

SKF USA Inc.
Condition Monitoring Center – San Diego
5271 Viewridge Court · San Diego, California 92123 USA
Tel: +1 858-496-3400 · Fax: +1 858 496-3531

Web: www.skf.com/cm

PUB CM3039 EN · July 2011