Gas Carburizing by the "Drip Feed" Method in Switzerland

By URS WYSS°

Atmospheres for gas carburizing can be formed by "cracking" two organic liquids, one of which supplies the carrier gas, the other, the carburizer. Amounts of the carburizing liquid are easily controlled through dew point readings, necessary quantities being automatically added to the carrier according to the desired carbon potential. (J28g, W27n; ST)

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In this Swiss installation, carburizing atmospheres are produced by cracking two organic liquids — one supplies the carrier, the other, the carburizer. Here, the pit furnace, which can handle parts up to 3 ft in diameter and 10 ft long, is open to accept the racked gears.
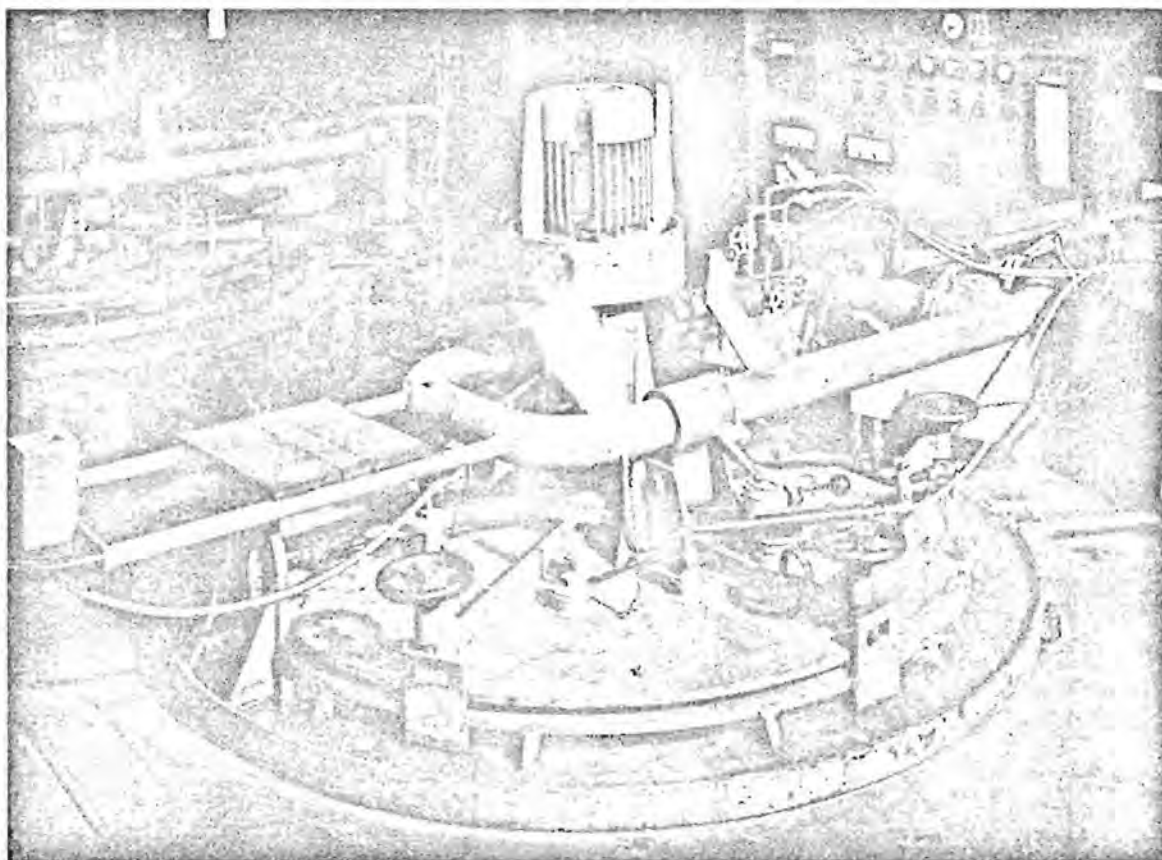

Fig. 1 — When the furnace has been loaded, the lid, which holds the drip feeding equipment, is closed tightly. The tubes leading into the furnace from the right convey the carrier and carburizer liquids. As these liquids drip into the hot chamber — their flows are controlled automatically — they crack to form the desired atmosphere.

AFTER WORLD WAR II, gas carburizing, based on the endothermic generator process, increased rapidly in Europe, especially in Germany and Switzerland. However, since that method has some complications, the trend is toward simpler generator-free techniques.

