WORKED FAN LAW EXAMPLES

Fan Laws

The 'empirical'—means very basic :-) FAN LAWS are as follows:-

$$\frac{Q_1}{Q_2} = \frac{RPM_1}{RPM_2}$$

Basically this equation says that if fan RPM increases by 10% then the flowrate (Q) would increase by 10%. If the fan RPM increased by (say) 25% then the flowrate would increase by 25%.

Simple as that! Whatever % the revs go up by the flowrate will go up by the same %.

The way I prefer to do this maths is to take the original flowrate, Q and multiply it by the % increase of the fan RPM to get the new Flowrate at the new fan speed. But how do you do that?

OK—suppose you buy a sandwich for £2.50 and next day they say it has gone up by 10%. How do you work out the new price. Two ways—one—you could take 10% of the price and add it on (so 25p plus £2.50 = £2.75).

Or—the way I prefer. Whatever the increase is in % terms—put a "1." before it. So 10% becomes 1.10. Multiply the original value by this so the sandwich at £2,50 x 1.10 = £2,75 (easy!)

So if the Flowrate Q_1 was 3.2m^3/s and the fan increased the speed by 10% - the **new flowrate Q_2** would be the original one multiplied by 1.10 (ie 10%)

Q_2 would therefore be Q_1 x 1.10 or 3.2 x 1.10 = 3.52 m^3/s (voila!)

Next fan law:-

$$\frac{Sp_1}{Sp_2} = \frac{(RPM_1)^2}{(RPM_2)}$$

rather

Can't draw it properly – but the brackets go all the way down as one big bracket than two little ones, one above another – but you get the idea?

The above equation could also be written as:-

$$\frac{Sp_1}{Sp_2} = \frac{(Q_1)^2}{(Q_2)}$$

Why? Because the very first equation at the top shows that:- $\frac{Q_1}{Q_2} = \frac{RPM_1}{RPM_2}$

So anywhere you see $\frac{RPM}{RPM}$ you could substitute it with:- $\frac{Q}{Q}$

In other words if RPM increased by 10% the Static Pressure (Sp) would increase ***to the square of the change***. Hmmm let's have a look at that.

So in this second fan law – if I said that the RPM (or flowrate – it would be the same for either) increased by 20% how would that affect Static Pressure.

It would increase by 20% squared. Gulp—how do we do that.

Well—as before simply put a "1." before the percentage and work from there.

So 20% would be 1.20 and if the new Static Pressure SP_2 would be the old one SP_1 multiplied by the 'square' of the RPM or Flowrate increase ……

For a 20% RPM or Flowrate increase—that would be the same as saying $SP_2 = SP_1 \times (1.20)^2$

…….. and of course $(1.20)^2$ is the same as 1.20 x 1.20 which equals 1.44

So to recap—in this example $SP_2 = SP_1 \times (1.20)^2$
$SP_2 = SP_1 \times 1.44.$

OK let's try one!

Example question:- ***Current fan duty is Flowrate = 1.5m³/s, Static Pressure -925Pa. If the motor speed was increased by 25% what would be the new flowrate and static pressure?***

Answer

If the **RPM** went up 25% the **Flowrate** would go up by 25%

So (FAN LAW 1) ….. the new Flowrate would be:-

Original Flowrate x 1.25 = $1.5m^3/s \times 1.25$ = $1.875m^3/s$.

First part was very easy!!

If RPM went up 25% the Static Pressure would go up to the **square** of the change in RPM – **or** Flowrate.

New SP will equal the **old SP x $(1.25)^2$**

Old SP was -925

so the **New** Sp will be:- $-925 \times (1.25)^2$ which equals $-925 \times (1.25 \times 1.25)$

New Sp will be -925×1.56 which equals -1443Pa. Job done!

OK lets go for another one!

