Quick Pipe and Duct Flow Calculations

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Simple calculation methods for estimating flow characteristics in pipes and ducts save engineers' time

Would you like to make a quick mental calculation to determine approximate flowrate, velocity, or pipe and duct sizes for many common situations? This article presents two methods for estimating flow characteristics without the aid of charts, tables, calculators or software programs. One method applies to liquid flow in pipes, and the other to air flow in ducts. The techniques are intended to be simple enough to yield useful answers within a few seconds.

Liquid flow in pipes

Sizing pipes for liquid transport nearly always requires an engineer to seek a preferred velocity to establish favorable flow characteristics. This calculation technique allows an engineer to estimate velocity, flowrate and pipe diameter relationships when reference data is unavailable. The technique first establishes a flowrate (Q, in gpm) corresponding to a velocity of 10 ft/s in a Schedule 40 pipe with diameter D (inches). That information can then be extrapolated for flow properties at other conditions. Equation (1) applies to the flow of liquids through pipes.

$$Q_{10} = D^2 \times 25 \quad (1)$$

Consider the following examples, which employ Equation (1) to quickly approximate pipe velocity.

Example 1. What flowrate will yield a velocity of 8 ft/s in a 2-in. pipe? First, mentally calculate the following using Equation (1): $Q_{10} = 2^2 \times 25 = 100$ gpm. This means that 100 gpm will flow in the 2-in. pipe at 10 ft/s. We want to determine the flowrate in the same pipe at 8 ft/s. We know that 8 ft/s is 80% of 10 ft/s, so similarly, 80% of 100 gpm is 80 gpm. Literature shows the velocity of 80 gpm in a 2-in. Schedule 40 pipe is 7.65 ft/s. Our estimate is within 5% of the literature value.

Example 2. What is the velocity of 2,500 gpm flowing in a 12-in. pipe? Again, we use Equation (1) to mentally calculate the flow at the reference velocity of 10 ft/s: $Q_{10} = 12^2 \times 25 = 3,600$ gpm flowrate at 10 ft/s. To determine the velocity at 2,500 gpm, we start with the fact that 2,500 is roughly 70% of 3,600. 70% of 10 ft/s is 7 ft/s. Literature shows the velocity of 2,500 gpm in a 12-in. Schedule 40 pipe is 7.17 ft/s. Our estimate is within 3% of the literature value.

Each problem is solved in two basic steps. The first is to multiply the square of the pipe diameter by 25. The second step is to determine the ratio of the target flow to the flow yielding 10 ft/s to arrive at the desired conditions. In a manner similar to the examples above, pipe diameters can be derived from flow and velocity data. That calculation is performed by assuming a pipe diameter, calculating its flow at 10 ft/s, comparing its flow properties at desired flow or velocity, and iterating to another diameter if necessary.

This technique is not exact, but it gives the engineer relatively accurate results very quickly. While Equation (1) is intended for Schedule 40 pipes, and accuracies for pipes with varying wall thicknesses will be slightly different, this calculation method will quickly yield a close estimation. Figure 1 displays how calculated values compare to literature values. The error between estimated values and actual values should be accurate enough for initial sizing estimates. However, accuracy is diminished significantly for pipes with a diameter of less than one inch.

Air flow in ducts

The technique used for liquids in pipes can be applied to air in ducts at standard (atmospheric) pressure and temperature. Equation (2) applies to air flowing at these conditions, using a reference air velocity of 2,000 ft/min.

$$Q_{2000} = D^2 \times 11 \quad (2)$$

Consider the following examples, which employ Equation (2) to evaluate flowrate (Q, in ft^3/min) in sheet-metal air ducts.