Swiss engineers have devised a drip-feed process, now being patented, which combines an uncomplicated working setup with good

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control of carbon potential and other advantages given by the generator method. In this arrangement, two organic liquids, which are very easily cracked, are simultaneously introduced into the furnace. The first liquid forms a carrier gas which scavenges the furnace and then provides the desired positive pressure during the carburizing cycle. Upon cracking, the second liquid produces the gas necessary for setting the desired carbon potential. The process, which has been in use for three years, is suitable for retort and chamber furnaces with or without closed quenching units.

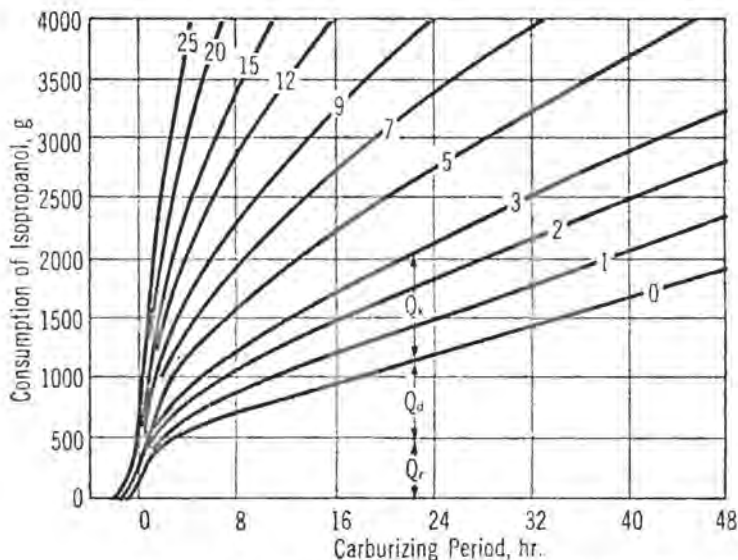With retort furnaces, such as shown on p.

Fig. 2 — If the flow of methanol (the liquid which forms the carrier gas in the carburizing furnace) is constant, the consumption of the carburizing liquid — isopropanol in this instance — varies with the surface area of the material being carburized. In this graph, Q_r, Q_d and Q_k refer, respectively, to the amount of carburizer liquid needed to condition the walls and retort of the furnace, adjust the carbon potential of the carrier gas, and carburize the parts. Numbers 0 to 25 indicate surface area in square meters.

a uniform carburizing temperature is attained, the carburizing liquid is automatically metered into the furnace through a solenoid valve regulated by a dew point control device. Figure 1 illustrates the controls. Consumption of carburizer gas depends on three factors:

Q_r — Consumption for conditioning the retort walls and trays.

Q_d — Flow consumption for adjusting the carbon potential of the carrier gas.

Q_k — Carburizer consumption, depending on the surface area to be carburized.

Since all three items, Q_r, Q_d and Q_k, may vary to a great extent, they have created difficult control problems for drip feed processes, particularly when significant differences in areas to be carburized exist from charge to charge. And when the carburizer flow is not reliably controlled according to the need of the moment, satisfactory and consistent case hardening is not possible.

Variation in Gas Composition

Assuming a constant flow of the carrier liquid (methanol) and automatic control of the flow of carburizer corresponding to the momentary shift in requirement, we can show, as in Fig. 2, that the proportion of the two liquids mainly depends on the area to be carburized. Alone, methanol cracks to about $33\frac{1}{3}\%$ CO and $66\frac{2}{3}\%$ H_2 (volume percentages according to the idealized equation: $CH_3OH \rightarrow CO + 2H_2$). However, as shown in Fig. 3, the CO content changes greatly with differ-

