Bandmill Strain System Response

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The responsiveness of the strain system of a bandmill is a critical factor for bandsaw performance and maintenance. The strain system applies the force, usually through the top wheel, that pulls that blade tight and gives the blade its stiffness. This paper discusses some experimental measurements of the movement of the top wheel during operation, and the implications related to design and maintenance.

Strain System Functions

The strain system, or top wheel assembly, has three functions:

1. Provide enough movement of the top wheel to change blades.
2. Apply the strain force to the blade.
3. Allow the top wheel to move as the blade length changes, but effectively still maintaining the same strain.

Strain, guide position and blade thickness are the three main factors that affect blade stiffness. The tighter the blade is pulled, the stiffer it will become. Strain also affects the tracking stability of the band on the wheels. The feed force bends the blade back during cutting, causing the band to track backwards. The more the blade bends the faster it moves on the wheels, so increasing the strain, will reduce the bending and help keep the band centered on the wheels.

Model of the Top Wheel System

The usual model for the top wheel system is the mass of the wheel, *M*, including adjustments for the mass of the wheel arbour and other moving parts, attached to three springs. See Figure 1. The stiffness of the strain system, *K*, depends on the design of the mechanism. All strain systems have some “give” to them that represented by the spring stiffness. The spring could be steel coil spring, a rubber block, a gas accumulator in a hydraulic system, or an air bag. The lever-arm or “dead-weight” strain systems have a theoretical stiffness of zero. Generally, all strain systems are designed to have as small a stiffness as possible, for reasons to be discussed below.

The other stiffness, *k*, is that of the band itself. Although the band is very strong, it does stretch axially. Its stiffness can be calculated as:

$$k = \frac{AE}{L*}$$

where

A = cross section area of the band
E = Young's Modulus
$L*$ = free span length between wheels

As an example, the following are typical values for a 5 ft. hydraulic strain bandmill with 16 Ga x 10" saws.

M = 1200 lbs
K = 6000 lb/in.
k = 146,000 lb/in.

It is evident that the stiffness of the strain system is insignificant compared to the stiffness of the band. To express the relative stiffness, a term, *ç*, is defined as:

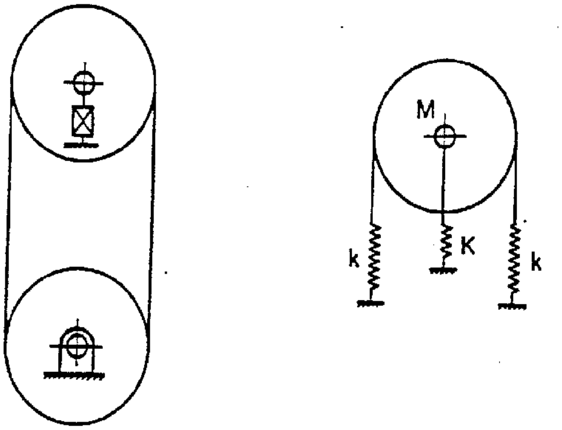

Figure 1. . Idealized Model of Bandmill.

$$h = \frac{2k}{2k + K}$$

For the above values, *ç*= 0.98, which could be interpreted to mean that 98% of the stiffness acting on the top wheel is from the band and 2% from the strain system. This ratio affects how much the top wheel moves during operation.

Top Wheel Behavior

When the blade is running, there are two effects that require the top wheel system to act. These effects are caused by the blade changing length, either due to temperature expansion or contraction, or from the centrifugal stresses put on the blade as it goes around the wheels.

1. Centrifugal Effects

Spinning the blade over the wheels puts an extra axial stress on the blade that caused it to become longer, which requires the top wheel to move up. The amount that it moves is given by:

$$d = \frac{r A v^2}{(k + K/2)} \qquad (2)$$

where

$ñ$ = density of steel = 490 lb/ft^3
A = blade cross-sectional area
v = blade speed

Typically, the blade speed is 10,000 ft/min., and for the 5 ft. bandmill, the top wheel will move up 0.012 in. If the blade does not move up, the effective strain on the bandsaw will decrease by

$$\Delta T = 2(1-h)rAv^2$$

Now the importance of the stiffness ratio, ç, becomes apparent. If ç= 1, then there is no change in the strain on the bandsaw when the blade is running at full speed. If, on the other hand, ç= 0, then the change in strain will be large (3,520 lbs for the 5 ft. bandmill running at 10,000 ft/min.). The physical meaning of ç= 1, is that the strain system stiffness, *K*, is zero. On the other hand, if the strain system is very stiff or absolutely rigid, then, ç= 0, which is undesirable.

