Smoking Puff Ratio of Cigarette and Its Determination Method

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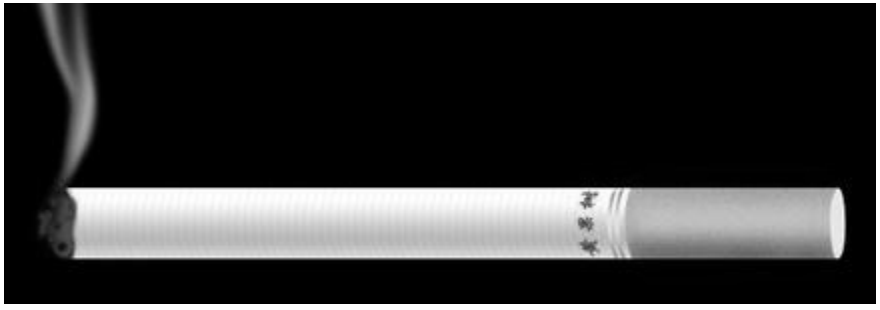
The Definition of Smoking Puff Ratio(SPR)



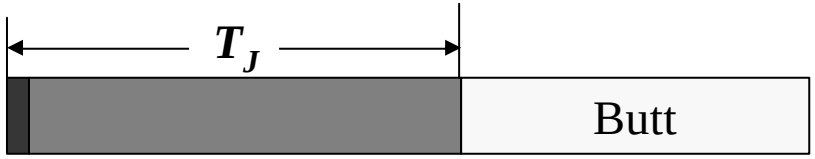
Tobacco burned during smoking

Tobacco burned during smoldering

$$SPR = \frac{\blacksquare}{\blacksquare + \blacksquare}$$

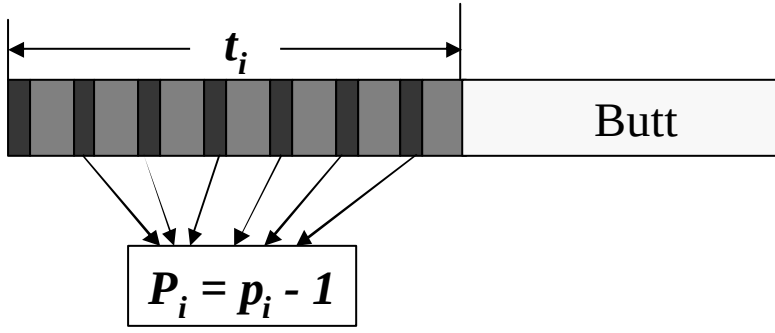
Cigarette smoking on different puff intervals

