

## INVESTIGATION ON THE INFLUENCE OF SOME PHYSICAL CHARACTERISTICS OF CIGARETTES UPON SMOKE COMPOSITION

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### ABSTRACT

Despite increased restrictions on tobacco use and cigarette smoking ban, a variety of blends and designs is on the rise. Various technical-technological measures have been made to reduce the amount of harmful matters in cigarette smoke. The most recent but insufficiently investigated approach of reduction of smoke yield is filtration of smoke particles through the acetate filters.

Investigations were made on the effect of pressure drop of the filter rod and cigarette and the rate of free combustion on the content of tar, nicotine and carbon monoxide in test cigarettes.

Cigarettes were produced on the industrial cigarette maker, and then tested on the Smoking Machine RM 20/CSR according to ISO 3308. The content of tar was measured according to ISO 4387, and the pressure drop of the filter rod and cigarette was measured according to BDS 11353.

The results have shown that both types of filters used, influence the smoke yield and the amount of harmful matters in smoke. Reducing denier per filament increases smoke removal efficiency. Filter type X (denier 3.0Y35 000) effectively filters the smoke so that the nicotine, tar and carbon monoxide contents are lower than the contents obtained by the filter Y (denier 2.7Y35 000).

**Key word:** cigarette, filter rod, pressure drop, physical characteristics of cigarettes, nicotine, smoke

### ИСПИТУВАЊЕ НА ВЛИЈАНИЕТО НА НЕКОИ ФИЗИЧКИ СВОЈСТВА НА ЦИГАРИТЕ ВРЗ СОСТАВОТ НА ЧАДОТ

И покрај зголемените ограничувања на употребата на тутун и забраната за пушење на цигари, на пазарот се се' поприсутни цигари со различни тутунски мешавини и дизајн.

Воведени се различни техничко-технолошки мерки за намалување на количината на штетни материи во чадот од цигарите. Еден од најстарите, но недоволно истражен пристап за намалување на приносот на чадот е филтрацијата на честички на чадот преку ацетатноцелулозни филтри. Истражувањата се направени со цел да се одреди ефектот на отпорот на повлекување на филтер-стапчето, отпорот на повлекување на цигарата и брзината на слободно согорување врз содржината на катран, никотин и јаглороден моноксид во тест-цигарите.

Цигарите се произведени на индустриска машина за цигари и потоа тестирани на машина за пушење RM 20/CSR во согласност со стандардот ISO 3308. Содржината на катран е мерена во согласност со стандардот ISO 4387, а отпорот на повлекување на филтер-стапчето и на цигарата е измерен според стандардот БДС 11353.

Резултатите покажаа дека и двата типа на филтри влијаат врз приносот на чаdot и количината на штетни материи во чаdot. Намалувањето на денијажата по влакно ја зголемува ефикасноста за отстранување на чаdot. Филтерот од типот X (дениер 3.0S35 000) поефикасно го филтрира чаdot, така што содржината на никотин, катран и јаглерод моноксид е пониска од содржината добиена со филтерот S (дениер 2.7S35 000).

**Клучни зборови:** цигари, физички карактеристики на цигарите, никотин, пушење, отпор на повлекување

## INTRODUCTION

Nowadays, manufactured cigarettes are the most widespread form of tobacco use. Despite the ban on tobacco use and smoking, there are many cigarette brands on the market made from different tobacco blends and with various designs.

For the tobacco industry, the most important thing is not only the survival of cigarette brands which have already been designed, but also, the production of new ones according to the demand and in accordance with the law. On the other hand, for the science, it is important to discover the relationships between the physical characteristics of cigarettes which form not only the taste, but also the composition of tobacco smoke.

The design of the cigarettes includes; cigarette geometrical characteristics, choice of tobacco blend, paper elements, as well as type and construction of the filter rods.

The pressure drop of a filter rod is a feature that smokers recognize and its varying depends on the mass of tobacco blends, width of the cut, density, and the characteristics of the preproduction materials (filter rod, filter strip, cigarette paper and etc.). That being said, it means that the pressure drop is a result of the complex action of all cigarette technological parameters and its varying has a direct impact upon the formation of tar and nicotine (Nikolic 2004).

The efficiency of the filter rod can be optimized by setting up the intersection, the length and deniers of the fibers, as well as by varying the length and diameter, the pressure drop, and the ventilation of a filter rod (Nikolic, 2004, Kirkova, 2004).

