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IX<sup>th</sup> CONFERENCE OF EUROPEAN MEAT RESEARCH WORKERS  
Budapest, 4<sup>th</sup> - 11<sup>th</sup> September, 1963

THE PRODUCTION OF WOOD SMOKE.  
THE TEMPERATURE OF THE COMBUSTION ZONE.

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The production of smoke is to-day one of the main problems in the technology of smoked foods. It is well known from practice that the flavour of wood smokes as well as that of the smoked product may differ depending on the conditions under which the smokes are produced. This view was recently corroborated by the work of Tilgner et al.<sup>1</sup> The flavour of the smoke was found to be in dependence of the air surplus factor and the temperature of the destruction zone of wood, as well as that of the combustion /oxidation/ zone of the volatile destruction products. Attention to these factors is given also in another paper of Tilgner et al.<sup>2</sup>

The temperature of smoke production is mostly reported to be within the range of 300 - 450°C<sup>3,4,5</sup> which is below the values known in physics and physical chemistry as the temperature of visible glow<sup>6</sup>. On the other hand, it is known from practice that the radiation of the glowing sawdust is perceived by the human eye without any difficulty even in daylight. This controversy was risen in an earlier paper<sup>7</sup>, and in another work<sup>8</sup> the author expressed the opinion that the formation of wood smoke occurs commonly in the temperature range of some 700 - 1000°C. The validity of this assumption has been proved in the experiment described in this paper.

EXPERIMENTAL:

A. Materials: In the experiments beechwood sawdust of three grades was used. The graduation of the sawdust was performed by means of the DIN laboratory sieves set. The rough grade corresponds to the sawdust which passed the sieve Nr. 4 / particles with a diameter of 1,6mm/, the middle grade - sawdust that passed the sieve Nr. 24 /particles 0,25 mm ID/ and the fine grade - sawdust which passed the sieve Nr. 40 /particles 0,15 mm ID/. The average humidity of the sawdust was 12 %.

B. Procedure: Smoke was produced by igniting the bottom layer of the sawdust loosely poured on a laboratory net from which the asbestos



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had been removed prior to the experiment. The ignition was initiated by means of a Bunsen burner but care was taken to avoid any inflammation of the sawdust. A fine thermocouple Fe-const. was immersed in the sawdust in half distance between the bottom and the upper layer /around 4 cm/ and the maximal temperature of the glowing sawdust was recorded by means of a MAW electronic recorder. The wires, the thermocouple was made of, were of 0,2 mm diameter each. The hot joint represented a sphere 0,9 mm in diameter.

C. Results: Seven temperature measurements were done for each of the three tested grades of sawdust. The results are listed in table 1.

Table 1

Maximal temperatures recorded in glowing sawdust /°C/

Replicates	Sawdust grades /mm/		
	1,6	0,25	0,15
1	745	885	1025
2	825	790	970
3	930	1025	850
4	780	930	770
5	1025	870	930
6	850	970	840
7	965	910	995

Some elementary statistical characteristics, as calculated for the above data, are gathered in table 2.

Table 2

Elementary statistical characteristics calculated for table 1.

Characteristics	Sawdust grades /mm/		
	1,6	0,25	0,15
sums	6120	6380	6380
sum of squares	5413300	5848750	5867450
variance	10445,24	5639,29	8755,95
mean	874	911	911

Student's t-values for the differences of means between the grades 1,6 and 0,25, 1,6 and 0,15, 0,25 and 0,15 are respectively 0,7724; 0,7061 and 0,0000.

By comparing the t-values with the theoretical one for  $p=0,05$  and 12 d.f. /2,179/ one can see that there are no significant differences between the mean values of temperatures found in the three grades of sawdust being tested. Therefore it is assumed that these three groups of data form one population with 21

replicates. From the data listed in table 2 it can be easily calculated that this population has an average temperature around  $899^{\circ}\text{C}$  - the fiducial limits  $/p=0,05/$  being from 859 to  $939^{\circ}\text{C}$ .

#### DISCUSSION OF RESULTS:

As is seen from the presented data the maximal temperatures measured in glowing sawdust are within the range 859 -  $939^{\circ}\text{C}$  and the differences resulting from the different size of sawdust particles / from 1,6 mm to 0,15 mm/ are negligible. Since the maximal recorded temperature for each measurement corresponds to the temperature sensible to the couple at the moment when the glowing zone reached the hot joint of the latter, this temperature may be identified with the superficial temperature of the glowing particles. Thus, the assumption being under test, is proved valid for the combustion of sawdust with free access of air and without flame formation. In case of flame formation, as it has been recognized on the margin of this experiment, the temperature rises rapidly to a level which is out of the MAW recorder range  $/1200^{\circ}\text{C}/$ .

The presented results are in fairly good agreement with those given by Lam<sup>9</sup> for cigarettes. It is thought that the low levels of temperatures reported by the aforementioned authors are due most probably to the fact that they used too rough instruments to the measurement of the superficial temperature of the sawdust particles and instead obtained the average temperature of the air stream at the moment when it crossed the glowing sawdust. This temperature is always lower of the temperature being at the same moment at the surface of the sawdust particles.

#### CONCLUSIONS:

- 1/ The temperature of the glowing sawdust ranges from 859 to  $939^{\circ}\text{C}$  with an average of  $899^{\circ}\text{C}$ , which confirms the assumption that this temperature should be within 700 and  $1000^{\circ}\text{C}$ .
- 2/ The effect of particle size upon the temperature of the glowing sawdust is negligible within the tested range of sawdust grades.
- 3/ The temperature of the glowing zone cannot be identified with that of the smoke stream when crossing the sawdust. The latter is a resultant of the stream velocity, temperature differences between the glowing zone and the atmosphere, etc.



### S U M M A R Y

The temperature of the flameless combustion of sawdust in the process of smoke production was measured by means of a fine thermocouple, immersed into the glowing zone. The results indicate that this temperature was commonly within  $859 - 939^{\circ}\text{C}$  with an average of  $899^{\circ}\text{C}$ . Thus, the expressed in an earlier paper assumption, concerning the level of this temperature, is proved valid. No significant effect of the size of the sawdust particles upon the level of the combustion temperature was found within the tested range of sawdust particles.

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