A Study on the Power Requirements for No Load Running of Bandsaw Machine

——Comparison of Spoke Type with Steel Plate Type——

Hikoichi SUGIHARA

(Division of Physics, section III)

Introductory Remarks

The power requirements for bandsaw machine is to be analysed into three components: 1. for sawing itself, 2. for no load running, 3. for feeding. This paper discusses the first two components only, with emphasis on 2. no load running.

Generally speaking, the power needed for no load running has been considered to be insignificant in comparison with the power needed for sawing itself.

But actually it is not only the amount of power itself to be considered, but we have to introduce the factor of time in addition to power.

When the time for no load running is very much longer than that for sawing, even though the power requirement itself is small, the amount becomes a subject of discussion.

Bandsaw machines differ as to type of upper wheel, the spoke type and steel plate type. Previously the spoke type was much more prevalent, but since the war there is a trend to shift to the steel plate type. One of reasons explaining this shift is that the steel plate type requires less power than the spoke type.

The aim of the author is to investigate the work done for no load running and for sawing itself and to take up the results of comparative experiments about the power required by respective types, and to treat this problem.

Power for No Load Running W_0 and for Sawing itself W_1

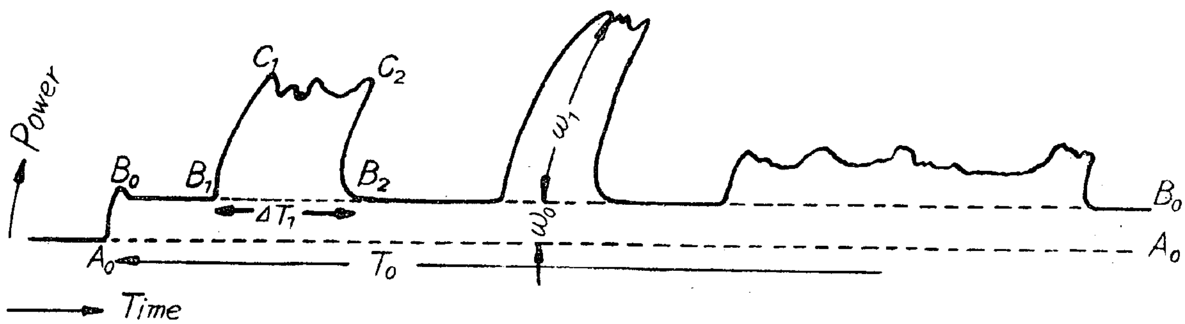
As previously mentioned, it is generally acknowledged that W_0 power for no load running is smaller than W_1 power for sawing itself. Putting it in concrete terms, some examples of ratio W_1/W_0 are as follows, calculated from the results of investigation by Ohsawa, Ishida and Miyajima.

2.02, 1.36, 2.66, 2.26, 3.85, 2.87

Except the well-grounded special cases——1.36 and 3.85, the ratio is 2~3 in normal conditions. But at high speed revolution it becomes one or less even in normal conditions.

On the other hand, according to the results of investigation by Hirai, Suzuki, and Shimizu or by the Laboratory of Sawing in the Government Forest Experiment Station, ratio T_1/T_0 ($T_1 = \Sigma \Delta T_1$ Total of time for sawing itself ΔT_1, T_0 Total of time for operating machine) is 1/3~1/4.

Fig. 1 Power- Time Diaram by Indicating Wattmeter



From these results ratio N_1/N_0 is assumed to be 1~1/2, $N_1 = \Sigma\, B_1 C_1 C_2 B_2 = \Sigma \{\Delta T_1 \times (W_1)_{\text{mean}}\}$ work done for sawing itself, $N_0 = T_0 \times W_0$ work done for no load running. Namely in sawmill operation, work done for no load running is twice as much as that for sawing itself.

Therefore, the reduction of the power needed for no load running of the bandsaw machine is as much important as the increase of sawing efficiency.