The pressure drop of the filter rod is one of the most significant parameters as the efficiency of the filter rod for removal of tar and

nicotine from the mainstream smoke directly depends on it.

By setting up the degree of fiber separation in the cellulose acetate track and its mass, the pressure drop of the filter can be directly regulated for  $\pm 10\%$  around the average of the capacity (Georgiev, 2002).

The tar is a solid residue of tobacco smoke aerosol. Carbon monoxide is a dominant gas, whereas the nicotine, as a semi-volatile compound, is divided into two phases of the smoke (Pillsbury et al., 1969, Ingebrethsen B.J., 1986).

The tar, nicotine and carbon monoxide (TNCO) are generated during the process of distillation and pyrolysis (thermal decomposition) of tobacco and in the process of ash oxidation during the heating of tobacco.

The primary role of the filter rod is to remove the tar particles through the process of mechanical filtration of the smoke aerosol (Keith, 1978, Baker, 1980). Filter fibers have very slight effect on the gas phase of the smoke. Some of the semi-volatile constituents of smoke present in the solid phase remain on the filter rod fibers (Morie and Baggett, 1975).

The remaining of the smoke constituents depends on two mechanisms such as selective filtration and elution. Constituents that have a great affinity for the filter remain on, whereas those of slight affinity elute. The acetate filter is less efficient at retaining the nicotine compared to the tar (Curran and Keifer, 1973, Georgiev, 2002, Kirkova, 2005 and 2007).

At present, many cigarettes have filter rods made of cellulose acetate which reduce the tar by 30-40%, and nicotine by 25-30% compared to the cigarettes without filter rods.

At the last conference of signatory countries of the ratified framework convention for

tobacco control of the World Health Organization FCTC/COP4, it has been recommended that attention should be paid to design characteristics and on their influence on smoke composition. The purpose of this examination is to determine the

relationship between the pressure drop of filter rod, cigarette pressure drop, cigarette combustion speed and their impact upon the reduction of tar, nicotine and carbon monoxide (TNCO) in the mainstream smoke.

## MATERIAL AND METHODS

For the purpose of this examination, manufactured cigarettes of Virginia tobacco blend were used, with the following physical characteristics: king size length - 84 mm, diameter - 7.92 mm, weight - 0,760 g, absolute moisture content - 12,50% and permeability of cigarette paper - 46 CU. The filter rod was made of mono acetate cellulose, with Y shape of the fibers, 25mm long and covered with impermeable paper.

Cigarettes differ only by the deniers of the filter rod and the variants are marked as a brand X/denier 3,0Y35 000 and a brand Y/denier 2,7Y35 000.

Measurements of the pressure drop of filter rod and cigarette were taken according to BDS 11353, whereas the free combustion

according to BDS 12975.

The cigarettes are conditioned according to ISO 3402 and tasted by smoking machines Borgwaldt M 20/CSR according to ISO 3308.

The tar content was determined according to ISO 4387 and water content in the capacitor according to ISO 10362-2. The presence of alkaloids expressed as nicotine was determined according to ISO 10315, and the carbon monoxide by ISO 8454.

For both samples of cigarettes, all tested parameters were measured in 8 iterations. In processing the results, arithmetic average value of the arithmetic average  $X_{av}$  was used, as well as arithmetic average value of the root-mean-square deviations  $S_{av}$ .

## RESULTS AND DISCUSSION

The results on pressure drop of filter rod and cigarette and the speed of free combustion

of the cigarette for both test- cigarettes are shown in Table 1.