Example 3. What flowrate will yield a velocity of 3,000 ft/min in a 10-in. duct? We must first use Equation (2) to mentally calculate the following: $Q_{2000} = 10^2 \times 11 = 1,100$ ft^3/min, which is the flowrate yielding an air velocity of 2,000 ft/min. We want to determine the flowrate that results in a velocity of 3,000 ft/min. 3,000 ft/min is 150% of 2,000 ft/min. Therefore, 150% of 1,100 ft^3/min = 1,650 ft^3/min. A check against the literature values shows that the velocity of 1,650 ft^3/min in a 10-in. galvanized sheet-metal duct is 3,100 ft/min. Our mental

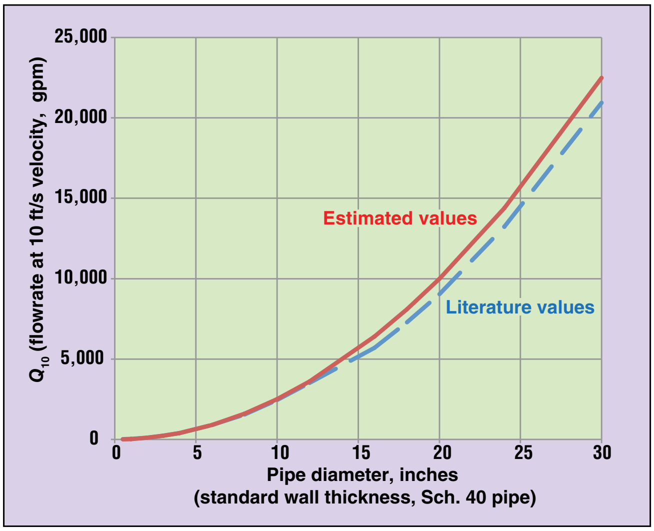

FIGURE 1. A comparison of literature values with calculated values shows that these quick, simplified pipe-flow calculations are accurate enough for initial sizing estimates

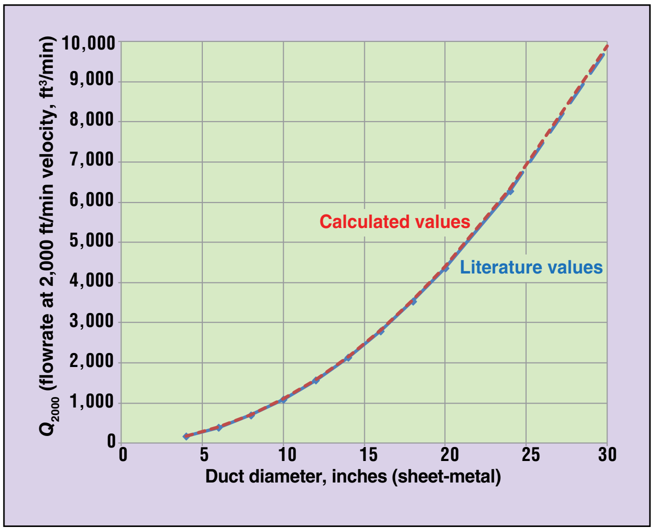

FIGURE 2. The rough estimates resulting from the duct-flow calculation method are extremely close to literature values for airflow in sheet-metal ducts

calculation is within 3.2% of the literature value.

Example 4. What is the velocity that corresponds to a flowrate of 6,000 ft^3/min in a 20-in. duct? First, of course, we must mentally calculate the flowrate corresponding to the reference velocity of 2,000 ft/min: $Q_{2000} = 20^2 \times 11 = 4{,}400$ ft^3/min. Now, we can solve for the velocity which corresponds to 6,000 ft^3/min flow in the pipe — 6,000 is slightly less than 150% of 4,400, and 150% of 2,000 ft/min is 3,000 ft/min. Literature shows the velocity of 6,000 ft^3/min in a 20-in. sheet-metal duct is 2,800 ft/min. Our estimate is 7% greater than the literature value, but a value somewhat greater than the actual was expected when we rounded to 150%.

This technique is accurate to within 1% if exact numbers are calculated for the flowrate percentages. As seen in Examples 3 and 4, accuracy diminishes if estimates are not exact. While this technique is intended for use with sheet-metal ducts, accuracies for ducts with varying wall thicknesses will not be significantly different. Figure 2 compares these calculations to literature values. The two lines are practically identical when calculations are precise, rather than rough estimates.

In conclusion, when rough initial estimates are needed, engineers can confidently apply these simple, time-saving methods to characterize flow in pipes and ducts. ■

Edited by Mary Page Bailey

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