On Some Analyisses of Grinding Phenomena by the Gauge Method in Belt Grinding

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by

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Abstract

Using the strain gauge pasted on the inside of the belt in belt grinding (named the strain-gauge method), a information describing grinding phenomena was obtained.

This present paper was dealed with following problems by analzing the information.

1) The tangential force, which is introduced by the means of strain gauge, was compared with the experimental value. In those result, comparing with the theoretical calculated values, there are some tendencies to the both results. and it is evident that the closer the point on curve to the tension side of abrasive belt is, the larger the tension force becomes.
2) The elongation of the aborsive belt in operation was investigated. And the result was usual one.
3) A difference in speeds and relative slips between the contact wheel and the abrasive belt in operation were calculated. And in those results, the higher the surface speed of contact wheel is, the more the difference between the surface speed of the contact wheel and the abrasive belt becomes, but the relative slip is reversed in that relation. Also, on the same surface speed of the contact wheel, those two factors (difference of speeds and relative slip) are decreases with increasing the hardness of contact wheel.

Introduction

Recently, the belt grinding has been widely recognized because of high quality performance. And although the general nature of belt grinding is well known, the details are still a subject for considerable speculation and require further study. For instance, if the tangential force acting upon a contacting area between the contact wheel and the abrasive belt and the the deformed from being affected by the centrifugal force are developed,[1] further investigation would be made such as over cut.[1,2]

However, no investigation about the tangential force and the deformed form had been obtained until we tried this method.[1]

Therefore, in this paper, using this method (named the strain gauge method), the following some experiments are investigated.

1) An analysis of the tangential force and the normal stress acting upon the contacting area between the contact wheel and the abrasive belt.
2) The elongation of the abrasive belt in operation.
3) A difference of speeds and relative slips between the contact wheel and the abrasive belt in operation.

Experimental apparatus and procedure

Figure 1 (a) and (b) show the experimental appartus. The strain gauge, pasted on the

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inside center of the belt, was connected two lead wires (about 0.5 mm dia.) as shown in figure 1 (a). Also two lead wires contacted with two cu rings set into the idle pully are introduced from the strainmeter to oscillograph through two Cu plates (named the strain gauge method). The experimental conditions are shown in Table 1 and Table 2.

