A New Time-Regulating Mechanism for a Pipe-Smoking Machine*

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INTRODUCTION

Up to now pipe-smoking machines have been built in a way principally equal to cigarette-smoking machines: during a fixed, short, time a puff is taken followed by an interval, also fixed (1, 2, 3).

This method seems to be correct. Yet *Elmenhorst* (1) pointed out that the variation coefficient of the mass of the total particulate matter is lowered by smoking a pipe by interrupted puffs.

With this in mind and looking for a smoking method more similar to pipe-smoking, we developed the following time-regulator.

THE TIME-REGULATOR

Studying pipe-smoking we found that the shortest puffs last no more than 0.5 sec and the longest puffs about 2 sec. The intervals varied from 0.5 to 120 sec. Furthermore, we did not find any regularity in the sequence of the puffs and intervals. As it is rather difficult to construct, in a purely mechanical way, a smoking machine working on the above mentioned scheme, we developed the photo-electric equipment shown in Figure 1.

In this equipment, we used an endless belt with holes of between 1.0 mm and 2.7 mm with different inter-spaces. In this way the puff duration varied between 0.2 sec and 1.8 sec. It took 4 minutes to reach the starting-point again. In order to measure the puff duration and intervals, a magnetic relay was connected parallel to the terminals of the solenoid valve. This relay switches on and off a rectified, flattened current of 2.2 V. Closing this circuit with a resistance of 3 K Ω and, parallel to it, one of 3 M 300 Ω , it was possible to connect the terminals of the resistance of 300 Ω directly to the entrance of a recorder.

With a paper velocity of 600 mm per minute, 1 mm passed in 0.1 sec. In this way, the puff and interval duration was transformed into the distance between starting and stopping points of the recorder pen.

Figure 1. Time-regulating and measuring part of the pipe-smoking machine.

- A: Amplifier for the photo-electric cell, inclusive magnetic relay for K
K: Solenoid valve to suction part
L: Lamp of photo-electric cell
F: Photo-electric cell
C: Control of K
M: Synchronous motor
N: Perforated endless belt
B: Magnetic relay for closing rectified circuit
G: Rectifier (silicon; 110 B 4)
R₁: Resistance 300 Ω
R₂: Resistance 300 Ω
R₃: Resistance 3 M Ω
R₄: Resistance 3 K Ω
E: Condenser 25 μ F 50 V
a: Belt-guides
S: Main-switch

REPRODUCIBILITY OF PUFF DURATION AND INTERVAL

The total cycle was determined ten times. Of these 10 graphs, the same 9 puffs and 9 intervals were measured in 0.1 mm (0.01 sec). The results are given in Table 1. Due to the inaccuracy of the measurement

Table 1. Measured puff duration and intervals in 0.1 sec.

Puff duration			Interval		
mean	s. d.	v. c.	mean	s. d.	v. c.
4.1	0.78	19.1 %	1.7	0.34	20.4 %
6.8	0.22	3.2	5.2	0.37	7.2
7.0	0.31	4.4	5.4	0.35	6.4
7.7	0.47	6.1	13.8	0.78	5.7
13.7	0.39	2.8	19.1	0.21	1.1
14.6	0.27	1.8	19.4	0.44	2.3
16.2	0.21	1.3	40.6	0.81	2.0
16.4	0.61	3.7	60.3	0.67	1.1
16.7	0.54	3.2	75.0	0.48	1.6

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of the shortest puff and interval duration, the first figures in both columns are unacceptable. For the other values however, one can say that the reproducibility is fair.

The total smoking cycle was 239.97 sec, divided in total puff duration of 57.13 sec and a total interval duration of 182.84 sec.

SMOKING TESTS

In the smoking tests we used a pipe of the specification of Figure 2.

A plexiglass mouthpiece (end) was fitted to the stem; at the other side it was connected hermetically with the glassfibre filterholder. The screw bowl made it possible to weigh the amount of tobacco after filling and to determine the draw resistance independently of the smoking machine. A ring of p.t.f.e. prevented air leakage between stem and bowl.

After some preliminary experiments we came to the following method of operation:

mass of tobacco:	1 g per pipe
draw resistance:	8 mm water pressure
draw vacuum:	14 mm w.p.
puff volume:	10 ml/sec.

To light the pipe we used 4 puffs of 1.8 sec with 3 intervals of the same time. The stem had to be cleaned after each run to prevent the stem condensate of the first pipe from coming into contact with the filter during the smoking of the second one.

Two blends of tobacco were smoked: Maryland and Mixture. To smoke the Maryland we had to run 6 cycles: total time 24 min; total puff duration 342 sec; total puff volume 3420 ml.

To smoke the Mixture we had to run 11 cycles: total time 44 min; total puff duration 627 sec; total puff volume 6270 ml.

The results of the experiments will be found in Table 2. The fact that the standard deviation (s. d.) and variation coefficients (v. c.) of the crude condensates are higher than those of the dry, shows that the moisture content of the CM-113 filters varies more than the dry t. p. m. A possible reason for this is the not quite uniform filling of the bowls, and the difference in smoking time between Maryland and Mixture. This can be the reason for the relatively high s. d. of the dry condensate. These points will be investigated.

Figure 2. Pipe used in smoking test.

All sizes in mm.

Table 2. Crude and dry condensate of two blends of smoking tobacco in mg per pipe.

Maryland		Mixture		Standard deviation and variation coefficient		
crude	dry	crude	dry		crude	dry
174.6	69.4	227.1	82.9	Maryland		
152.4	67.9	216.2	91.9			
161.5	74.4	212.5	108.7	mean	163.5	72.0
152.9	71.7	180.3	85.6	s. d.	14.0	3.8
166.4	76.1	168.7	92.7	v. c.	8.6%	5.3%
156.2	76.9	182.7	94.2			
149.4	75.7	182.8	89.6	Mixture		
138.5	70.4	174.1	94.3			
148.1	67.6	185.2	97.5	mean	191.4	94.5
142.9	66.9	198.6	110.0	s. d.	19.3	8.4
155.9	75.3	176.7	92.3	v. c.	10.1%	8.8%

SUMMARY

A pipe-smoking machine was constructed which simulates pipe-smoking. A photo-electric cell and a perforated endless belt were used for the time-regulation. The reproducibility of the puff and interval duration was fair; that of the crude and dry condensate of two types of tobacco smoked in this machine requires more investigation.

ZUSAMMENFASSUNG

Es wurde eine Pfeifen-Abrauchmaschine entwickelt, die dem menschlichen Pfeifenrauchen besser entspricht als die bisher hergestellten Maschinen. Zur Regulierung von Zug- und Intervalldauer werden eine photo-elektrische Zelle und ein endloses perforiertes Band verwendet. Die Reproduzierbarkeit von Zug- und Intervallzeit ist gut. Die Reproduzierbarkeit der Mengen feuchten und trockenen Kondensates erfordert weitere Untersuchungen.

RESUME

Une machine à fumer la pipe est décrite qui répond mieux au fumage naturel que les appareils développés jusqu'ici. Le réglage de la durée des bouffées et des intervalles se fait par une cellule photo-électrique et par une bande perforée sans fin. La reproductibilité de la durée des bouffées et des intervalles est bonne. La reproductibilité du rendement en condensats sec et humide sera le sujet d'études futures.

REFERENCES

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