Table 1 Physical characteristics of test-cigarettes

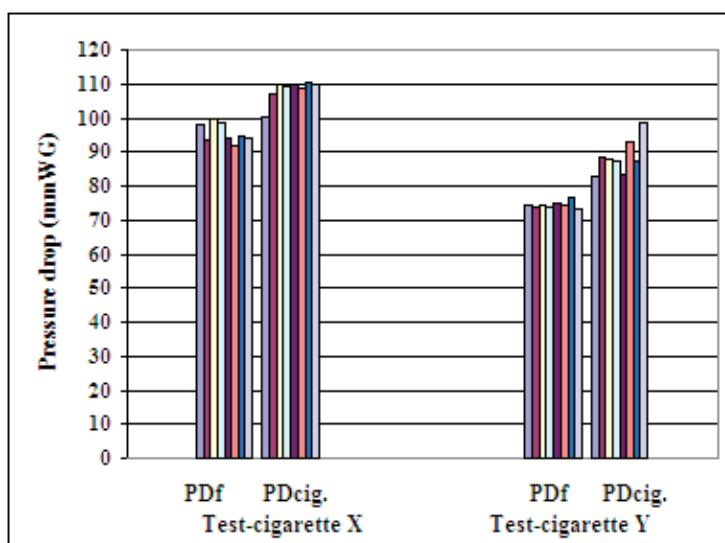
Physical characteristic	$X_{av}$	$s_{av}$	$v_{av}$	<i>min</i>	<i>max</i>
<b>Test cigarettes X</b>					
Pressure drop of filter rod (mmWG)	95.56	2.830	2.96	91.90	99.80
Pressure drop of cigarette (mm WG)	108.12	5.126	5.78	100.20	110.30
Free combustion (min)	7.04	0.311	4.41	6.72	7.49
<b>Test-cigarettes Y</b>					
Pressure drop of filter rod (mmWG)	74.32	1.041	1.40	73.05	76.40
Pressure drop of cigarette (mm WG)	88.64	3.387	3.13	82.90	98.74
Free combustion (min)	6.91	0.246	3.56	6.40	7.10

In test-cigarette X, the pressure drop of the filter rod is 95.56 mmWG, whereas in test-cigarette Y, the pressure drop decreased at 74.32 mmWG. Consequently, the test-cigarette X has a greater pressure drop compared to test-cigarette Y.

It means that with the decrease of denier of the filter rod fibers from 3, 0 to 2, 7, the pressure drop of filter rod and cigarette also decreases.

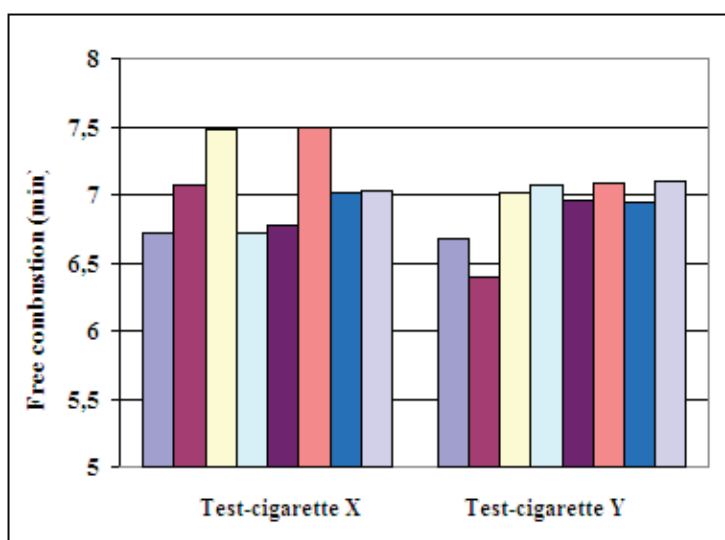
The variation between the values for pressure drop of the filter rod in test-cigarette X is higher compared to the values for this parameter in test-cigarette Y. Thus, it indicates uneven charges in cigarettes.

The change of the values for pressure drop of the filter rod and of the whole cigarette is shown in Graph 1.



Graph 1 - Movement of pressure drop of filter rod and cigarette (mmWG) in both test-cigarettes

PDF(mmWG) pressure drop of filter rod  
 PDCig(mmWG) pressure drop of cigarette



Graph 2 Movement of free combustion (min) in both test-cigarettes

The parameter values of free combustion in both test-cigarettes are very close. There is a slight tendency for slowing the combustion in test-cigarette X. The speed of free combustion depends not only on the pressure drop but also on the type of paper, width of burning tobacco, weight, smoothness of tobacco fill in the cigarette

and the mutual influence of all these factors.