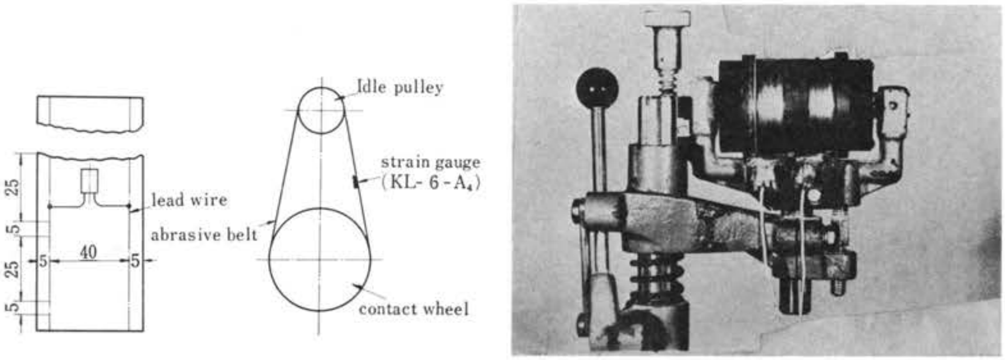


Figure 1 (a) and (b) Experimental apparatus

Table 1 Experimental conditions

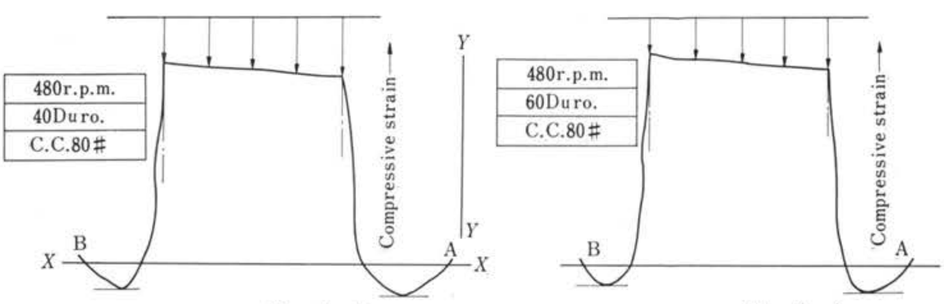
Abrasive bels	Size	1525×50×0.6 mm
	Abrasive grain	C.C. 80#
	bond	Resinoide
Work piece	Material	Epoxy Resin
	Size	100×30×10 mm
Experimental conditions	Work speed (m/min)	271.4, 452.4, 622
	R.P.M. of contact wheel	480, 800, 1100
	Inital tension (kg)	16

Table 2 Experimental condition of contact wheel.

Size of contact wheel	ϕ180×50 mm
Hardness (Duro.)	*Hs*: 40, 60
Thickness of rubber	15 mm
Peripheral surface	plain-faced

Theoretical consideration

Figure 2 (a), (b) and (c) show the examples of the figure from the oscillograph. In those figure, X axis is shown the passing times of the revoluting belt and Y axis is shown the strain indicated with upwords in case of accepting the compressive strain, that is, the compressive force and downwords in case of receiving the tension force on the strain gauge, respectively. A and B points show the start and end points of increased tension force which arise from contacting the abrasive belt with the contact wheel. Moreover, it is obvious that the higher the speed



(a)

