CHEMICAL UTILIZATION OF WOOD WASTE

1931

No. R945

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin
In Cooperation with the University of Wisconsin

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Before this audience it is not necessary to discuss the amount of wood waste available for utilization. It is common knowledge that wood wastes are large, not only in aggregate, but in proportion to the wood utilized; it is the common and correct opinion that it is very desirable to utilize as much as possible of this waste by present methods of recognized utility and that it is even desirable to make great efforts to develop new methods of utilization. It is possible, however, that we have heard wood waste discussed and deplored so much that we have lost our sense of proportion and have come to think that forestry is unique in its waste production. In order to get a proper perspective on wood waste, it is necessary to compare it with other industrial and agricultural wastes.

The miner leaves in the ground ore that will not pay for mining, he brings in to the smelter and does not utilize a large proportion of gangue, and he leaves in his tailings whatever metal that can not be recovered at a profit. As a single concrete example, the copper miners have brought to the smelter ores that contained less than 1.5 percent copper and have wasted the other 98.5 percent without any qualms or conscience and without any criticism from mining engineers or economists. In fact, they have been praised for developing the mining and smelting methods that made possible the handling and discarding of so much waste with a profit on the whole operation.

Many of the agriculturist's crops consist largely of stems, stalks, or leaves that are either not harvested or are harvested and not utilized. The miller of certain grains separates hulls that he does not utilize. As a concrete example, the corn farmer grows a crop of which about 60 percent is waste and 40 percent grain, a ratio of waste to product only a little lower than that usually ascribed to lumber operations.

In order to make these comparisons convincing it is necessary to foresee and meet the obvious criticism that will be raised against them. The foreseen criticism is that the miner does not waste his metal and the farmer does not waste his grain, but the lumberman does waste his wood; that the miner's and farmer's important wastes are only by-products while the lumberman's largest wastes are in his product and that therefore the comparisons are not permissible.

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[1]Presented at 30th annual meeting, Society of American Foresters, at Washington, D. C., Dec. 29-31, 1930. Published in Jour. Forestry, February 1931.

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It must, however, be kept in mind that, although the lumberman's product is sometimes considered to be the substance wood, yet the value of this product is still largely controlled by the sizes and forms that can be profitably cut from the sizes and forms in which it naturally occurs. Under manufacturing conditions of this kind the by-products of the industry may be of the same substance as the product. It seems permissible, therefore, to compare the by-products of mining and agriculture, which are different in substance from the products, with the by-products of lumbering, which are different only in form from the main products.

It is hoped that this very brief and general comparison of wood waste with other wastes has indicated that the lumber industry is not uniquely culpable in its wastefulness. The previous discussion also shows that the forester has a certain advantage in his attempts to develop methods for waste utilization. Since the waste is largely composed of wood, the same as the product, any research on the fundamental properties of wood, planned to give information of value in connection with more efficient utilization of the product, also gives information of value in the development of new methods for the utilization of the by-products. In other words, the wood technologist does not have to go out of his own field to study wood waste utilization while the corn technologist must enter a new field to study cornstalk utilization.

There is still another point of view for wood waste that is more charitable than the usual one. In most estimates of the amount of mill waste, everything brought to the mill and not sold is considered waste. The facts of the case are that probably 60 percent of the wood usually classified as mill waste is used as fuel by the power plant at the sawmill, or by the mill employees. Such fuelwood is not a direct source of income, but the wood is certainly not wasted and instead should be considered an example of proper waste utilization. Many sawmills also sell fuelwood, but even this wood, which brings direct income, is usually classed as waste. Not only in comparison with other wastes, but in actual proportion of wood harvested there is less wastage of wood than is commonly believed.

The subject of wood waste utilization is so complicated that it is impossible to generalize without becoming inaccurate. In order to reduce the complications it is desirable to limit this discussion to chemical utilization and even to exclude from chemical utilization certain processes that are commonly and perhaps properly considered chemical. In chemical utilization are usually included all processes in which the wood is treated chemically even though the product may owe its value to fibrous or structural properties rather than to chemical properties. This discussion, however, will be limited arbitrarily to those processes that produce chemicals from wood and will therefore exclude the very important pulp, paper, and fiber board products.