- T_J : **smoldering time**



- $P_i = p_i - 1$ $(i=1,2,\ldots,I)$,

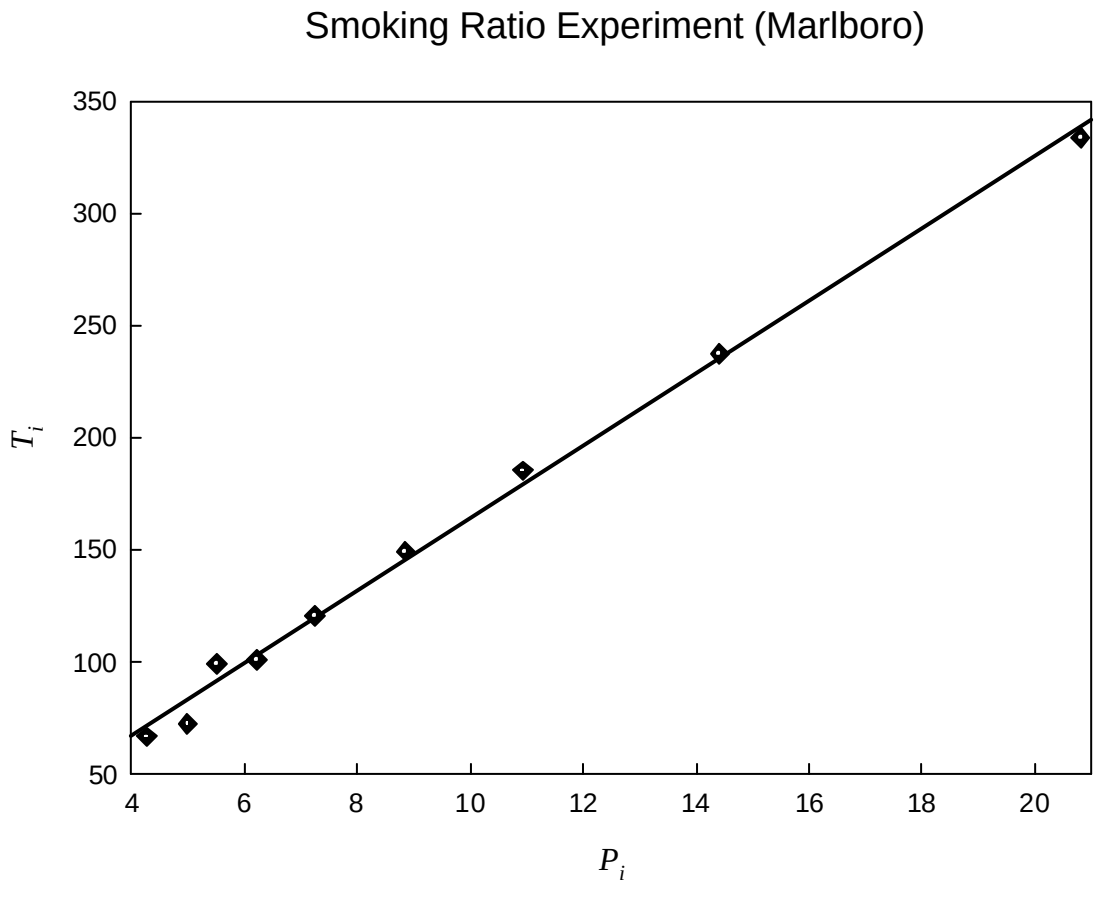
  p_i **is the puff on the** ***i*****th puff interval**



- $T_i = T_J - t_i + 2 \times P_i$ $(i=1,2,\ldots,I)$

  t_i **is the smoking time on the ith puff interval**

In fact, P_i is the puff increase on different puff intervals comparing cigarette smoldering, while T_i represents the smoking time reduction on different puff intervals comparing cigarette smoldering.