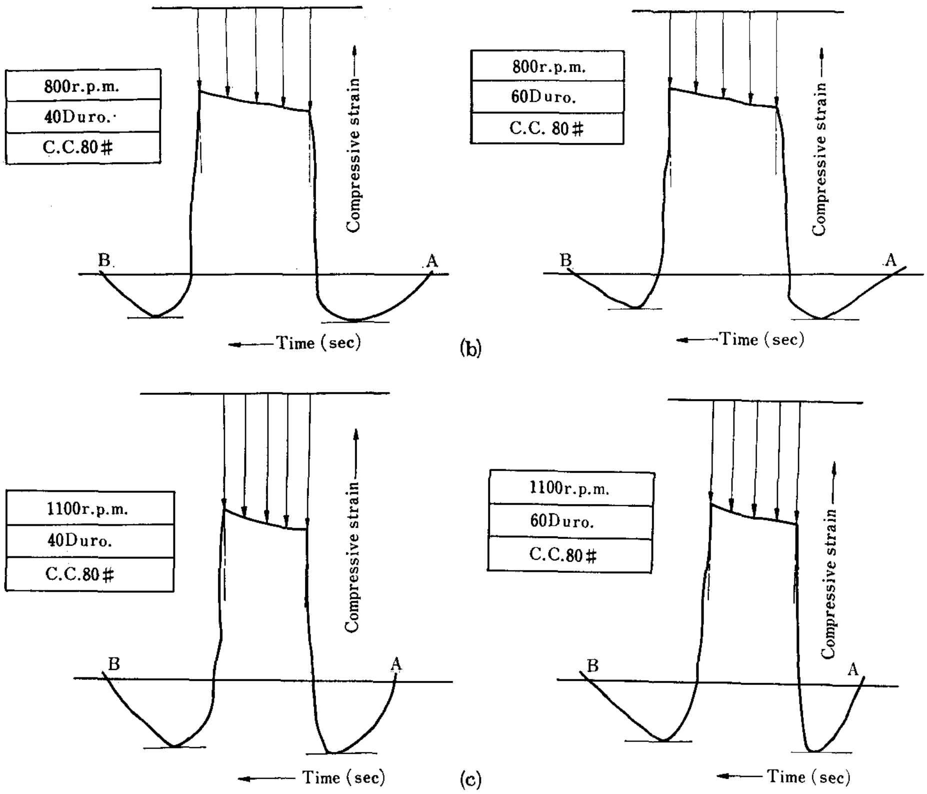


Figure 2 (a), (b) and (c) Figures obtained from Oscillsgraph

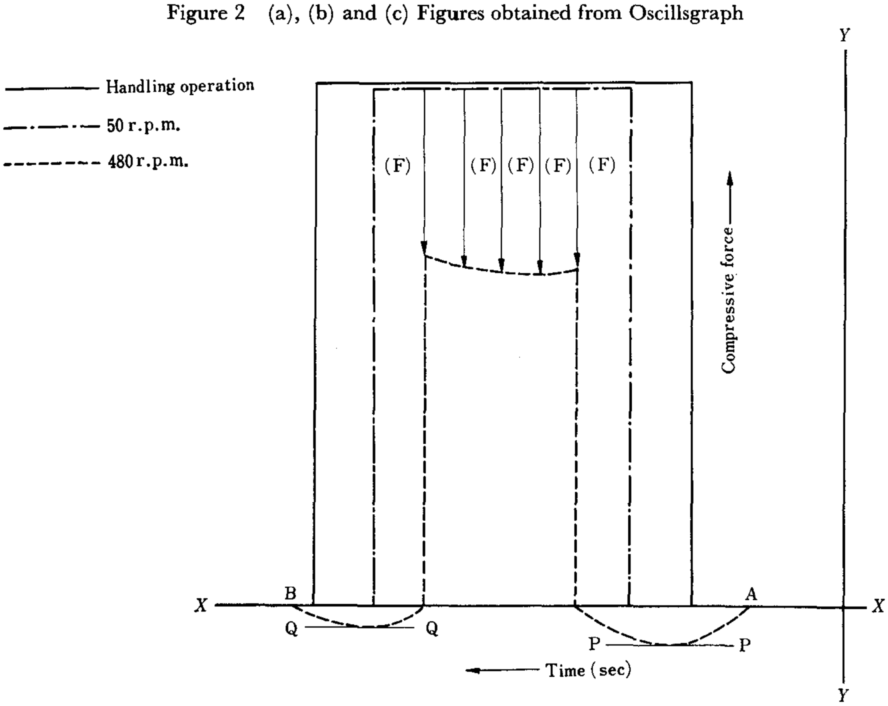


Figure 3 Schematic view relating to the compressive force against passing times.

of contact wheel, the larger the tension force becomes.

Figure 3 show the schematic view relating to the compressive force against passing times (s) as shown in figure 2.

Considering that the top parts of recutangular are nearly same hights and no increased tension generally in case of both 50 R. P. M. and handling operation as shown in this figure, in case of 50 R. P. M, the tangential force (F) acting upon the strain gauge pasted on the belt in operation is used as the fundamental value for the following experiments.

Experimental results and discussion

1) An analysis of the tangential force and the normal stress acting upon the contacting area between the contact wheel and the abrasive belt. When the contact wheel is revolving with the surface speed of V m/min, the force operated on the abrasive belt is expressed by the following equation.

$$\mathrm{Fe} = e^{u\theta}\left\{F_2 - \frac{V^2}{g}(W_b - W_R) + \frac{V^2}{g}(W_b - W_R)\right\} \qquad \cdots\cdots\cdots\cdots\cdots (1)$$

Where,

u: Frictional coefficent between the contact wheel and the abrasive belt.

θ: Arbitary winding angles (radian) measured from the base line which connects the beginning point of contact on the loose side of abrasive belt with the center of the contact wheel.

F_2: Tension force on the loose side of abrasive belt.

V: Surface speed of the contact wheel.

W_b, W_R: Weight per unit length of the abrasive belt and the contact wheel (1.17 g/cm, 1.05 g/cm, respectively).

Using the contact points and the tension forces acted upon those points as shown in figure 2 (a), (b) and (c), μ may be found. These values and F_2 are shown in table 3.

Table 3 Increased tension force (ΔT_0), F_2 and Frictional Cofficent against various contact wheels.

