

CHARCOAL INOUSTRY IN THE U.S.A.

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SYNOPSIS

A history and a description of the production methods are given for the charcoal industry in the United States. Kilns and continuous retorts are used to produce the charcoal required to make nearly 800,000 tons (725,000 metric tons) per year of briquets. Nearly all the charcoal is used for cooking. There is potential for use of high-strength charcoal in cupola furnaces.

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### INTRODUCTION

The history of the charcoal industry in the United States provides an interesting insight on how the needs of an emerging nation, various world events, new chemical products, and new chemical synthesis processes effected the harvesting and utilization of our forest resources.

For example, our emerging nation required iron and steel products. This required forests to be harvested for the charcoal that was used in the blast furnace. Charcoal was also required for gun powder. Later a world war, the airplane, and the automobile created a need for chemical byproducts from wood such as acetone for munitions and acetate for airplane dope and automobile lacquers. Photography and bakelite created a demand for acetate and formaldehyde from wood. All of these needs for charcoal and chemical byproducts created jobs and prosperity for many people in rural America.

### CHARCOAL PRODUCTION

Charcoal production data for selected years are shown in Table 1. Charcoal production peaked in about 1882, and probably that production peak has never been surpassed since because the 1970, 1980, and 1985 production figures are for charcoal briquets that contain char from other sources along with starch binder and other ingredients.

### EARLY CHARCOAL PRODUCTION

The charcoal iron industry began in the United States with the construction of a furnace about 80 miles from Jamestown, VA, at Falling Creek in about 1620. In 1622 it was destroyed, and there are no written accounts of the furnace operations. In 1645 a furnace was constructed near Saugus, MA, and it operated successfully until 1675. Additional furnaces started up in many localities near iron ore deposits. The iron works were built like plantations and included an entire community of homes, stores, churches, and woodlands.

The early blast furnaces were 20 to 30 feet high with a diameter of 4 to 8 feet. They were constructed on a steep hillside so raw material could be easily charged through the top. They produced 1 to

6 tons of iron per day. About 1 ton of charcoal was required each ton of pig iron.

After the Revolutionary War, ironmaking expanded rapidly when the colonists moved westward. The first blast furnace west of the Alleghany Mountains was built in 1790, and in 1796 a furnace was constructed in Pittsburgh to start the great iron and steel center. Until at least 1832 U.S. pig iron was made with wood charcoal. In 1850 pig iron production was 563,000 tons from 377 furnaces. About one-half was charcoal iron and the other half was made with coal. Charcoal iron production increased until 1880 when about 800,000 tons were produced. This amounted to 14% of the pig iron production, and it required about 700,000 tons of charcoal. By 1892 charcoal pig iron was only about 5% of iron production.

The reduction in the use of charcoal for iron was mainly a result of changing technology to larger blast furnaces. Charcoal does not have adequate strength to support the necessary height of overburden in the higher furnaces. Charcoal was also priced out of use when large quantities were needed for the iron production centers. Vast forests were harvested for charcoal production and the longer distances increased the transportation costs.

The early charcoal was produced in earthen kilns and brick beehive-type kilns (Figs. 1,2,3). Kiln operation to obtain high yields of good quality charcoal was an art gained from experience. The progress of the charcoaling operation was judged by observing the color and amount of smoke leaving the kiln. The earthen kilns had a capacity up to about 10 to 15 cords of wood. The brick beehive-type kiln had a capacity of up to about 30 to 40 cords of wood. The charcoal preferred by the iron industry was the high crushing strength charcoal that could be produced from the dense hardwoods such as maple, birch, beech, oak, and hickory.

#### THE HARD-DISTILLATION INDUSTRY

The hardwood-distillation industry was started in about 1812 with collection and condensation of the gases from a beehive kiln. The collection of the gases from these kilns was cumbersome due to

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multiple stacks, and the gases were contaminated with combustion products resulting from air infiltration into the kiln.

During the latter part of the 1800's, externally heated steel retorts were replacing beehive kilns for hardwood distillation. capacity of most retort plants was in the range of 20 to 100 cords, but a few had capacity up to 225 cords (Fig. 4). They operated on a 24-hour cycle. The byproducts of charcoal production were now crude pyroxigneous acid and noncondensable gases. The charcoal was used for iron and heating. The pyroligneous acid was refined to make acetate of lime, methanol, and tar. The tar was burned to heat the retort, and the noncondensaable gas was burned to dry and preheat the wood.