$T=16.17 \times P+2.175$, $R^2= 0.9958$

The calculation of SPR

- $T = k \times P + b$
- $SPR_i = (k \times p_i + b)/(T_J - 2 + k)$

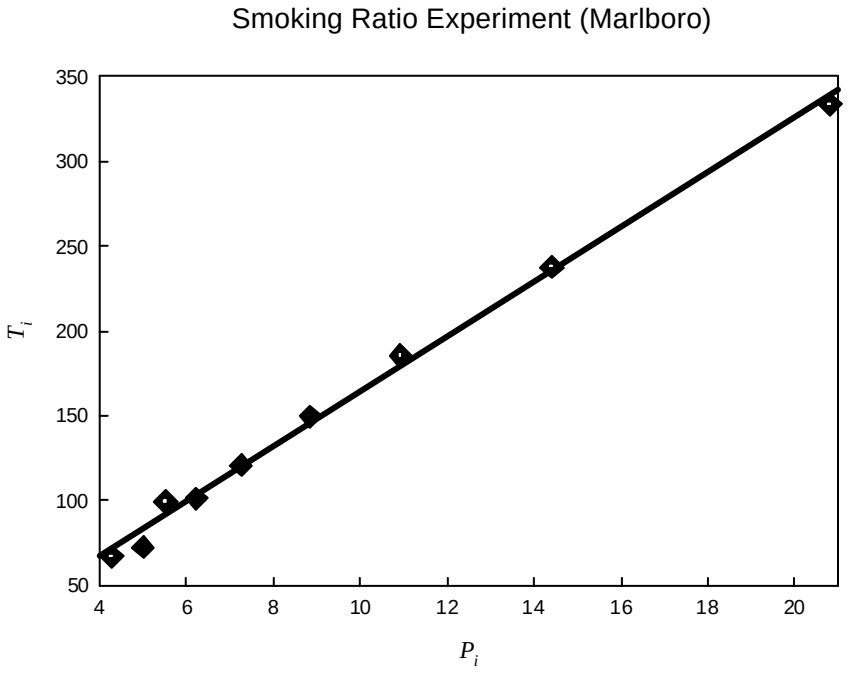
  T_J : **smoldering time**

  p_i : **the puff on the *i*th puff interval**

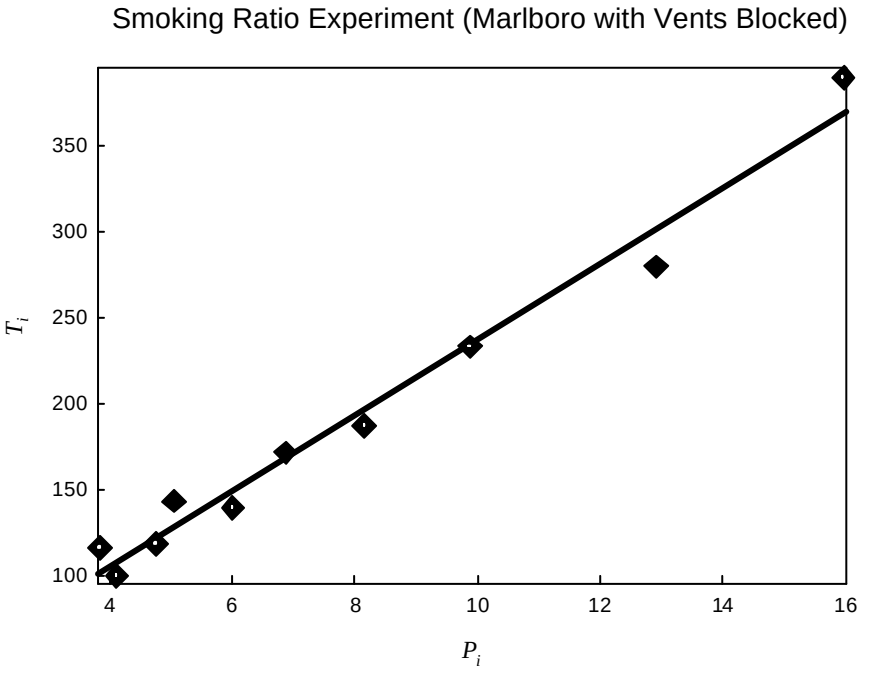
(k ×p_i+b) is the equivalent smoldering time corresponding to p_i,

(T_J-2+k) is the total smoldering time of a cigarette (including the igniting puff)

The influence of venting to SPRs



SPR_{60}=22.24%



SPR_{60}=32.57%

Venting the tipping paper results in a significant decrease of SPR

The influence of tobacco and accessory materials to SPRs

Accessory materials for Baisha (Boutique) , SPRs= 25.6%±0.7%

	Nise	Baisha (hard)	Baisha (Harmony)	Baisha (Boutique)	Cut stem
SPR	25.01	26.74	25.16	25.31	25.68
R^2	0.9888	0.9832	0.9914	0.9780	0.9854