No.	R.P.M.	Hardness	Increased tension force (ΔT_0)	F_2 (kg)	μ
1	480	40	0.164 kg × 9 = 1.48 kg	17.5	0.14
2		60	〃 × 7 = 1.15	17.2	0.13
3	800	40	〃 × 14 = 2.30	18.3	0.095
4		60	〃 × 12 = 1.97	18.0	0.118
5	1100	40	〃 × 20 = 3.30	19.3	0.06
6		60	〃 × 18 = 2.95	19.0	0.075

Table 4 shows the tangential force (F_c) and the normal stress (θ) at each position in the winding angles.

Table 4 Tangential force and normal stress at each positions in the winding angles

No.	θ (rad.)	Tangential force (Fe) (kg)	normal stress (Q) (kg/cm²)	No.	θ (rad.)	F_c	Q
	0	17.50	0.385		0	17.20	0.378
	0.81	20.82	0.446		0.81	19.09	0.420
(1)	1.62	21.87	0.481	(2)	1.62	21.25	0.465
	2.43	24.67	0.542		2.43	23.56	0.518
	3.23	27.46	0.604		3.23	26.13	0.574

No.	θ (rad.)	F_c	Q	No.	θ (rad.)	F_c	Q
	0	18.30	0.402		0	18.00	0.396
	0.81	19.76	0.434		0.81	19.79	0.435
(3)	1.62	21.40	0.470	(4)	1.62	21.77	0.478
	2.43	23.04	0.520		2.43	23.92	0.526
	3.23	24.86	0.546		3.23	26.25	0.577

No.	θ (rad.)	F_c	Q	No.	θ (rad.)	F_c	Q
	0	19.30	0.424		0	19.00	0.418
	0.81	20.25	0.445		0.81	20.13	0.445
(5)	1.62	21.22	0.466	(6)	1.62	21.45	0.471
	2.43	22.37	0.492		2.43	22.78	0.500
	3.23	23.33	0.513		3.23	24.10	0.530

However the tension force (F_c), as above mentioned, is the value considered the centrifugal force arising from the rotation of the contact wheel, so that the tension force (F) shown in figure 2 is value substracted the tension force (F_0) in case of being not caused by the centrifugal force from F_c. Also, F_0 is expressed as following equation by reference to equation (1).

$$F_0 = e^{u\theta} \cdot F_2 \qquad \cdots\cdots\cdots\cdots\cdots (2)$$

F_0 is shown in table 5.

Table 5 Tension force (F_0) in case of being not caused by the centifugal force

No.	Inctial tension force (kg)	θ (rad.)				
		0	0.18	1.62	2.43	3.23
1	16	16 (kg)	19.04	20.00	22.56	25.12
2	"	"	17.76	19.68	21.92	24.32
3	"	"	17.28	18.72	20.16	21.76
4	"	"	17.60	19.36	21.28	23.36
5	"	"	16.80	17.60	18.56	19.36
6	"	"	16.96	18.08	19.20	20.32

Figure 4 (a) and (b) show the experimentally measured and theoretically caluculated values obtained from the equation (1) and (2), respectively.

In those figures, comparing with the theoretically calculated values, the experimentally measured values are about two times larger in any speeds. However there are same tendencies to the both curves. And it is obvious that the closer the point on curve to the tension side of abrasive belt is, the larger the tension force becomes.

2) The elongation of the abrasive belt in operation.

The abrasive belt, pulled at 16kg of initial tension in static condition, was elongated owing to the increased tension in caused of the centrifugal force in operation. Therfore, using the value of young's modulus (E) obtained from the figure (2), elongation (Δl) of abrasive belt will be decided from the following equation (4).

$$\varepsilon = \frac{\Delta l}{l_0} = \frac{T_0}{A \cdot E} \qquad \cdots\cdots\cdots\cdots\cdots (3)$$

