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Balancing — No Longer Smoke and Mirrors

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Balancing — No Longer Smoke and Mirrors

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

We all experience unbalance and balancing in everyday life:

- washing machine on “spin dry” vibrating due to unevenly distributed clothes;
- ceiling fan swaying back and forth as it spins;
- getting new tires and you are asked if you would like your wheels “balanced”.

Picture or imagine:

- spinning a Frisbee with a 1” sphere of clay stuck to one side;
- swinging a stone around, overhead, on a string.

In all the above examples,

- the mass center and geometric center are misaligned;
- there is an out of balance condition;
- the object is not balanced or has unbalance.

When an unbalanced object is spun, it vibrates in rhythm with the rotation and the forces caused by unbalance are relative to the square of the rotational speed. Two key equations are:

$$\text{Unbalance} = \text{Mass (or Weight)} \times \text{Radius}$$

$$\text{Displacement} = \text{Unbalance} / \text{Total Mass (or Weight)}$$

In the pages that follow, through stories, equations and problem solving, balancing is discussed as more math and common sense and less smoke and mirrors.

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Balancing — No Longer Smoke and Mirrors

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Introductory story — Balancing is smoke and mirrors

In the late 1970's a balancing machine salesman visited a customer's plant who had just received a new balancer from the salesman's competitor. The plant manager said they were very happy with their automatic balancing machine and offered to show it to the salesman. The manager walked the salesman out on the floor and the two of them watched the operator and balancer in action.

The operator placed a part on the balancer and closed the door. The balancer spun the part, stopped, welded on a weight, spun up again, stopped, and displayed "good part". The operator removed the balanced part, put in a new part, and closed the door. The balancer spun up the part, stopped, welded on a weight, spun up again, stopped, and displayed "good part". This scenario was repeated several more times as the salesman and the manager watched.

The manager commented, "We just love our new machine. All day long it balances parts by welding on weights and puts out good parts". The salesman suggested having the operator place a "balanced part" back in the balancer again just to see what would happen. So the operator placed the previously balanced part back in the balancer again and closed the door. The balancer spun up the part, stopped, welded on a second weight, spun up again, stopped, and displayed "good part". The manager had the operator take another previously "balanced part" and put it into the balancer again. Again, the balancer spun up the part, welded on another weight, spun up again, and displayed "good part". Suddenly the manager was not so happy with his balancing machine. It had become clear; this machine was not balancing the parts at all. They had purchased an expensive welding machine to weld weights on their parts.

Balancing — Shedding some light

Production Managers who have just added a new balancer to their shop or production line often ask "How do I know if my part is balanced?" This question is usually asked after the person has had some basic training in balancing and has started balancing some parts. They quickly realize that visually, there is no measurable difference between a "balanced" part and an "unbalanced" part. They can see the "balanced" part has some holes (or other correction) and the "unbalanced" part has no holes (or other correction.) The balancing machine says, "Good part," but they still feel a need to ask "How do I know if the part is REALLY balanced?" and "What if the balancer is wrong?" I will attempt to answer these questions in the pages that follow, such that "if you can fog a mirror" you can probably understand balancing.

Basic balancing principals

The simplest form of unbalance is called "Force unbalance", "Static unbalance", or "Single plane unbalance". These are all words for the same thing. If you take an unbalanced gear, mount it on a shaft, and set it between two knife edges; the heavy spot will roll to the bottom. When this part is spun up and the heavy spot is spinning around, the forces generated by the heavy spot, pull the gear in the direction of the heavy spot. This is similar to spinning a stone on a string. The forces caused by the unbalance increase or decrease as the square of the change in the rotational speed. Unbalance is usually measured and specified in units of ounce-inches, gram-centimeters, or gram-millimeters. Roughly, 1 oz-in = 72 g-cm = 720 g-mm. See Figure 1 and Figure 2.