The hardwood-distillation industry was the precursor of the petrochemical industry. Before petrochemical production, all industrially important organic chemicals were obtained from wood. A list of the chemicals and the yields obtained from wood are in Tables 2 and 3 (1). Wood continued to be the major source of industrial chemicals until the late 1920's. The recovery of acetone as a byproduct of butanol fermentation decreased the importance of l cetone from wood. The biggest blow, however, to the importance of wood chemicals came in 1925 when synthetic methanol arrived from Germany at 45 cents per gallon, which was 32 cents below the price of pure-grade methanol from wood distillation. Commercial Solvents Corporation began the first commercial synthetic methanol production in the United States in Indiana on May 11, 1927, from carbon monoxide and hydrogen collected also as byproduct from butanol production.

In 1930 about 50 hardwood-distillation plants were still in operation, but most closed down during the 1930'a. In 1950 five were still operating, and this number was reduced to one by 1960. In 1969 the last plant located l t Marquette, MI, closed down (Fig. 4). Some of the history of the charcoal production for iron and steel production is chronicled in the Journal of the United States Association of Charcoal Iron Workers that was published occasionally during the 1880's.

#### THE SOFTWOOD-DISTILLATION INDUSTRY

Softwood species were also distilled, but the products were different than obtained from hardwood species. The only commercially successful

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plants used longleaf pine (Pious palustris) lightwood, knots, and stumps. The products were charcoal, and pine tars and oils. Turpentine was refined from the oils. The yield of charcoal was 350 to 400 pounds per ton of wood and turpentine and pine tar yields were 6 to 6 gallons and 20 to 30 gallons, respectively. The softwood distillation industry was not as large as the hardwood-distillation industry. In 1919 Hawley estimated that 12 to 13 plants were operating (2). The last plant, located in Louisiana, operated occasionally during the 1970's.

The construction of the ovens and methods of operation varied considerably between plants. Some were externally heated ovens, similar to those used form hardwoods, with a capacity of about 10 cords. Host, however, were smaller capacity retorts heated by internal flues. Operation varied from collecting all of the distillate externally, as for hardwoods, to collecting the volatile distillates externally and the remaining from the bottom of the kiln.

The charcoal product was used for fuel. The liquids were refined for various end uses. Turpentine was refined from the oil liquids and the remaining oil was refined for solvent, chemical, and phamaceutical uses. The tar was used for cordage, rubber, okum, roofing cements, and pharmaceutical.

#### RECENT CHARCOAL PRODUCTION

During the 1950's, charcoal production begain to increase to meet the demand for its use for restaurant and recreational cooking fuel. Since most of the large wood-distillation plants had ceased operations, new sources were needed. To meet this demand many small kilns were constructed in rural areas to utilize low-grade logs from woodlots and slabs and endings from sawmills.

In 1961 there were 1,977 charcoal-converting units in the United States (3). These included 262 brick lilns, 805 concrete and masonry block kilns, 430 sheet steel kilns, and 480 other units such as retorts and ovens. Ninety-four % of these producing units were located in the eastern portion of the United States and nearly one-third in the central states. The East accounted for 98% of the

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charcoal production. Thirteen large producers accounted for 56% of the total production.

The use of lump charcoal that had been screened to remove pieces less than one-half inch was common. This, however, left no use for the large amount of fines. This accumulation of charcoal fines and the desire to produce a uniformly sized product with uniform burning rates led to the production of briquette charcoal. The briquetting process consists of dry grinding the charcoal and mixing with a starch solution to form a paste. The paste then goes to a double-roll rotary press which delivers the formed briquets to a continuous drier. In about 3 hours the moisture content is reduced from 40% to less than 1%. The briquets may contain charcoal and starch and various amounts of coal, clay, and char from lignite or agricultural residues. The briquets contain as much as 25% ash.

Charcoal is presently produced commercially in either kilns or continuous furnaces from primary wood-processing residues and from low-quality roundwood. A kiln is used if the raw material is in the form of roundwood, sawmill slabs, or edgings. The most common kilns in the United States are constructed of poured concrete (Fig. 5). They have a capacity of from 40 to 100 cords of wood and operate on about a 7- to 12-day cycle. If the raw material is in the form of sawdust, shavings, or milled wood and bark, it is converted to charcoal in a continuous multiple-hearth furnace commonly referred to as a Herreshoff furnace. The capacity is usually at least 1 ton of charcoal per hour. The yield of charcoal is about 25% by weight on a dry basis. The first reference to the use of the Herreshoff furnace for charcoal was reported in 1948 (6). Presently there are about 16 Herreshoff furnaces in operation that produce over one-half of the charcoal that is produced from wood and bark.