This is the reason that strain systems are designed to have as low as stiffness as possible: to maintain the strain on the blade when it has reached full speed. This also gives one reason why a "dead" or rigid strain system is undesirable: the strain is smaller than expected.

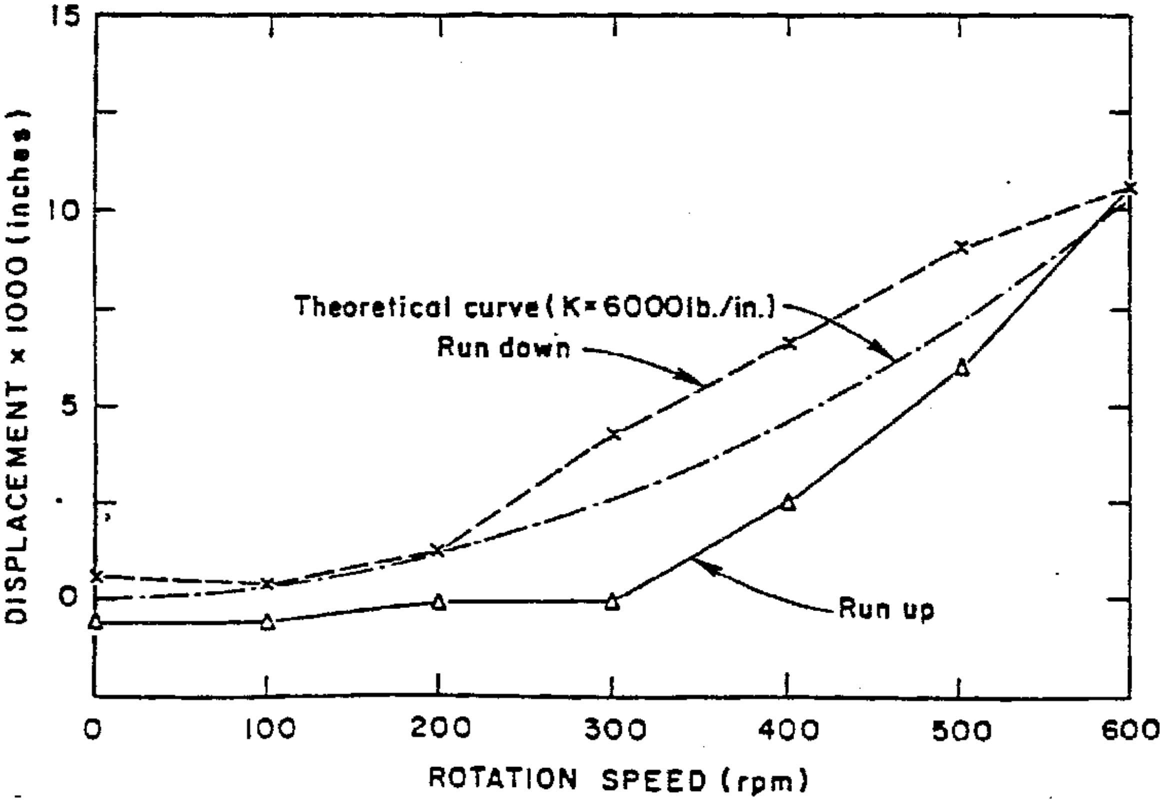

Figure 2. . Wheel Displacement Due to Centrifugal Effects.

Figure 2 is the measured movement of the top wheel during start-up and stopping of a 5 ft. hydraulic strain bandmill. There is some obvious friction occurring that causes the different paths for run-up and run-down. However, the movement is close to what is predicted.

Since the run-up test includes the effects of friction and the stiffness ratio, it can be used to evaluate a strain system. The movement of the top wheel can be easily measured by mounting a dial gauge under the top arbour. When the machine is new or known to be in good condition, the amount of lift can be measured and recorded. If, in the future, the lift is less, then the strain system has a problem. Also, using the above formulas, one can calculate the stiffness ratio.

2. Friction Effects

During the same test as shown in Figure 2, the actual force on the strain cylinder was measured by fitting the clevis with strain gauges. The results of these measurements are shown in Figure 3. The strain at start-up was 15,000 lbs. As the blade speed was changed, the force on the cylinder changed by about 200 lb. due to friction in the strain system and top wheel assembly. Note that the variation in the force is in the opposite direction as the motion of the wheel.