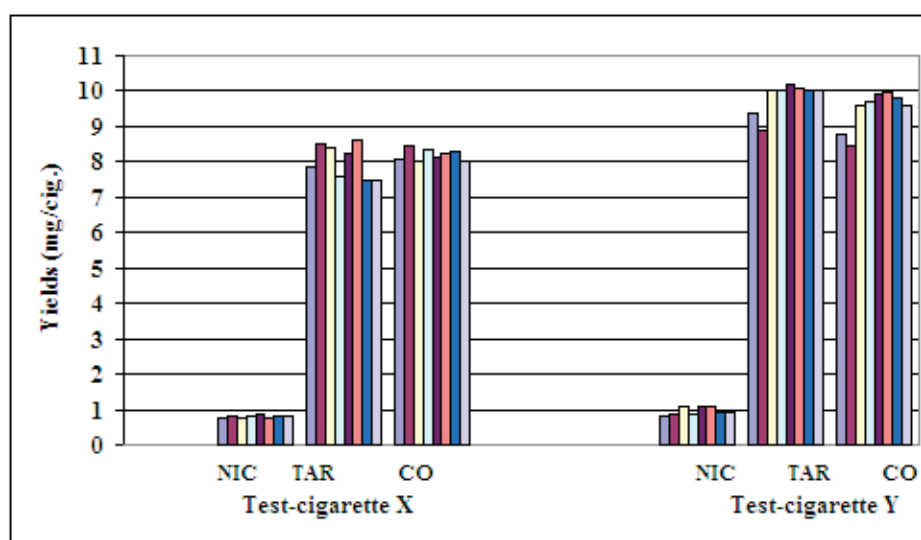
The change of values in free combustion in the examined test-cigarettes is shown in Graph2.

Measurements of the harmful elements tar, nicotine, and carbon monoxide in the mainstream smoke are shown in Table 2.

Table 2. Chemical characteristics of test-cigarettes

Chemical characteristics	X av	s av	v av	min	max
<b>Test-cigarette X</b>					
Nicotine (mg/cig)	0.80	0.031	3.92	0.75	0.84
Tar (mg/cig)	8.02	0.478	5.96	7.46	8.64
Carbon monoxide (mg/cig)	8.21	0.166	2.02	8.02	8.48
<b>Test-cigarette Y</b>					
Nicotine (mg/cig)	0.96	0.111	4.96	0.83	1.11
Tar (mg/cig)	9.82	0.449	4.57	8.90	10.20
Carbon monoxide (mg/cig)	9.47	0.555	5.86	8.45	9.90

The presence of tar, nicotine, and carbon monoxide (TNCO) in the mainstream smoke in both test-cigarettes is shown in Graph. 3.



Graph 3 - Presence of nicotine (NIC), tar (TAR) and carbon monoxide (CO) (mg/cig.) in both test-cigarettes.

It is safe to say that the change in pressure drop leads to a change in the process of combustion, and it unarguably influences the quantity and composition of smoke.

The decrease in pressure drop of the filter-rod in the test-cigarette Y increases the content of nicotine in the mainstream smoke by 20% and the tar by 22% compared to the same parameters in cigarette X.

As for the content of carbon monoxide, this parameter increases by 15% in test-cigarette Y compared to cigarette X. If these values are

expressed in ratio, in test-cigarette X, the yield of tar compared to the one of nicotine is 10.0, whereas in test-cigarette Y, the yield is slightly higher - 10.2.

In both cigarettes, the tar and carbon monoxide ratio is approximately 1:1. It is 0,97 in test-cigarette X, and 1,04 in test-cigarette Y.

The speed of free combustion of cigarette is proportionally reduced with the increase of tobacco density in cigarette and the diameter of filter-rod.

## CONCLUSION

According to the results, there is dependence between the pressure drop of filter-rod, the pressure drop of cigarette and the free combustion of cigarette. It can be seen that the change in the pressure drop of test-cigarettes strongly influences the obtained yields of tar, nicotine and carbon monoxide in the mainstream smoke.

In test-cigarette Y, the decrease in the pressure drop of the filter-rod contributes to the increase of nicotine content in the mainstream smoke by 20% and of the tar by 22% compared to the content of these parameters in cigarette X.

Thus, there is a higher retention of harmful substances if the cigarette is more

efficiently filtered as in cigarette X, which has higher density and pressure drop of the filter-rod.

Unlike the pressure drop of cigarettes, the speed of free combustion remains unchanged in both cigarettes.

It still has not been proved how it reflects the smoking characteristics of cigarette and it consequently remains to be the aim of the following examinations.

The results of the investigation show that many factors influence the content of the mainstream smoke, which will be gradually disclosed according to the design change of the cigarette.

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