86, feeding of the liquid which forms the carrier gas — methanol is satisfactory — begins after the loaded furnace reaches 650 C (1200 F). About 1 kg (2.2 lb) per hr is fed during the scavenging period; later, the rate drops to 0.3 to 0.6 kg (0.66 to 1.32 lb) per hr. After
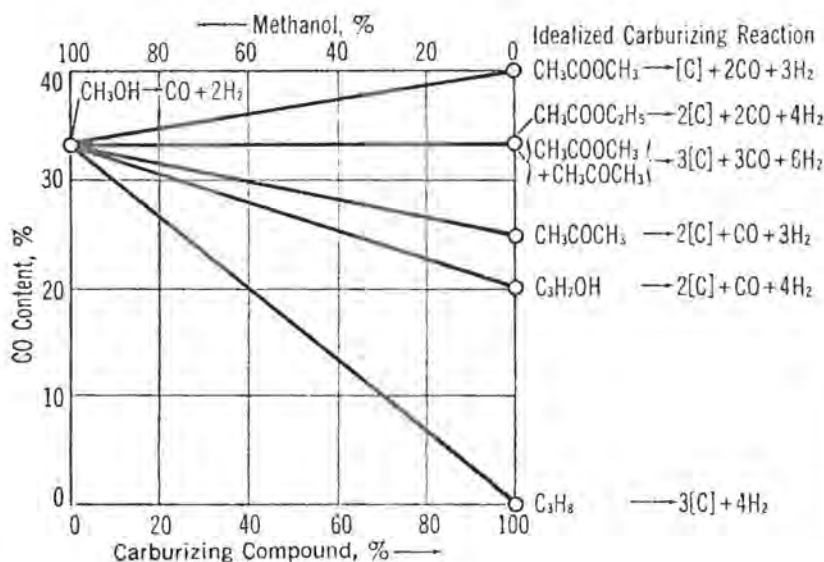

Fig. 3 — When the carrier, methanol, cracks, one third (by volume) of the gas which is formed consists of carbon monoxide. The indicated carburizing compounds can be added in varying amounts; when they crack and react with the surface, the CO content changes, and carbon is introduced into the surface to be carburized.

ent carburizers when the ratio of carburizer to methanol is varied. This graph delineates all ratios of mixtures, from pure methanol to pure carburizer, along with the corresponding "idealized" carburizing reactions. Theoretically, according to this chart, ethylacetate ($CH_3COOC_2H_5$) and the mixture of equal molar amounts of methylacetate (CH_3COOCH_3) and acetone (CH_3COCH_3), when used in any proportion with methanol, produce no deviation from the basic composition of the gas; their reaction products conform exactly to those formed when methanol is cracked.

In actual practice, though, small quantities of H_2O, CO_2 and CH_4 also form, as well as CO and H_2. Given a carbon potential of 1% and a furnace temperature of 900 C (1650 F), the true reactions for cracking of ethylacetate and isopropanol result in the gas compositions shown in Table I. It can be seen that the reaction gases resulting from the breakdown of methanol and ethylacetate have the same composition; the gas resulting from pure isopropanol is different. However, experience has also shown that either isopropanol or acetone is suitable as carburizing mediums if the ratio of carburizing surface to furnace volume is not too high and the methanol is fed rapidly enough. Since the rate of carburizer flow does not affect the composition of the carrier gas, it can be controlled automatically according to the actual instantaneous requirement.

Mechanism of Some Reactions

When alcohols and ketones are cracked, CO and CH_4 form directly, but with acetates, CO_2 is formed first. However, this CO_2 reacts very quickly (either with split CH_3 radicals or with CH_4 or H_2) to produce CO. Also, the CH_3 radicals react very quickly with either H_2O (forming CO) or with nascent II (producing CH_4, a more stable compound). Carburizing of steel follows the [C]-CO-CO_2 equilibrium which is also associated with the water-gas equilibrium. Methane (CH_4) contents, which are higher than those conforming to equilibrium conditions, may exist because the reactions are relatively slow, but they will not disturb the [C]-CO-CO_2 and water-gas reaction.

As mentioned before, small quantities of H_2O, CO_2 and CH_4 are also formed during cracking and carburizing reactions, conform-

Table I — Actual Composition of Furnace Gases Resulting From Cracking and Carburizing Reactions

Carburizing Medium	Gas Content, %				
	CO_2	H_2O	CH_4	CO	H_2
CH_3OH (methanol)	0.350	0.960	0.680	32.35	65.66
$CH_3COOC_2H_5$ (ethylacetate)	0.350	0.960	0.680	32.35	65.66
C_3H_7OH (isopropanol)	0.130	0.695	1.025	19.42	78.73

ing to equilibrium conditions and according to furnace temperature and carbon potential. Figure 4 shows the dew point as a function of carbon potential and furnace temperature. Experience has proved that the dew point is an excellent criterion of carbon potential, being independent of the area of workpieces and furnace volume.

Fig. 4 — In carburizing furnaces, dew point correlates with furnace temperature and carbon potential. Each line indicates a 25 C (45 F) increment of furnace temperature between 850 and 1000 C (1560 and 1830 F).