WHITE PAPER
Feeders

Material Effect on Power Requirements for Screw Feeders
by Bryon Vlier, Hapman Product Specialist

A screw feeder is commonly used to meter flow in powder processing applications because of ease of use, low maintenance, and material integrity without degradation. The relatively simplistic equipment design of the screw feeder can be misleading when selecting and specifying motor and auger sizes.

Sizing feeders with the proper motor and auger for optimal processing is not as straight forward as matching the capacity of the auger/ feeder to the material. Horsepower requirements can vary significantly with different materials. As the auger diameters increase, the differences in material can result in a dramatic increase in horsepower requirements. This is because the surface area of auger and material contact increase dramatically.

Materials that have a high coefficient of friction can result in big changes in horsepower requirements. The length of the feeder nozzle and auger is another significant factor in the horsepower requirements. When a feeder is elevating material, two other factors must be considered, the angle of the incline feeder and the overall height. The angle will determine the overall length of the feeder.

An illustration of this concept requires a specified material example. The example materials selected in this study are used to demonstrate the differences in power requirements based on the extremes of material properties of seemingly similar elements.

The mentioned example materials are not intended to be a comprehensive list.

Screw feeder augers come in various sizes to accommodate a variety of material characteristics and processing needs.

The basis for analysis will be a series of assumed low, medium, and high volume feeder sizes. The low volume is 60 in3 to 5 ft3/hr, with a 600 in3 hopper, (LV) the medium volume is assumed 1 ft3 to 50 ft3/hr with a 1 ft3 hopper, (MV), and the high volume 5 ft3 to 1,000 ft3/hr with a 3 ft3 hopper, (HV).

To calculate the horsepower given an auger size, you can use these set of equations:

$$HP_f = \frac{LN\,F_dF_b}{1{,}000{,}000} = \text{(Horsepower to run an empty feeder)}$$

$$HP_m = \frac{CL\rho\,F_fF_mF_p}{1{,}000{,}000} = \text{(Horsepower to run a feeder full*)}$$

C = Capacity in ft3/hr
e = efficiency (Assumed to be 85% for chain driven augers)
Fb = Hanger bearing friction (Use 2.0 for Nylon bearing)
Fd = Auger diameter factor
Ff = Flight factor (Assumed 1.0 for standard augers)
Fm = Material characteristics factor (friction factor)
Fo = Overload factor (Use the equation Fo = -0.567(HPf+HPm) + 3.113) Use 1.0 for HPf+HPm > 5.2
L = Total Length of auger, feet
N = Operating speed, RPM (use 100 rpms)
ρ = Density of material lb/ft3
HPf = Friction Horsepower
HPm = Horsepower required to move material
HP = Total Horsepower

Property Table for Powders

Powder	Fm	ρ, lb/ft3
Activated Carbon	1.2	17
Lime	2.0	35-42
Flour	0.4	48
Baking Powder	0.6	56
Sand	1.7	99

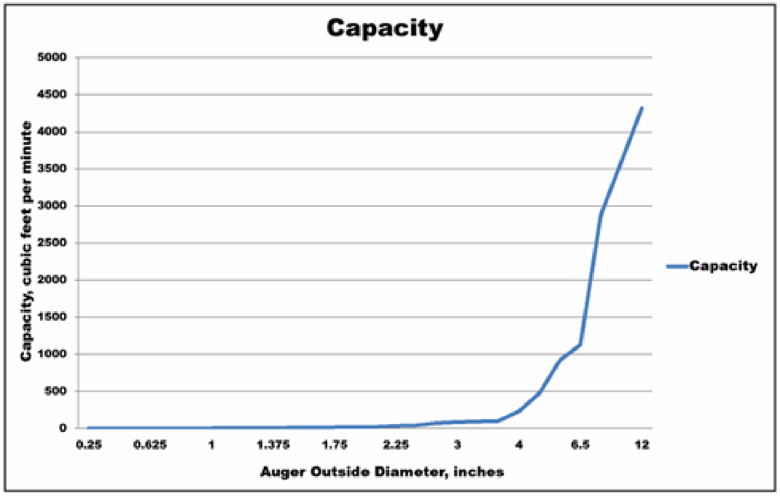
Feeder Sizes and Properties

Feeder Model	F_d	Auger Sizes, inches	Standard Lengths, inches	Auger Sizes, inches
LV Feeder	1.2	17"	22"	0.25" - 1.25"
MV Feeder	2.0	35" - 42"	30"	1.375" - 2"
HV Feeder	0.4	48"	42"	2.25" - 6.5"

*All assumptions and calculations in this study are assumed a 100% full auger.

Figure 1 shows the overall capacity of all three size feeders with various size augers. The 8", 10" and 12" are not part of the standard auger for these three feeders, but are shown for completeness of data. Capacity dramatically increases from 3" to 12".