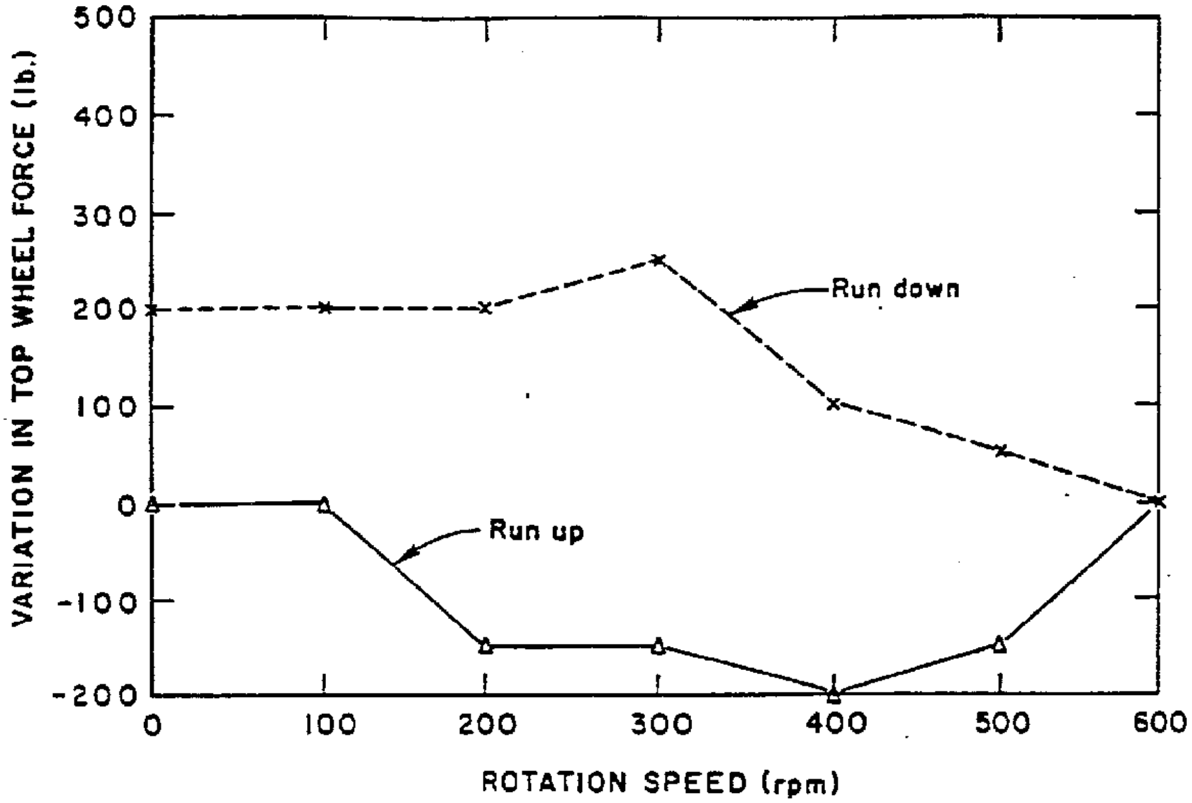

Figure 3. . Variation in Top Wheel Force due to Centrifugal Effects.

3. Temperature Effects

The other factor that causes the blade to change length is the temperature of the blade. As the blade warms up it will get longer. If the top wheel does not move up, then the strain on the blade will reduce by an amount,

$$\Delta T = (1 - h) a tLk \qquad (5)$$

and the movement of the top wheel due to a uniform temperature change, *t*, would be

$$d_t = h a tL/2 \qquad (6)$$

where

á is the coefficient of thermal expansion of the blade = 6.5 (10^{-6})/ °F
L = total blade length

For the 5 ft. bandmill example, the top wheel will move up 0.012 in. for every 10 °F increase in temperature. Also, if the strain system were "dead" with ç=1, the actual strain on the blade would decrease by 3,650 lbs.

To observe the top wheel motion, a 6 ft. air strain bandmill was instrumented so the motion could be measured and recorded. The bandmill was cutting 20 in. to 30 in. deep cants, 24 ft. long. The average cutting time was about 8 sec.

