The Barn Raiser

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Understanding Fan Laws

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The purpose of this article is to explain the basic proportional relationships between fan speed, air flow, system pressure and fan horsepower. The equations that utilize these relationships are known as the "fan laws". These laws are particularly useful in determining what the impact on the system characteristics will be when the system fan's RPM varies. These laws can be applied to any fixed system; a fixed system is one in which the combination of ductwork, filters, hoods, cyclones, etc., remain unchanged and only the fan speed varies. Information such as static pressure, fan speed, and air velocity should be gathered on the existing system in order to predict the new fan / system performance. Each of these fan law relationships take place simultaneously and cannot be considered independent.

A system fan is required to overcome the forces that result from friction of moving mass within the system. The faster the air moves through the system the more energy is required to overcome the increased resistance to flow. The energy required to overcome the system friction is Static Pressure (SP). The system Velocity Pressure (VP) is the pressure that results from the air moving within the system. The combination of these two pressures is known as Total Pressure (TP).

The law of physics that governs the movement of air is expressed as:

$V = \sqrt{2gh}$ or $V^2 = 2gh$

Where: V = velocity of air flow (ft/min or m/min)
g = force of gravity (ft/sec² or m/sec²)
h = pressure causing flow (in H²O @ 68°F or cmHg@ 0°C)

From this equation we can see that the pressure required to cause flow within a system is proportional to the square of the velocity. This means that a system's Static Pressure will vary as a square of the change in air velocity. The change in air velocity is then used to calculate the change in air volume. This relationship makes it possible to calculate the change in static pressure that results from a change in air volume.

$((CFMnew) / (CFMold))^2 = SPnew / SP\ old$

Where: CFM = System Air Volume (ft³/min or m³/hr)
SP = Static Pressure (in H²O @ 68°F or cmHg @ 0°C)

Fan type, fan size or air volume will not effect the relationship of Air Volume to Static Pressure, unless the system is physically altered in some way (i.e. new filter media, capping of a duct branch or hood, rerouting of ductwork, material plugs in the system, etc.)

The first fan law states that the system air volume (CFM) varies directly with the fan RPM

$CFMnew = (RPMnew) / (RPMold) * CFMold$

Where: CFM = System Air Volume (ft³/min or m³/hr)
RPM = System Fan Wheel Speed (revolutions per minute)

As a fan wheel revolves it will discharge a specific volume of air with each revolution. If the fan is sped up resulting in a higher RPM the increased volume of air discharged by the fan is exactly proportional to the increase in RPM's.

The second fan law states that static pressure varies with the square of the change in RPM:

$SP(new) = ((RPM(new)) / (RPM(old))^2 * SP(old)$

Where: SP = Static Pressure
RPM = System Fan Wheel Speed (revolutions per minute)

This equation is derived from the two (2) previous equations. Since static pressure varies with the square of the CFM difference and CFM varies directly with the change in RPM, RPM's can therefore be substituted for CFM in the system equation. *See Page 2 for continuation*

"The Barn" built in the 1930's to house Welsh ponies, serves as Mid-South's offices.

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The third fan law states that system fan's break horsepower (BHP) varies with the cube of the change in RPM:
BHP (new) = ((RPM(new)) / (RPM(old))³ * BHP(old)

As the fan speed changes the point of operation on the Static Pressure-Air Volume curve remains unchanged as long as the system remains fixed. Therefore the fan break horsepower varies proportionally with the cube of the change in RPM.

It is extremely important to check and make sure that the new fan speed (RPM) does not exceed the fan's maximum safe operating speed that is found in the fan manufacture catalog.

Obeying these laws isn't a choice because the consequences of breaking them are enforced by imprisoning your system.

Citations:

"Fan Laws and System Curves" NYB Engineering Letters
New York Blower.
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"Fan Laws" Delhi-Industries Engineering Tips
Delhi Industries
<http://www.delhi-industries.com/Engineering/Engineering.asp.>

Mr. Roy Lee Murphy, SR.

Mid-South started our 40th year of business by giving Mr. Roy Lee Murphy Sr. a new **Razorback** executive chair and now that place sits empty since his passing to a better seat by the side of Jesus Christ his savior. Yet we know how Mr. Murphy enjoyed coming to work here and those of us who remain will do our very best to carry on the work our senior founder and original CEO started. Below is an article Mr. Murphy shared some years back with the employees of Mid-South which expresses best how much he relished the job, so we thought it fitting to convey his thoughts with our friends as we pay tribute to this good man…

Isn't it great to have a place of daily work that you want to come to!

Isn't it great to look forward to seeing the people you work with daily!

Isn't it great to be involved in a business that truly is trying to "Build a Better Mousetrap"!

Isn't it great to have good clients and customers that seem to need our help and services!

Isn't it great to be in a business where we can conduct ourselves by the highest moral and ethical standards!

Isn't it great to be able to sleep well at night. Knowing we have done our best and have been of service to others!

And most of all,

Isn't it great to have touched the lives of so many people, young and old, and perhaps nudged them forward in a straight and narrow path of personal growth and fulfillment!

Roy L. Murphy, Sr.

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