Allowable Vacuum for Wood Turning

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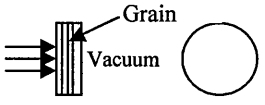
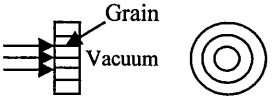
Woodturning crafters desire a device that allows a smooth finish on the bottom of the item. A vacuum chuck device allows the crafted item to be held without marring the finished surface, thus allowing a smooth finish to be applied. The different types of wood, the variations in grains, and the size of the vacuum chuck however, require careful control of the vacuum to prevent fracturing of the finished piece. This paper calculates the allowable vacuum on specific woods.

It should be noted that wood material can have great variation in grain, moisture content, and voids. Worm or insect holes may exist that could greatly weaken any wood material. The analysis and results provided here assume that the wood material is of uniform and average consistency, 3/16" uniform thickness, no voids and with 12% moisture content.

The calculated fracture stresses depend greatly on whether the pressure is applied across the grain or with the grain.



Across Grain



With Grain

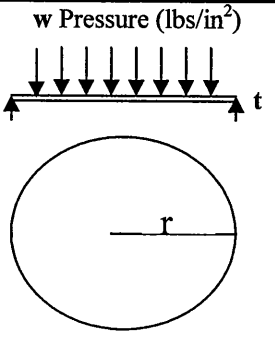
Wood is decidedly weaker under conditions where pressure is applied with the grain. Because most cases of wood turning use with-grain conditions, we will calculate the allowable stress using the with-grain condition. We will also use a factor of safety of two to compensate for 1) weak spots, 2) low moisture content, 3) wood material variations, and 4) poor vacuum gauge calibration. In most cases, a safety factor of two will be sufficient but if you feel the unknowns are great then use a higher number by multiplying the allowable vacuum (Table 2) value by the ratio of 2/higher FS to get a lower allowable, or, a smaller chuck will serve the same purpose.

The calculations assume circular flat plates of constant thickness **t** with a uniform loading pressure **w**. The basic formula for determining the allowable pressure on a round object is:

Edges supported with uniform load over entire surface.

$$S = k \times \frac{w \times r^2}{t^2 \times FS}$$

Source: Marks Standard Handbook for Mechanical Engineers, 8th edition pg 5-52



S = stress in psi
r = radius in inches
w = vacuum pressure in psi
t = plate thickness in inches = 3/16"
k = coefficient for circular plates = 1.24 for this case
FS = Factor of Safety