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THE RATE OF COMBUSTION OF CARBON DEPOSITED ON THE CATALYST IN THE CATALYTIC CRACKING PROCESS

The purpose of the experimental work was to determine in a laboratory reactor the rate of combustion of carbon deposited on the catalyst at various temperatures. The dimensions and the arrangement of the reactor were chosen in such a way that the combustion approached isothermic conditions.

The reactor consists of a tube about 1" diameter which is placed in a lead bath of 2.8" diameter. The lead bath is heated by an electrically heated jacket. In the center of the reactor a thermocouple well is located through which 3 thermocouples can be distributed uniformly through the catalyst bed. The temperature of the outside of the lead bath and of the lead bath itself is also determined.

Air and nitrogen are taken from the plant system and are preheated in a coil placed in the lead bath; the gases flow through the catalyst from the top to the bottom.

The reactor is brought to temperature by means of nitrogen and the amount of nitrogen used is equal to the amount of air used in the subsequent experiments; when the desired temperature has been reached, the nitrogen flow is stopped and the catalyst (18 cubic inches (300 cc.)) filled rapidly into the reactor. Air, amounting to 3,000 - 5,000 volumes per volume of catalyst, is then passed over the catalyst. Since the concentration of CO_2 in the air would only be very small, the amount of carbon burned off is not determined from the CO_2 concentration but by removing the catalyst after a definite combustion time and determining the remaining carbon by combustion. The catalyst contains 2.1% of carbon which was obtained by cracking Austrian oil at 788°F in a 30.5 cubic inch reactor at a space velocity of 0.6, a reaction period of 30 minutes, followed by a purging period of 5 minutes, using 4.2 cubic feet of nitrogen per hour; the catalyst used was catalyst #3248 from the semi-commercial unit. The results of experiments with this catalyst are shown in the following table:

% Carbon left on the catalyst after:

Temp. °F.	10 min.	20 min.	30 min.	1 hour	2 hours	4 hours
734*)	1.88	1.76	1.74	1.43	1.36	1.04
806*)	1.70	1.65	1.44	1.00	0.78	0.57
887*)	1.11	0.98	0.62	0.53	0.45	0.28
968*)	0.85	0.53	0.40	0.23	0.26	0.12
995**)	0.40	0.22	0.13	0.10		

*) Amount of Air: 32.8 cu.ft./hour Amount of catalyst: 18 cu.in. (300 cc) = 0.62 lbs.(235 g.)
**) " " " : 53 cu.ft./hour

Another series of reactions was carried out with a catalyst with 4.2% by weight of carbon. The carbon was put on the catalyst by cracking in the same laboratory reactor as before with a space velocity of 0.4, a cracking period of 3 hours, a temperature of 488°F., and otherwise using the same conditions and charge stock as before. The results are shown in the following table:

% Carbon left on the catalyst after:

Temp. °F.	10 min.	20 min.	30 min.	1 hour	2 hours	4 hours
887	2.29	1.75	1.22	0.69	0.33	0.13
968	0.89	0.60	0.44	0.36	0.26	
			0.42	0.22	0.14	

Amount of Air: 32.8 cu. ft./hour
Amount of Catalyst - same as before

The attempt to obtain a completely isothermic reaction was not quite successful. At the beginning of the combustion, in about the first 5 minutes, a temperature rise could not be avoided. The error must be estimated to about 25%, i. e., that the time which is required to burn off a given amount of carbon at a given temperature will, in reality, be 25% longer than the time read from the curve.