Comparative Experiments about the Power Requirements for No Load Running with Steel Plate Type and Spoke Type

In Table 1 are shown the results of comparative experiments of both types by KIKUKAWA IRON WORKS with a 43″ bandsaw machine.

Table 1. Results of Experiment by KIKUKAWA IRON WORKS

n r.p.m.		820	850	1010	1020	1100	1180	1220	1420
i amps.	Steel plate type		12		14.5	17.5		21	22.5
Line Current	Spoke type	15		25			29.5		

The machine used :

diametre of wheel 43'' (1100 mm)

weight of lower wheel 339 kg.

" upper " { spoke type 142 kg.
steel plate type 143 kg.

saw blade : width 5'' , thickness 21 B. W. G. ,
length 22' - 6'' , pitch 1 $^1/_4$'' ,
pulling force 2500 lbs.

The machine was driven by a 3- phase induction motor, and the values in Table 1 show the ones of line current indicated by an ammeter at the input side.

The motor used :

3-phase induction motor, squirrel-cage type, manufactured by HITACHI, output 11.2 kw (15 H. P.) , pole 4, voltage 200/220, cycle 50/60, full load current 42/38

Results of Rock Test

60 cycle, 44 volt, 40 amps. 1195 watts

Full Load Test

efficiency 90.5%, power factor 88.5%, slip 2.7%, starting current 182 amps.

The speed of revolution was changed by exchanging driving or driven pulley.

The machine was not covered.

For the comparison only the upper wheel was exchanged and the other conditions remained unchanged.

Then, output of 3-phase motor P_2 is given by equation (1).

$$P_2 = \sqrt{3} \cdot \eta \cdot \cos\varphi \cdot V \cdot \mathbf{i} \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

η : efficiency $\cos\varphi$: power factor

V : line voltage **i** : line current

In this experiment V was constant 220 volts.

The values of **i** were obtained as in Table 1.

To know the output of the motor P_2, consequently the work done by machine W, it must be given η and cos φ. But they change with **i**, so the relation between P_2 and **i** of this motor has been obtained by circle diagram made of the above described characteristic test. It is shown by Fig. 2.

From the curve of Fig. 2. is given as in Table 2 the power P_2 or W consumed as the R. P. M.'s vary.

In Fig. 3. is graphically represented the result, W in H. P.

Fig. 2

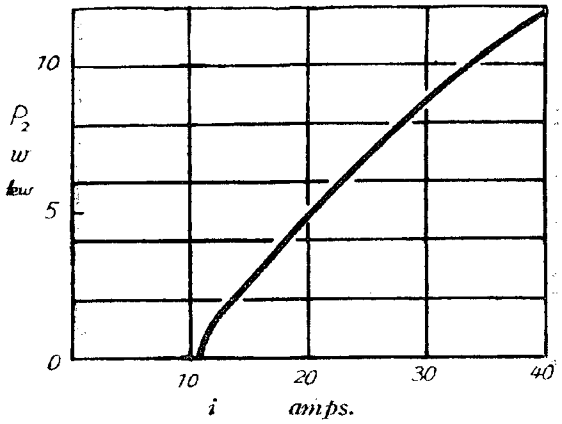
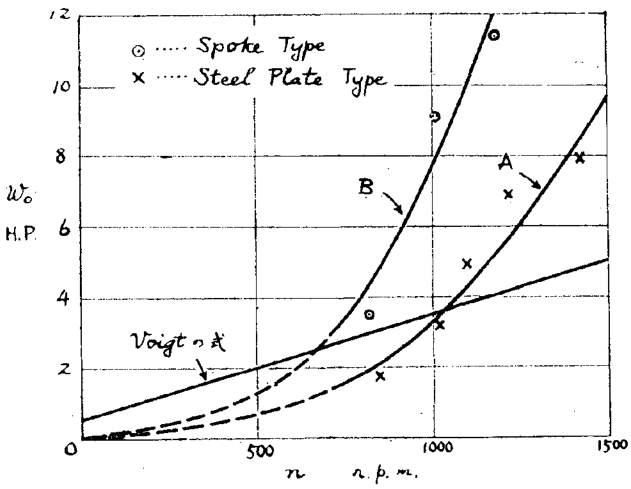