To alleviate the air pollution problem associated with charcoal kilns and furnaces, the gases from the kilns and furnaces are burned. The gases can be burned with additional fossil fuel to recover heat and steam (5,6), or in afterburners (7) to nearly eliminate visible air pollution and odors.

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The increase in production since the 1960's reflects the use of charcoal briquets for home and recreational cooking. The charcoal presently produced is nearly all consumed for cooking as charcoal briquets. Some charcoal is used for ferrosilicon production, filtration processes, and horticultural uses.

In the near future, our market for charcoal briquets is expected to continue to grow as it did in the past few years. The raw material supplies, however, will tighten from competition with uses of wood residues for fuel. Thus, the cost of raw material will increase at least as much as the cost of wood fuel increases. Historically, charcoal plants were constructed because of the availability of unused and low-cost wood residue. With increased demand for wood fuel, new sources of assured wood supplies for expansion of charcoal production are difficult to locate. Thus, it is expected that the cost of charcoal will increase at a rate that is higher than the increase in cost of wood fuel.

#### HIGH-STRENGTH CHARCOAL BRIQUETS

There is potential for the use of high-strength charcoal briquets as a portion of the carbon now used in cupola furnaces for the production of cast iron. Many of the furnaces are located in the Great Lakes area near wood supplies and many are heated with coke made from high-quality coal. Special properties required of briquets for use in a cupola furnace include fixed carbon of over 85% and strength adequate to prevent crushing by the overburden in the furnace. Certain size and surface area requirements must also be met to permit adequate flow of gases through the furnace bed and contact with the molten iron. The chemical analysis and strength properties can be evaluated by testing samples, but size and surface area need to be tested by trials in a furnace. It is expected that charcoal briquets could replace a portion of the coke without affecting the cupola furnace operation.

Charcoal briquets made in Japan from densified sawdust briquets appear to have the properties suitable for use in a cupola furnace. The production process involves coating extruded wood briquets that were made by densifying sawdust to a specific gravity of about 1.3. This

coaling process, however, would have to be modified to increase the production rate and to reduce the costs to allow charcoal to be competitive with coke.

#### REFERENCES

1. NELSON, W. G. Waste-wood utilization by the Badger-Stafford process. Industrial and Engineering Chemistry 22(4), 1930, pp. 312-315.
2. HAWLEY, L. F. Wood distillation. The Chemical Catalog Company, Inc., 1923, p. 95.
3. U.S. Department of Agriculture. Charcoal and charcoal briquette production in the United States, 1961. Forest Service, Division of Forest Economics and Marketing Research, 1963.
4. GOOS, A. W., M. A. TREPANIER, and M. K. JOHNSTON. Some experiments in sawdust carbonization. Forest Products Research Society Proceedings, Vol. 2, 1948, pp. 55-59.
5. RIENKS, Jack. Charcoal burner and waste heat systems. In: Wood residue as an energy source, Forest Products Research Society Proceedings No. P-75-13, 1975, pp. 104-106.
6. SPRINGER, Gerald E. Structure and process for reclaiming heat from charcoal production facility. U.S. Patent No. 4,280,878, 1981.
7. HARTWIG, John. Control of emissions from batch-type charcoal kilns. Forest Products Journal 21(9), 1971, pp. 49-50.

**TABLE 1**  
**Charcoal production for selected years**

<b>Year</b>	<b>Thousands of tons</b>
1850	260
1882	700
1905	266
1910	500
1920	200
1930	450
1940	250
1950	250
1960	320
1970 <sup>1</sup>	500
1980 <sup>1</sup>	800
1985 <sup>1,2</sup>	800

<sup>1</sup>Charcoal briquet production from all sources including wood, bark, lignite, coal, and agricultural residue.

<sup>2</sup>Estimated.