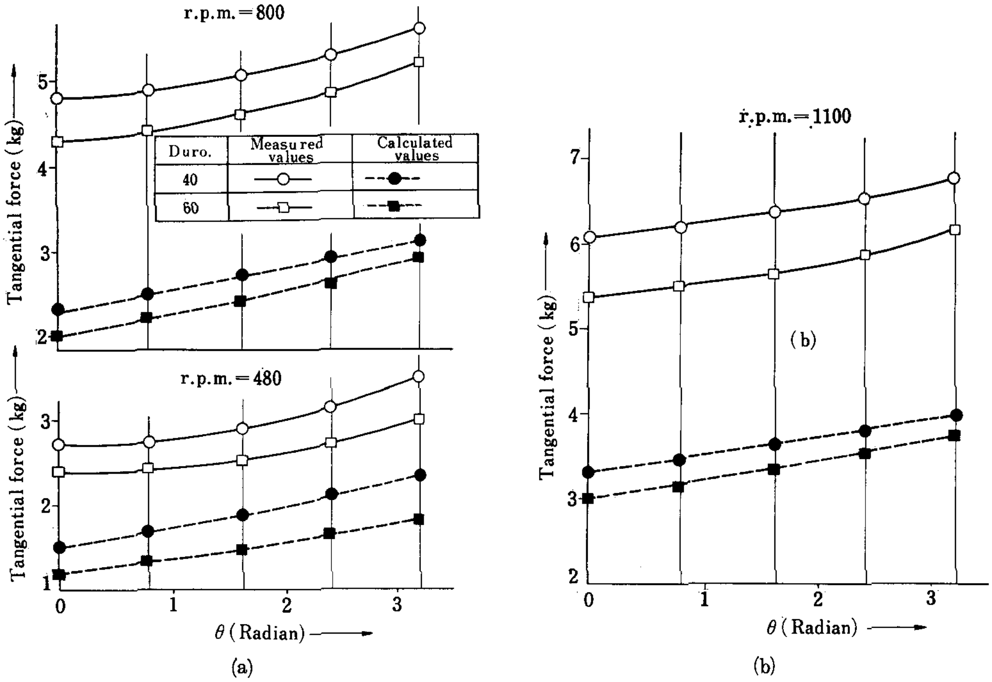


Figure 4 (a), (b) Tangential force of measured and calculated force against radian of winding angles.

$$\Delta l = l_s - l_0 = \frac{\Delta T_0 \times l_0}{A \cdot E} \qquad \cdots\cdots\cdots\cdots (4)$$

Where,

ε: Strain rate (2440×10^{-6} in case of 32kg).
Δl: Elongation of the abrasive belt in operation.
l_0: Length of the abrasive belt pulled at 16kg of initial tension (1527mm).
T_0: Tension force (32kg)
A: Sectional area of the abrasive belt (50mm^2)
E: Young's modulus of the abrasive belt obtained from equation (3).
l_s: Length of the abrasive belt in operation.
ΔT_0: Increased tension force (refer to table 3).

Table 6 shows the elongation of the abrasive belt in operation.

It is obvious that the elongation decreases as the surface speed and hardness of contact wheel are higher as shown in table 6.

Table 6 Elongation of abrasive belt in operation

No.	Elongation (mm)
1	0.22
2	0.18
3	0.31
4	0.27
5	0.43
6	0.39

3) A difference in speeds and relative slips between the contact wheel and the abrasive belt in operation.

According to the following equation,[3] the difference of the speeds of the abrasive belt between the entrance and the exit to the contact wheel is obtained.

$$v = \frac{F_1 - F_2}{A \cdot E + F_1} v_1 \qquad \cdots\cdots\cdots\cdots (5)$$

Where,

v: Difference of the speeds of the abrasive belt between the entrance and the exit to the contact wheel.

v_1: The speed on the neutral axis of the abrasive belt (in our investigation, the surface speed of contact wheel is used owing to thin belt).

E: Young's modulus (refer to equation 3)

A: Sectional area of the abrasive belt

F_1: Tension force occured to the tension side of the abrasive belt (refer to table 7).

F_2: Tension force occured to the loose side of the abrasive belt (refer to table 7)

Table 7 Tension force Occured to the tension and loose sides of abrasive belt, respectively.

