Chapter 11

VIBRATING-WIRE FORCE TRANSDUCERS

The resonators (wires – as described in this chapter, rods, beams or tubes) are mechanical modifiers in which an elastic element is excited into vibration at its natural frequency, the value of which depends on the desired input quantity, e.g. force [11.1]. The output is thus at a frequency depending on the measurand.

11.1. VIBRATING WIRE AS FORCE MEASUREMENT PRINCIPLE

Reports of the use of vibrating-wire transducers (VWT) have appeared in 1928, in a paper by Davidenkoff, while the initial experiences in the UK were gained at the Building Research Station [11.2]. As related by a founder’s nephew [11.3], the Wirth-Gallo company first started building vibrating-wire transducers in USA decades ago, but today there are modern incarnation, compact and inexpensive aluminum units having smart geometry (Fig. 11.1).

Fig. 11.1
Vibrating-wire force transducer (VWFT) as adapted by DMS from TWG
The idea is quite simple: A wire is stretched between two points and vibrates while an alternating current runs through it. The natural magnets around the wire have been removed from this photo so you can see the wire stretched across the center near the top of the unit. It is held on either side by a pair of sapphire cylinders squeezed together by conical steel pins pressed into the opposite sides of the two blocks on top.

In use, the force to be measured is applied to a rod inserted through the hole in the thick bottom section and fastened with set screws to the block in the center of the machined aluminum unit. As you can see from the geometry of the device, if you push up on the center block it will deflect upwards, causing the two sets of horizontal supports to angle outwards (going from rectangular to parallelogram shape), which in turn will cause the two blocks holding the wire to be pulled farther apart. The actual movement is microscopic: The mechanism is designed to transfer force to the wire, not actually move any significant amount. (In fact the whole complex geometry is designed to minimize the negative effects, like metal creep and fatigue.)

Why not just use piezoelectric crystals or strain gauged force transducers? Because is difficult to keep them accurate under severe operating conditions. Imagine wanting to be able to weigh the garbage collected from each individual house on a collection route, by putting transducers on all four wheels of the garbage truck. This is not only being done in a number of European countries, but soon will be a legal requirement that all garbage collection service by priced by their weight! Transducers on the wheels of a garbage truck have what can only be described as a hard life. One minute they are being run over pot holes at high speed, slamming a truck weighing many tons down hard on the transducer. The next minute they are being asked to accurately weigh a few kilograms of garbage, by measuring the increases in weight of the multi-ton truck when a new bin is tipped into it. The basic requirement for profitability is the ability to accurately weigh truckloads \[11.4\]. The better systems are highly sensitive to ever incremental weight changes and compensate for environmental factors (e.g. ambient temperature).

A good image is worth a thousand words; the exact functioning of a VWFT can be explained in Figure 11.2 [11.5]: Between the two supporting blocks (9) is a prestressed wire (6). The two permanent magnets (10) produce a magnetic field perpendicular to the wire (6). If a current is applied, the wire deflects due to the electromagnetic force. With the help of exciter electronics the wire can be put into vibration. The frequency of the vibration is determined by the stress applied to the wire by the two fixing blocks (9). The two quartz cylinders (12) pressed into the fixing blocks guarantee a constant retaining force on the wire. A force applied to the rod (11) acts on the central block (7) and deforms the double-parallelogram device composed of positions 1, 2, 3 and 4.