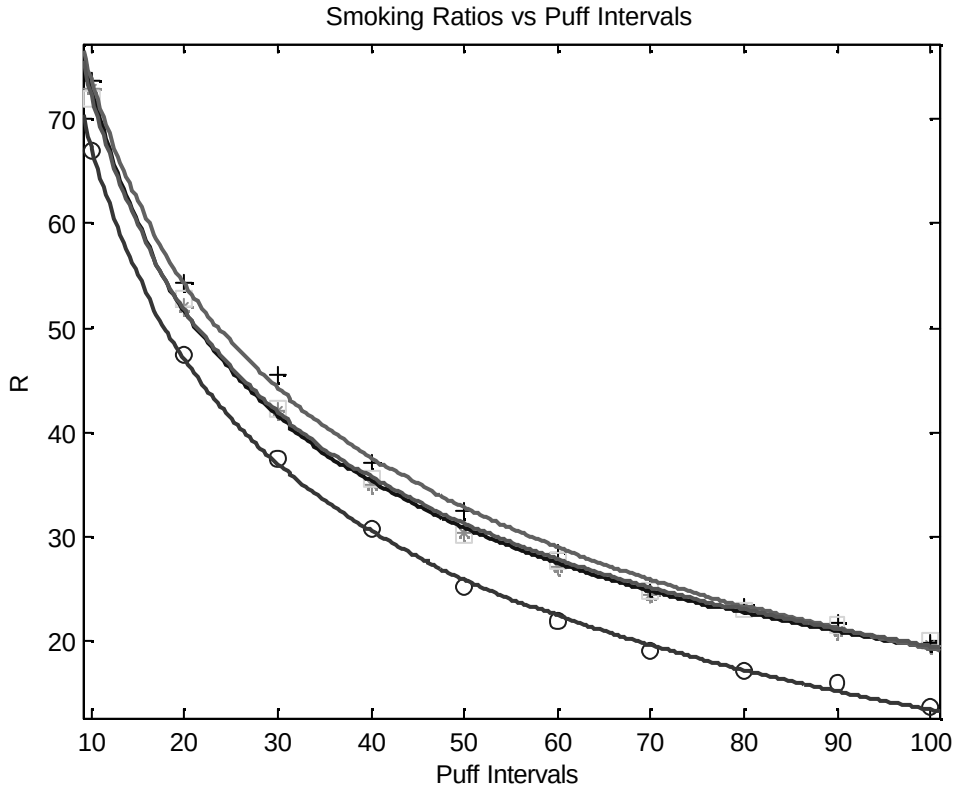
Accessory materials for Baisha (Hard), SPRs= 27.8%±1.1%

	Nise	Baisha (hard)	Baisha (Harmony)	Baisha (Boutique)	Cut stem
SPR	26.76	27.65	26.79	28.90	28.97
R^2	0.9884	0.9991	0.9909	0.9871	0.9665

SPR values of different cigarettes with the same accessory materials vary in a relatively small range, while there exist obvious distinction of SPR values between different accessory materials.

The accordance of SPR values over the same accessory materials supplies us with the possibility that the smoke component yield of blended tobacco might be calculated by that of single-grade tobaccos according to their proportion.

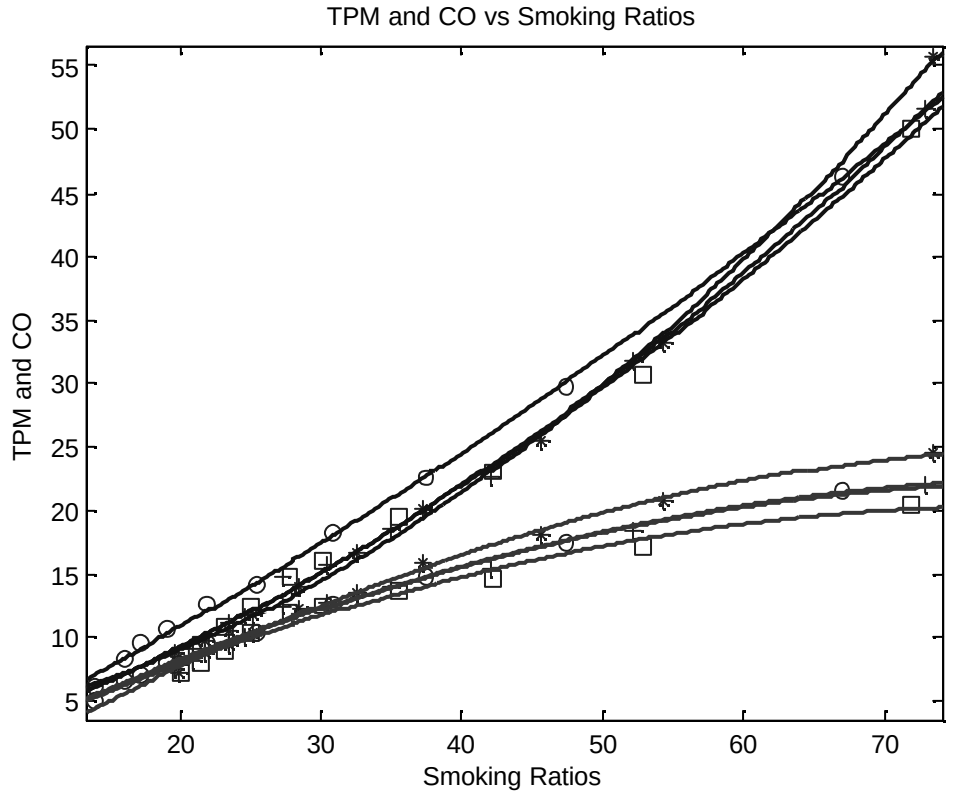
The correlations of SPR with puff interval