Example question:- ***Current fan duty is Flowrate = 2.5m³/s, Static Pressure -1200Pa. If you increase the fan speed by 25% - how does that increase the duty?*** (By "duty" the question means flowrate and Static Pressure)

So if fan speed goes up 25% then Flowrate must go up the same, ie by 25%

New Flowrate = old Flowrate x 1.25

New Flowrate = 2.5m^3/s x 1.25 which equals 3.125 m^3/s

Static Pressure would change to the square of the change in RPM (which was 25% - or is the same as multiplying by ..... 1.25)

So **new** Static Pressure = **old** Static Pressure x $(1.25)^2$ putting some figures in now .....

New Static Pressure = -1200 x (1.56) which = -1875Pa

Last fan law (How does POWER change with RPM or Flowrate?):-

$$\frac{KW_1}{KW_2} = \frac{(RPM_1)^3}{(RPM_2)} \text{ or the same as } \frac{(Q_1)^3}{(Q_2)}$$

So this fan law works just the same as the others but in this case you have to "cube" the change in RPM or flowrate. The "cube" of 1.25 is written $(1.25)^3$ and is the same as (1.25 x 1.25 x 1.25).

OK lets go for one more!

Example question:- ***If you increase the Flowrate in a system from 2m^3/s to 2.4m^3/s – what effect would that produce on the KW consumed?***

Tricky .... as in this example question – you are not given a numerical value the original KW – you cannot calculate an **actual** KW but you **can** calculate by what **%** the KWs would increase! Let me show you!

KW increases to the cube of the change in either RPM or Flowrate. In this example question you have been given flowrate (ie not RPM) – so we'll work with that.

If the flowrate goes from 2m^3/s to 2.4m^3/s that's clearly a 20% increase.

New KW will = **old** KW x $(1.20)^3$ and $(1.20)^3$ is 1.20 x 1.20 x 1.20 or = 1.728

Remember when we started this we said to convert a % to a workable numver—put a "1." before the %?

Well—we can do that in reverse. You have calculated that the new KW will be 1.728 times more than the original KW. So take the "1." back off the number and you get the % increase. Let me show you.

!.78—take the 1. back off leaves 728 or 72.8% increase in power consumption (for a 20% increase in flowrate or speed .... Wow)

Practice Fan Laws questions for you (with answers on the next page (but try to work them out yourself first!)

Question 1

If the revs increase 10% what would that do to the Flowrate and Static Pressure if the original Flowrate was 1.3m³/s and the Static pressure was -610Pa?

Question 2

If the Flowrate increased from 1.5 to 2m³/s what would that do to Static Pressure and KW if the original Static Pressure was -725Pa and the original KW was 3.6KW?

Question 3

If the revs increased by 25% what would that do to flowrate in the following system, give two clear answers? Initial Flowrate = 1.5m³/s, Initial Static Pressure = -800Pa

Answers

Question 1

Original Flowrate was 1.3 m^3/s
Fan increased by 10%
Same as multiplying by 1.10
New Flowrate will be old one multiplied by 1.10

New flowrate therefore would be 1.3 x 1.10 = 1.43m^3/s

Original Static pressure was –610Pa
Fan increased by 10%
Static increases to the square of 10% ie (1.10)2 which equals 1.21

New Static pressure will therefore be –610 x 1.21 which equals –738Pa

Question 2

Original Flowrate was 1.5m^3/s which increased to 2.0m^3/s (that is a 33% increase)

Original Static pressure was –725Pa and this will increase to the square of the change in Flowrate ie $(1.33)^2$ which equals 1.78

New Static Pressure = original Static Pressure x 1.78 or –725 x 1.78 which = -1291Pa

Original KW was 3.6 and this will increase to the 'cube' of the change in flowrate

So new KW = Old KW x $(1.33)^3$

New KW therefore = 3.6 x 2.35 = 8.46KW

Question 3

Using the same principles as above:-

New Flowrate = 1.5 x 1.25 = 1.875 m^3/s
New Static Pressure = -800 x $(1.25)^2$ = -800 x 1.56 = -1248Pa