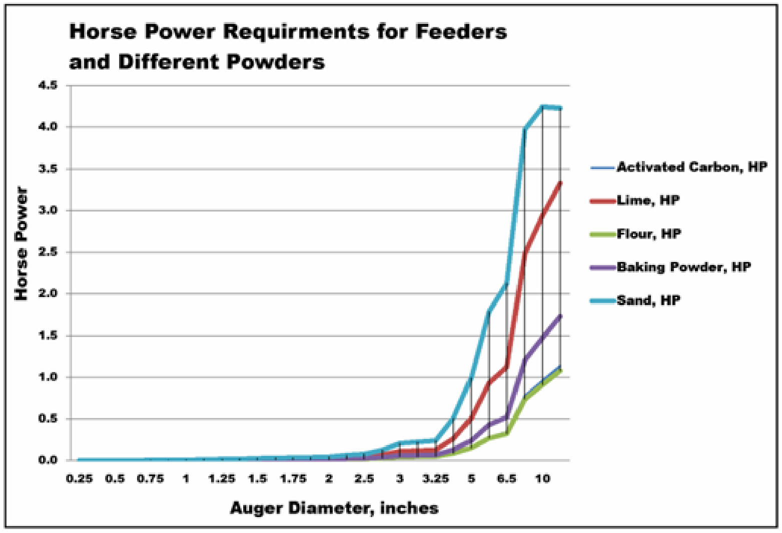
Figure 1



Power Required for Different Materials

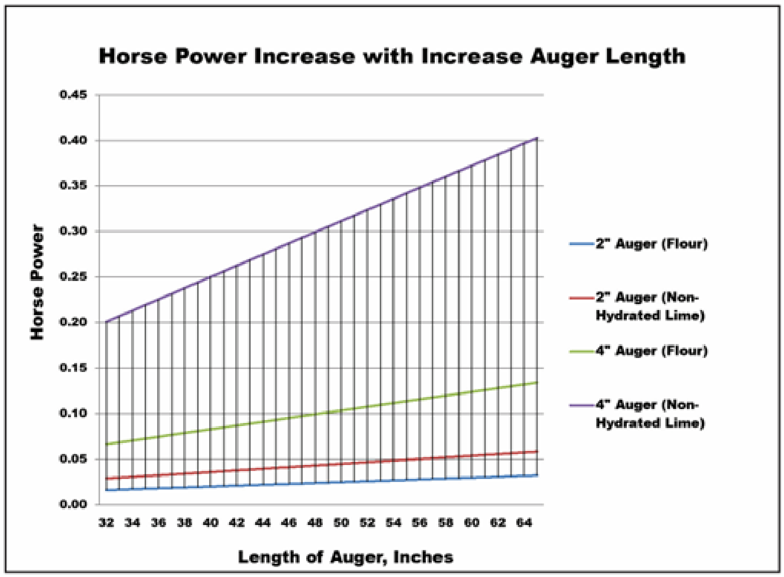
The graph in Figure 2 shows the calculated horsepower draw for three different size feeders using five different powders. The horsepower is graphed versus the size auger. The auger is sized based on the rate required. The power draw is a result of the size of the auger and the friction factor for the material. The graph in Figure 3 shows the power draw increase to 2.13 horsepower for sand with a 6 ½" auger. For larger augers (larger than 6 ½") the horsepower increases dramatically and could be in excess of 4 horsepower for sand with a 12" auger.

Figure 2



The lengths of the augers are based on industry standard feeder sizes and range from; 22 inches, to 30 inches and to 42 inches. The standard auger length and diameter depends on the size feeder and delivery rate. However, when the length of the nozzle increases, the amount of horsepower

Figure 3



required increases roughly proportionally (see Figure 3).

Even when two separate materials appear to be the same, small variations in properties can produce very different result in the auger sizing and the horsepower requirements. When performing feeder sizing, it is critical to know the exact type of powder and not just the name of the material.

As seen in Figure 4, non-hydrated lime and hydrated lime are very different in the horsepower requirements. This is mainly a result of a much larger coefficient of friction (Fm = 2.0) for non-Hydrated Lime versus Hydrated Lime (Fm = 0.8). The horsepower difference of 0.7 horsepower for a 6.5" auger and as high as 2.3 horsepower for an auger 12" in diameter. Clearly with larger augers, you may have an undersized motor if you used the hydrated lime.

Special Vertical Feeder Case

To this point, the study has only evaluated a horizontal feeder. In many cases material must be fed vertically into a silo, mix tank, reactor, dry mixer or some other storage or process equipment. Vertical feeding requires additional power. The total horsepower calculation can now be expanded by adding a third horsepower HPl (lift). So the completed equation would be:

$$\text{Total HP} = \frac{(HP_f + HP_m)F_o + HP_l}{e}$$

The horsepower to raise a given amount of material is calculated as; the work done lifting the material divided by the time, (power = work done / time). This can be expressed in the case of lifting 100 pounds of material in ten seconds up 10 feet. The work done is equal to 100lb X 10 feet or 1000 lb-ft. Since it was done in 10 seconds the power is equal to P = 1000 lb-ft/10 seconds or 100 lb-ft/

second. One horse power is equal to 550 lb-ft/second. Therefore, the horsepower required is equal to 100/550 or 0.182 HP.

Continuing with this logic, a comparison can be made between flour and non-hydrated lime. The in 2" and 4" augers shown in Figure 5 illustrate the horsepower requirement increases with both the length of the auger and the height the material lifted. When a feeder is set at a 20 degree angle, the length of the auger increases and larger horsepower requirements result. For the same type of powder the 60 degree angle is best; however no slippage was calculated. In general, a shorter length of auger to reach the elevation is optimal. In practice, the amount of slippage will increase with increased angle, and operation is generally less efficient above 60 degrees.

Conclusion

This study evaluated the impact that auger diameter, material moved, length and lifting height have on the power required for a screw feeder. The many different types of screw feeders were not considered in this study, but the foundation of principles will apply to most variations. The feeder auger must be completely full of material to allow for accurate and consistent delivery. For this reason, the study did not discuss less than 100% full auger.

ABOUT THE AUTHOR

Bryon Vlier is the product manager for feeders at Hapman. He holds a BS in industrial design and has more than 15 years of industry related experience.

For more information, contact Bryon at 269-382-8288, or by e-mail at bryon.vlier@hapman.com.

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