No.	R.P.M.	Hardness	F_2 (kg)	F_1 (kg)	F_1-F_2 (kg)
1	480	40	17.5	0.164 kg×11.4+16 kg=17.87 kg	0.37
2		60	17.2	〃 × 9.5+ 〃 =17.55	0.35
3	800	40	18.3	〃 ×16 + 〃 =18.62	0.32
4		60	18.0	〃 ×14 + 〃 =18.30	0.30
5	1100	40	19.3	〃 ×22 + 〃 =19.61	0.31
6		60	19.0	〃 ×20 + 〃 =19.28	0.28

Also, according to the following equation, relative slips during contacting with the contact wheel and abrasive belt is obtained (in the present investigation, relative seips of idle pulley is neglected for the reason that diameter of its is small and the frictional coefficent is also little).

$$L-\left(\frac{L}{V}\times v\right)=L\times\frac{V-v}{V} \qquad \cdots\cdots\cdots\cdots\cdots (6)$$

Where,

L: Length of the winding arc of the abrasive belt.

V: Speed of the abrasive belt is not sliding $\left(\frac{\pi\cdot D\cdot N}{60}\right)$

$V-v$: Difference with the speeds of the abrasive belt.

v: Speed of the abrasive belt which is sliding.

D: Diameter of the contact wheel.

N: R. P. M

The difference between speeds of the abrasive belt and the relative slips are shown in table 8.

Table 8 Difference between speeds and relative slip of abrasive belt.

No.	Difference of Speeds (cm/sec)	Relative slip (cm)
1	1.15	0.074
2	1.09	0.070
3	1.65	0.064
4	1.54	0.060
5	2.18	0.060
6	1.92	0.054

In this table, it is obvious that the higher the surface speed of the contact wheel is, the more the difference between the surface speed of the contact wheel and the abrasive belt becomes, but the relative slips is reverse in that relation. Also, for the same surface speed of the contact wheel, those two factors (difference of speeds and relative slips) are decreases with increasing the hardness of contact wheel as above mentioned.

To recognizing the above arguments, the time contacting between the contact wheel and the abrasive belt is investigated by using the following equation.

$$\frac{185.5}{360}\pi D\left(\frac{\frac{\pi DN}{60}-\frac{185.5\pi D}{360\,t}}{\frac{\pi DN}{60}}\right)=\frac{185.5}{360}\pi D\left(1-\frac{185.5}{6}\times\frac{1}{tN}\right) \quad \cdots\cdots\cdots\cdots\cdots (7)$$

Where,

t : Times contacting the contact wheel with the abrasive belt assuming that the relative slips are 0.072, 0,062 and 0.06mm when those speeds of the contact wheel are 480, 800 and 1100 R.P.M (refer to table 8), respectively.

The calculated values theoretically are determined as shown in table 9.

Table 9 Contacting times between the contact wheel and the abrasive belt.

R.P.M.	calculated values (sec)	measured values (sec)
480	0.065	0.064
800	0.039	0.036
1100	0.028	0.026

Also, the contacting times measured with figure 2 (a), (b) and (c) are shown in table 9 (in our investigation, the feed of paper is used to 100 cm/sec).

Regarding to the two little difference between theoretically calculated and experimentally measured values, it will be recognized that this research carried out was exactly.

Conclusions

From above mentioned, the following are conclued.

1) Using the gauge method, the tangential force and normal stress on the some points contacting the contact wheel with the abrasive belt are researched.

2) And, comparing the theoretically calculated values with the experimentally measured values are about two times larger in any points. However, there are same tendencies to the both results.

3) The elongation decreases as the surface speed and hardness of contact wheel are higher.

4) For the difference between the speeds of the contact wheel and the abrasive belt in operation, the higher the surface speed of the contact wheel is, the more the difference between the surface speed of the contact wheel and the abrasive belt becomes, but the relative slips is reverse in that relation. Also, for the same surface speed of the contact wheel, those two factors (difference of speeds and relative slip) are decreases with increasing the hardness of contact wheel.

Abknowlegment

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