Apparatus for the Determination of the Burning Velocity of Cigarette Paper*

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1. INTRODUCTION

The static burning rate of a cigarette is influenced by, among other things, the burning velocity of the paper used in the manufacture of the cigarette (1). It is therefore important to have available an apparatus to determine the burning velocity of cigarette paper.

As no apparatus can be bought and nearly all manufacturers have their own method of determining the burning velocity, the results are not always comparable. Consequently, a simple apparatus was constructed to arrive at a method by which the burning velocity of cigarette paper can be determined in an arbitrary comparative way.

Paper is burned in this apparatus under standardised conditions. In the case of bobbin paper, the time needed for burning a standard length of 250 mm, the burning time, is measured in seconds. The burning velocity of the paper — in mm/s — is then calculated by dividing 250 by the measured time. In the case of the burning velocity of leaflet papers for roll-your-own cigarettes, the burning time of a length of 50 mm is measured.

2. CONSTRUCTION OF THE APPARATUS

The apparatus consists of a base [a] and a glass chimney [b] (see Fig. 1). The base contains a built-in transformer to heat a nichrome wire [c] for the ignition of the paper. This wire has a diameter of 0.4 mm and a resistance of 0.6 Ω . It is mounted on the top of the base and spring loaded [d] to keep it stretched when heated. Just below the nichrome wire a clamp system is situated to fix the lower end of the cigarette paper strip. The clamp [e] is carefully adjusted in position so that the cigarette paper strip is touched over its full width by the nichrome wire. By pressing the button [f] on the

Figure 1. Apparatus for the determination of the burning velocity of cigarette paper.

a: base	d: spring	g: steel plate
b: glass chimney	e: clamp system	h: magnet
c: nichrome wire	f: button	i: cigarette paper strip

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base, the nichrome wire is heated by the electric current. The chimney consists of a glass cylinder — 50 mm inner diameter and 305 mm long. This makes possible the mounting of paper strips up to 38 mm wide. The cylinder is placed on top of the base and centered by a rivet. In the lower end of the glass cylinder there are four cut-outs to allow the air to flow into the cylinder. The nichrome wire passes through two of these openings while, through a third opening, the lever of the paper clamp is brought outside the cylinder. The upper end of the cylinder has two diametrically placed grooves to position the top mount of the cigarette paper strip. This mount consists of a steel plate [g] and a small magnetic bar [h], allowing the cigarette paper strip to be stretched. The length of the steel plate is 30 mm when a strip of bobbin paper is burned and 245 mm when the burning time of a leaflet of roll-your-own paper is to be determined.

A schematic drawing of the apparatus is given in Figure 2.

Figure 2. Schematic diagram of the burning time meter.

3. EXPERIMENTAL SECTION

To determine the burning time of bobbin paper, a strip of about 350 mm is cut off. Two marks are placed on this strip: one about 20 mm from the lower edge, the second exactly 250 mm higher. The strip is fitted into the clamp, stretched along the upper mount and held in place by the magnet.

To determine the burning time of a leaflet of roll-your-own paper, two marks are placed on the leaflet: one about 10 mm from the lower edge, the second exactly 50 mm higher. The leaflet is first attached to the special top mount by the magnet and then fitted into the bottom clamp.

After the paper has been put into place, the button on the base is pressed until smoke curls up from the place of contact of nichrome wire and paper and the paper starts burning over the full width. The time required for the burning zone to pass from the lower mark to the upper mark is measured with a stop-watch.

Table 1. Determination of the burning time of 25 samples of cigarette paper made from one batch.

Sample	Burning time (s/250 mm)	Sample	Burning time (s/250 mm)
1	84.7	14	86.1
2	89.4	15	82.9
3	87.4	16	82.9
4	86.5	17	85.9
5	84.6	18	84.1
6	86.2	19	83.7
7	86.3	20	84.3
8	83.9	21	84.2
9	86.0	22	85.3
10	81.1	23	85.3
11	86.0	24	84.8
12	85.6	25	82.8
13	85.8		

Mean 85
S. D. 1.70
Coeff. of var. (% of mean) 2.00

Twenty-five bobbins manufactured from one batch of cigarette paper were sampled. For each sample five replicate determinations of the burning time were made. The mean value for the 25 samples was 85.0 s. The standard deviation was 1.70 s. The coefficient of variation was 2.0% of the mean value. The results have been listed in Table 1.

Table 2. Burning time and burning velocity of 15 different cigarette papers as mean values of 5 determinations.

Sample	Burning time (s/250 mm)	Burning velocity (mm/s)	Coeff. of var. in % of the mean value of the sample
1	82.9	3.02	4.5
2	93.0	2.66	2.8
3	★	—	—
4	90.5	2.76	2.3
5	91.9	2.72	2.5
6	83.8	2.98	2.6
7	69.7	3.59	3.1
8	91.3	2.74	3.0
9	96.6	2.59	1.3
10	92.2	2.71	4.0
11	95.5	2.62	1.4
12	★	—	—
13	★	—	—
14	89.2	2.80	2.4
15	85.0	2.94	1.9

★ failed to burn.

Secondly, the burning time and burning velocity were determined for 15 cigarette papers of different origins. The results listed in Table 2 show that different burning times and burning velocities were obtained. Finally the burning time and velocity for 4 types of roll-your-own paper were determined. The results are listed in Table 3. They show the same features as mentioned in Table 2, except that the coefficient of variation is somewhat higher.

Table 3. Determination of the burning time of 4 samples of roll-your-own cigarette paper of different origin.

Sample	Burning time (s/50 mm)	Burning velocity (mm/s)	Coeff. of var. in % of the mean of 5 de- terminations
1	16.9	2.84	2.4
2	17.2	2.79	5.2
3	14.8	3.25	5.1
4	15.2	3.16	8.8

4. DISCUSSION

Since the 25 samples were tested over a two weeks' period by different operators, the reproducibility as well as the repeatability are considered good and the method shows no operator sensitivity. Apart from the burning time of the paper (about 1.5 minutes), the marking of the paper and the stretching in the apparatus are the only additional manipulations required. The total time required for a fivefold determination of the burning time of one sample is therefore about 15 minutes.

Since Table 3 shows that the determination of the burning time of small paper strips is fairly reliable, it will also be possible to determine the burning time of paper stripped from cigarettes. In this way it will be possible to study the influence of migration of compounds out of the paper to the tobacco or out of the tobacco to the paper on the burning velocity of the used paper.

Further, Table 2 shows that there were commercial papers that failed to burn. We did not study the reason for this phenomenon, because this was beyond the scope of this study, as were the difference of the burning velocity of tobacco-free cigarette paper and the static burning rate of a cigarette.

SUMMARY

The construction and functioning of an apparatus to determine the burning time of cigarette paper is described. The apparatus makes it possible to rapidly and accurately determine the burning time and burning velocity of cigarette paper.

ZUSAMMENFASSUNG

Aufbau und Funktionsweise eines Gerätes zur Bestimmung der Abbrennzeit von Zigarettenpapier werden beschrieben. Abbrennzeit und Brenngeschwindigkeit von Zigarettenpapier können mit Hilfe dieses Gerätes schnell und genau gemessen werden.

RÉSUMÉ

La construction et le fonctionnement d'un appareil permettant de déterminer la durée de combustion du papier à cigarette sont décrits. Grâce à cet appareil, on est en mesure de déterminer très rapidement et très exactement la durée et la vitesse de combustion du papier à cigarette.

REFERENCES

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