TABLE 2  
Yield of various products per ton of dry wood

Intermediate products		Final products	
		Charcoal, lb.	600
		Noncondensable gas, cubic feet	5,000
Total 100% spirits, gal.	5	C.P. methanol, gal.	3
		Methyl acetone, gal.	.7
		Allyl alcohol, gal.	.1
		Ketones, gal.	.2
		Methyl acetate, gal.	1.0
		Soluble tar, gal.	22
Settled tar, gal.	11	Pitch, lb.	66
		Creosote oil, gal.	3
Acetic acid (as 100%), lb.	101	Ethyl acetate, gal.	14.7
		Ethyl formate, gal.	1.3



M151-486

FIGURE 1 : Building a charcoal pit. Connecticut, 1901. (M151



FIGURE 2 : Completed charcoal pit. Ladder is for climbing to the top to repair earth covering during cooling and to open the pit. Cross pieces keep earth from washing down during rains. Connecticut, 1901. (M151 487)



FIGURE 3.--Brick beehive kilns, Coaldale, Colorado, 1916. (H113 959)



FIGURE 4 : This hardwood distillation plant included carbonization and refining facilities for the production of acetic acid, methanol, and charcoal in lump, briquet, and activated forms. Michigan, about 1940. (M113 849)

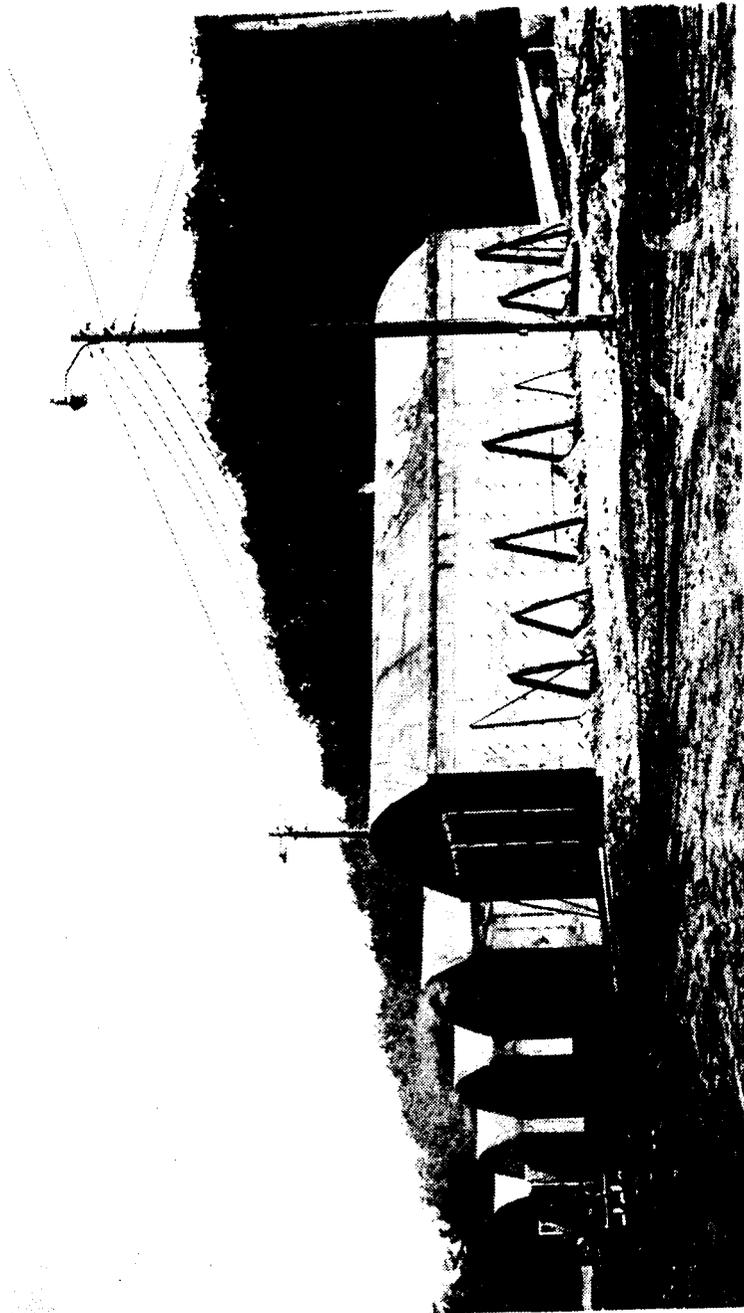


FIGURE 5: Missouri-type poured concrete kilns. Capacity about 50 cords. Burner and stack at right side are to collect and burn wood gases to eliminate air pollution. Wisconsin, 1971.