Table 2. Powers at each R. P. M.

	n r. p. m.	i amps.	p_2 or W kw
Steel Plate Type	850	12	1.3
	1020	14.5	2.4
	1100	17.5	3.7
	1220	21	5.2
	1420	22.5	5.9
Spoke Type	820	15	2.6
	1010	25	6.8
	1180	29.5	8.5

Fig. 3



It is obvious from Fig. 3. or Table 2 that the steel plate type needs less power than the spoke type, and the greater **n**, the greater the difference.

Considerations about Power for No Load Running

Power P_2 of motor output is subsequently consumed as follows for no load running of bandsaw machine:

1. W_{01} transmission loss of belt and from lower wheel to upper wheel.
2. W_{02} friction loss on bearings by pulling force and weight of wheels.
3. W_{03} drag loss of rotating parts in air.

1) W_{01} is so small as 1∼2% that we neglect it.

2) W_{02} is expressed by equation (2)

$$W_{02}=\mu\cdot P\cdot \mathbf{r}\cdot\omega \quad\cdots\cdots (2)$$

ω : angular velocity of wheel $\omega=\pi\mathbf{n}/30$ 1/s

P : load on bearing, **kg**

μ : friction coefficient of rotation

r : radius of inner surface of bearing

pulling force : 2500 lbs. i.e. 1125 kg.

weight of upper wheel : 142 kg and 143 kg

〃 lower 〃 : 339 kg

∴ bearing load of upper wheel : 1125+142=1267

〃 lower 〃 : 1125−339=786

As the bearings in this machine are single row ball bearing No. 6313 and double row self-aligning radial roller bearing No. 22312, the radius of inner surface **r** are 30 mm and 32.5 mm. Friction coefficient μ is presumed to be 0.002∼0.004 in ball bearing and 0.004∼0.008 in radial roller bearing.

Thus a rough estimation of W_{02} is as follows.

$$\begin{aligned} W_{02} &= \frac{0.003+0.006}{2}\cdot(1267+786)\cdot\frac{0.03+0.0325}{2}\cdot\frac{\pi}{30}\mathbf{n} \\ &= 0.032\ \mathbf{n} \quad \text{kg.-m/s} \\ &= 0.43\times10^{-3}\ \mathbf{n} \quad \text{H. P.} \cdots\cdots (3) \end{aligned}$$

By the equation (3) W_{02} is only about 1/2 H. P. at $\mathbf{n}=1000$ (r. p. m.).

From these considerations we come to the conclusion that the power W_0 for no load running is consumed almost for drag of rotating parts.

3) Although W_{03} could be theoretically calculated from frictional resistance of rotating disk, drag of cylinders in an infinite row and so on, the state of air flow in this case is so much complicated that the theoretical calculation is unable to de done actually.

Therefore according to the theory that frictional resistance of rotating disk or flat plate is proportional to $v^{1.8}$ (v: relative velocity of air and surface of the objects) and drag of cylinder in flow to v^2, we determine the coefficients of equation (4) and (5), getting together the equation (3), so that it is in most reasonable conformity with the values of experiments. Then we obtain them as follows.