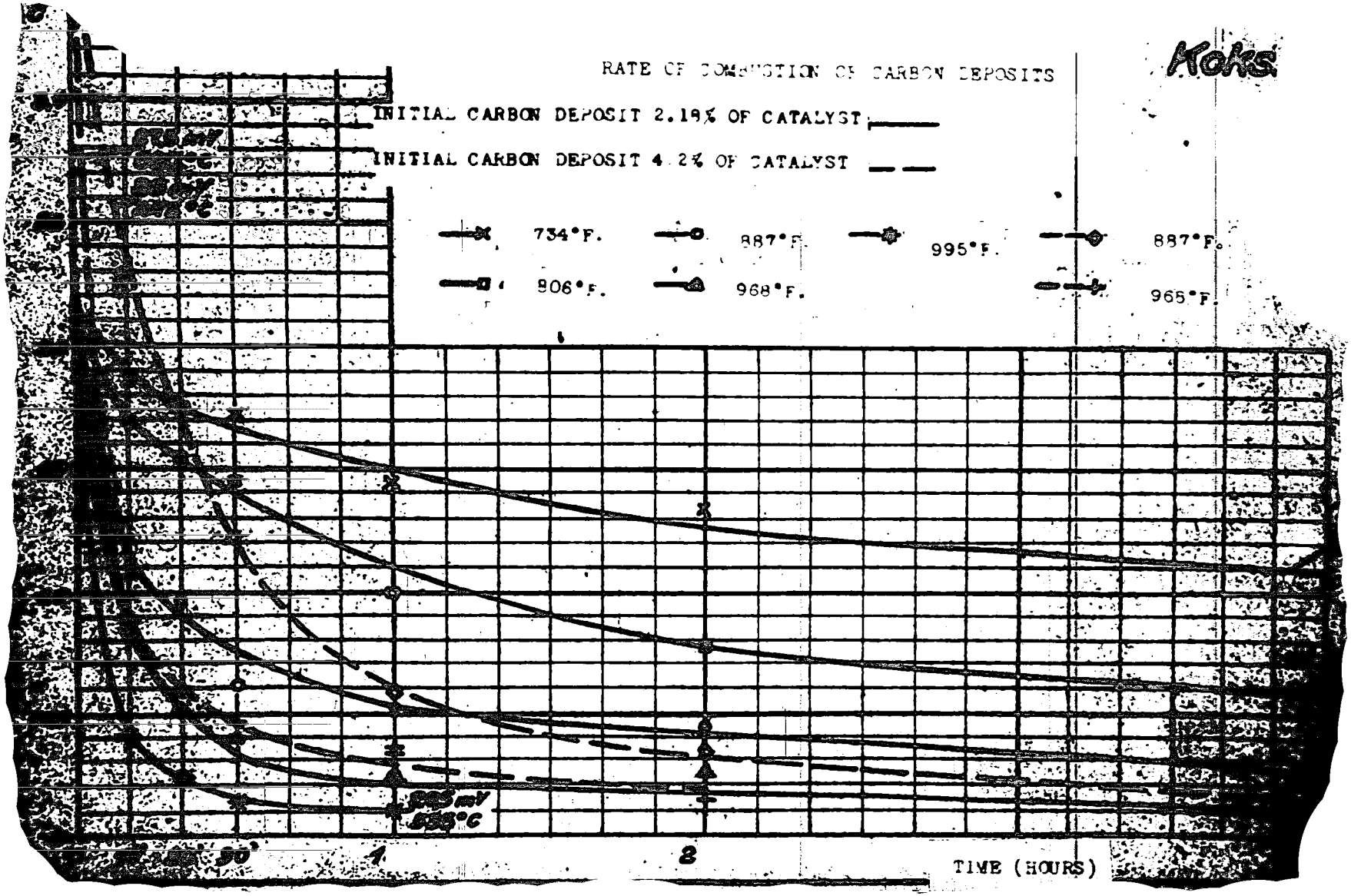
The data indicate that the velocity of combustion increases when the reactor temperature is raised. The curves in the attached diagram show, again, the combustion characteristics of the carbon deposited on cracking catalyst.

The carbon deposit does not burn with uniform velocity. At 734°F. about 28% of the carbon is burned off in the first half hour, whereas in the subsequent 3.5 hours only about 25% is burnt. (This should not mean that in the course of carbon deposition 2 different modifications of carbon have been formed. It can, however, be assumed that the phenomenon represents a disproportionation reaction involving the originally probably homogeneous deposit.)

It can be further seen that for complete combustion of the carbon high temperatures and very long reaction times are necessary. For practical purposes, complete removal of the carbon is not necessary.

From the inspection of numerous samples of used catalyst which has been used in reactors of varying designs, it can be estimated that at least about 0.2% by weight of carbon can be left on the catalyst without decreasing its activity noticeably.

On the basis of this assumption, it can be seen from the diagram that for an average regeneration temperature of 968°F., 75 minutes are required for regeneration and at 995°F., 25 minutes. The correction factor of 25% has been applied in this estimate.


RATE OF COMBUSTION OF CARBON DEPOSITS
Koks
INITIAL CARBON DEPOSIT 2.19% OF CATALYST
INITIAL CARBON DEPOSIT 4.2% OF CATALYST
734°F.
887°F.
995°F.
887°F.
806°F.
968°F.
965°F.
1
2
TIME (HOURS)