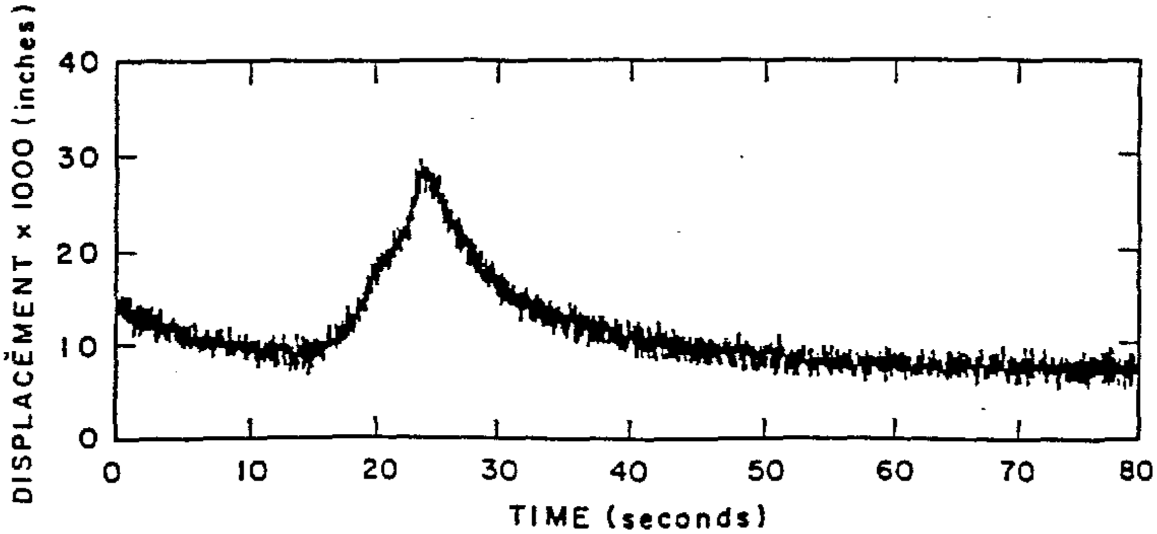

Figure 4. . Top Wheel Motion During Cutting a Single cut.

Figure 4 shows the top wheel movement for a single cut, and Figure 5 for series of closely spaced cuts. These curves are consistent with the cant cutting time and the exponential rate of heat loss after the cut is complete. Note that for the multiple cut sample, the blade did not always cool completely before the next cut started, and as a result, the wheel moves higher than for a single cut. If the strain system were to freeze in this extended position, and the blade temperature to return to normal, then the blade would be under significantly higher stress, which could result in gullet cracking.

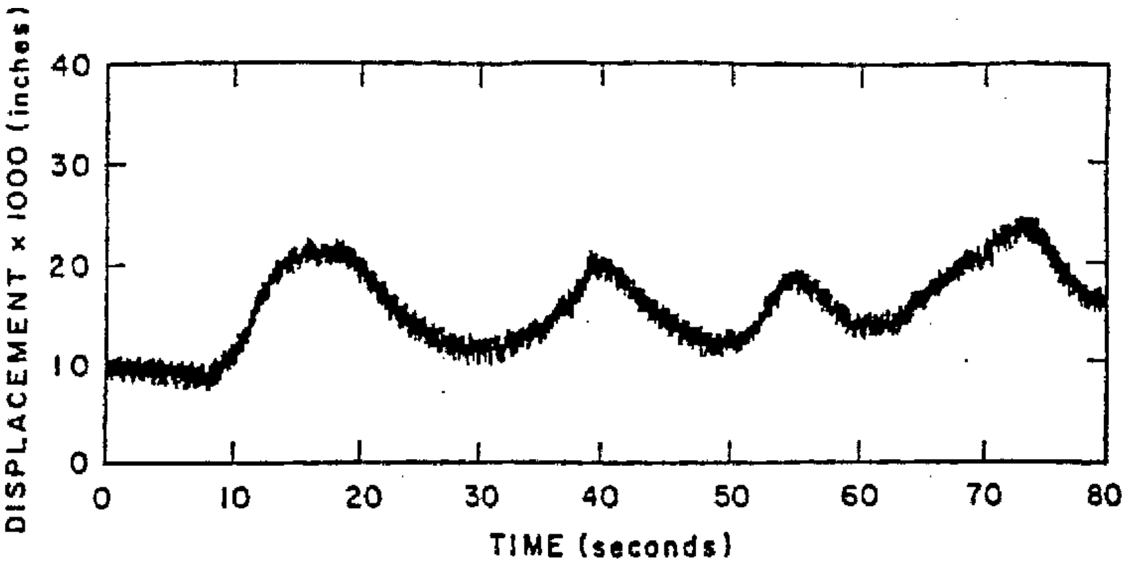

Figure 5. . Top Wheel Motion During Multiple Cuts.

Discussion

The results and analysis presented shows the importance of having a strain system with low stiffness and low friction. If the top wheel sticks in the lower position, the strain will be less than expected, resulting in less blade stiffness and more sawing deviation. If the top wheel moves up freely in response to the blade getting longer, but then sticks in the extended position, then the blade will be under much more stress than expected, resulting in gullet cracks.

References

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