W_0 in H. P.

for steel plate type $\quad A = 0.43\times10^{-3}\mathbf{n} + 12\times10^{-9}\,\mathbf{n}^{2.8}$ ··························(4)

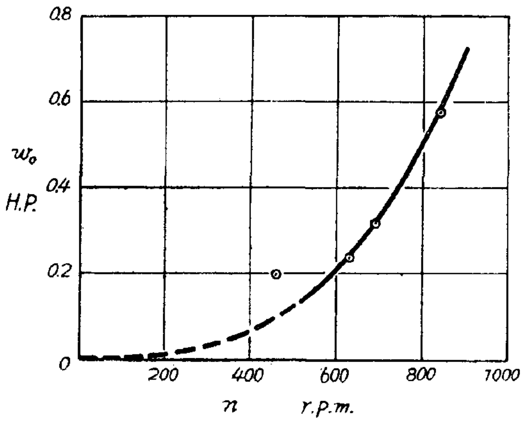
for spoke type $\quad B = 0.43\times10^{-3}\,\mathbf{n} + 12\times10^{-9}\,\mathbf{n}^{2.8} + 4.4\times10^{-9}\,\mathbf{n}^3$ ······(5)

In this connection, Reynolds number in the experiment is $10^4 \sim 10^5$. The power theoretically calculated is $0.147\times10^{-9}\,\mathbf{n}^{2.8}$ (H. P.), assuming the upper wheel as rotating disk and $2.22\times10^{-9}\,\mathbf{n}^3$ as cylinders in flow.

In Fig. 3 the curves A and B are representing the equation (4) and (5), and the straight line is the equation by *Voigt*, the empirical formula for no load running of bandsaw machine. This straight line nearly coincides with the curve B in the neighbourhood of $\mathbf{n}=700$, the ordinarly velocity (7900 ft/min.) at that time (1925) for bandsaw machine.

Moreover Fig. 4 shows the results of the author's experiment about small type

Fig. 4



bandsaw for woodworking (30″, 2 H. P., spoke type). The curve in Fig. 4 is the equation (6).

$B' = 1\times10^{-9}\,\mathbf{n}^3$ ···(6)

Summary

Concluding this paper, the author summarizes the contents as follows :

1. The power requirement for no load running in bandsaw machine is less than the one for sawing itself, but considering the time for sawing and comparing the work done, the requirement for no load running is larger than that for sawing itself.

2. Comparing the power for no load running of steel plate type machine with the one of spoke type machine, the former obviously requires less power than the latter.

3. And the power increases in proportion to $\mathbf{n}^{2.8}$ or $\mathbf{n}^3$ ($\mathbf{n}$: number of revolution), so the difference becomes very much larger at high speed operation.

4. Therefore the steel plate type of bandsaw is much more efficient and suitable, especially at high speed operation, as regards the work done in operating the machine with the smaller power requirement in no load running.

The author wishes to acknowledge the courtesy of KIKUKAWA IRON WORKS which helpfully offered the materials for this study.

This paper was read at the 63rd Meeting of the Japanese Forestry Society, April 6. 1954.

Litcrature Cited:

1) M. Ohsawa, S. Ishida and H. Miyajima : Studis on the electric power consumption in the lumber manufacturing operation, Trans. of 62nd Meeting of Jap. Forestry Soc. p. 207, (Apr. 1953) (in Japanese with English résumé).

2) S. Hirai, Y. Suzuki and T. Shimizu : An analytical investgation of the sawing work, Jour. Jap. Forestry Soc. **32** No. 3 71 (1950) (〃)

3) The Laboratory of Sawing : One example of the operation study at the saw mill, Bull. Government Forest Experiment Station, No. 68 (Feb. 1950) (〃).

4) Voigt : Holzmarkt **42** Nr. 18 189 (1925).

訂　正

〃木材研究〃 第10号

帯鋸刃による挽材に関する研究

第1報　送り力及び歯振量の挽材に及ぼす影響

付録　三相交流図示電力計による仕事量の測定法

頁	式	誤	正
19	1	P = 1.07w	P = 1.07w − 0.12
〃		なる関係があるなる関係があることになる。	なる関係があることになる。
〃	4	K = 0.981w − 0.023w²	K = 0.981w − 0.02w² − 0.11
21	10	K = 1.00w′ − 0.024w²′	K = 1.00w′ − 0.024w′² − 0.11
13	4行目	C = D	C = αD