The correlations of SPR with puff interval

Lengthening the puff interval leads to a rapid decrease of SPR.

The correlations of SPR with TPM and CO



The correlations of SPR with TPM (blue) and CO (red)

Shortening the puff interval results in an increase of total particulate matter (TPM) and carbon monoxide (CO). The increasing rate of TPM along with the increase of SPR value is significantly higher than that of CO.

The correlations of SPR with TPM and CO

The fitting function is $y=ax^2+bx+c$

		a	*b*	*c*	R^2
Marlboro (White)	TPM vs *SPR*	0.0025	0.5345	-0.8230	0.9989
	CO vs *SPR*	-0.0033	0.5640	-1.6820	0.9977
Baisha (Boutique II)	TPM vs *SPR*	0.0049	0.3414	0.4527	0.9975
	CO vs *SPR*	-0.0034	0.5743	-1.9370	0.9843
Baisha (Soft)	TPM vs *SPR*	0.0073	0.1849	2.4060	0.9987
	CO vs *SPR*	-0.0038	0.6684	-4.0990	0.9970
Baisha (Gold nobility)	TPM vs *SPR*	0.0044	0.3691	0.0941	0.9959
	CO vs *SPR*	-0.0034	0.5466	-1.6110	0.9730

The coefficients of quadratic term (*a*) of TPM to SPR are all positive, while the coefficients of quadratic term (*a*) of CO to SPR are all negative

CO yields of One puff on different puff intervals

Puff interval (s)	Marlboro (White)	Baisha (Boutique II)	Baisha (Soft)	Baisha (Gold nobility)
10	0.92	1.14	1.46	1.09
20	1.04	1.36	1.67	1.26
30	1.11	1.43	1.73	1.37
40	1.14	1.57	1.88	1.56
50	1.13	1.68	1.84	1.70
60	***1.20***	***1.85***	***1.90***	***1.80***
70	1.13	1.66	1.81	1.74
80	1.11	1.64	1.78	1.65
90	1.10	1.62	1.79	1.61
100	0.96	1.61	1.62	1.57

The CO yield of one puff reaches its highest value when the puff interval is set to 60s, which is utilized by ISO smoking pattern.

Conclusion

- In this paper, we introduced the concept of smoking puff ratio of a cigarette and proposed a method to determine it.
- The proposed method is simple and operationally convenient. It requires no additional instrument but smoking machine, and no extra measurement but cigarette smoking.
- The experimental results showed that SPR values of different cigarettes with the same accessory materials vary in a relatively small range. And accessory materials are the more important factors affecting SPR than cut tobacco.
- The increase of SPR can lead to the corresponding increase in TPM and CO. While the TPM shows a significantly higher increase rate than CO.
- The introduction of SPR can help evaluate the actual intake of smoke components on different smoking habits and the actual transfer rate of chemical compounds from cut tobacco into mainstream smoke.