Present Status of Chemical Utilization

The present status of the chemical utilization of wood waste is not encouraging. Three processes in commercial operation within the last 15 years using wood as a raw material for oxalic acid, ethyl alcohol, and galactan, respectively, are no longer in operation. Hardwood distillation has been declining for several years on account of competition with new synthetic and fermentation processes that make its principal chemical products, acetic acid, acetone, and methanol. The production of tanning extracts from wood and bark is about stationary, but chestnut is the main species used for this purpose and soon there will be no more chestnut to utilize. There is, however, one promising development so far as present methods are concerned -- the chemical use of wood cellulose is expanding. Specially purified wood cellulose has competed successfully with cotton cellulose as a raw material for making viscose rayon. Its use may expand in this field and there is a possibility that it may even enter the field of other rayons and of other chemical cellulose products.

Except for the further development of this one promising existent process, future progress in chemical utilization will apparently depend largely on new processes. For this reason there is little basis for a discussion of what the future processes are likely to be or what waste or how much waste is likely to be utilized, and such a discussion will not be attempted. There is, however, sufficient basis for a pertinent discussion of the direct and indirect values that may be given to wood waste by chemical utilization and of the effect that the costs and supplies of wood waste may have on developing successful utilization processes.

Effect of Utilization on Value of Waste

It is a common impression that a successful chemical method for wood waste utilization would necessarily give a value to the waste commensurate with the profit on the process. Except under certain unusual conditions, however, such an increase in value would not follow. If the owner of the waste also owns and operates the utilization process, he can charge himself as much as he wants for the waste up to the limit of the profit in the process, or he can figure all his profits on the process and charge off the waste at the cost of handling. If the owner of the waste does not own the process he must take what he can get for his waste in competition with other wood waste producers and this will probably be little more than the cost of handling. The old law of supply and demand rules here and unless the demands of the utilization process (or indirectly, the demands for the products of the utilization process) are greater than the supply of waste suitable for the process the value of the waste to its owners is not materially increased.

There is a well-known example of chemical waste utilization that confirms and elaborates this conclusion. We have heard many times how coal tar, that black, sticky, evil-smelling by-product of the gas industry, through chemical research became the foundation of a new branch of chemistry and the chief raw material for several new industries in which it is transformed into dyes, perfumes, medicinals, explosives, and other important and high-priced articles. This is indeed a beautiful picture and an accurate one. By implication, however, an inaccuracy has crept into the picture; it is commonly implied that these wonderful developments have redounded to the great profit of the producers of coal tar. In order to discuss what has actually happened to coal tar from the point of view of the producer, it is necessary to distinguish two fractions of the crude tar, the light oils and the tar proper, because there are differences in the way they are utilized. The light oils, which make up only a small part of the total tar, are pretty completely utilized, but only a part of them are used in making the high-priced chemicals. Most of them are used as motor fuel or solvent, and the price is therefore controlled by competition with other similar fuels and solvents -- not by their chemical uses. The main fraction of the crude tar, the tar proper, is only about two-thirds utilized, the rest of it being used as fuel at the plant. The use of coal tar as a raw material for making high-priced chemicals has therefore been without effect on its value; the value is controlled by the low-priced uses. One small fraction of the tar is largely utilized and its value has been raised accordingly, but the main part of the tar still has a value only very slightly above its fuel value.

One reason for limiting this paper to those types of "chemical" utilization in which the products are chemicals now becomes evident. The markets for chemicals are likely to be very restricted in comparison with the markets for structural materials, such as paper and fiber boards, and conclusions based on probable extent of the markets do not apply with equal validity to both types of utilization. For applying the "supply-and-demand" principle to wood waste, let us assume that a successful commercial method is developed for making dyes from wood and that the dyes so made replace 30 percent of artificial dyes previously made by other processes. Approximately 1,000,000 pounds of artificial dyes were made in this country in 1929; we may, therefore, assume a demand for 300,000 pounds of wood dyes. If the dyes were produced with a yield of 10 percent of the wood used, 3,000,000 pounds or 1,500 tons of wood per year would be required. This amount is certainly not great enough to have any appreciable effect on the value of wood waste.

It is not meant to imply from these examples that <u>all</u> wood waste must be utilized before the value of any of it is materially increased, but only that all the waste equally suitable for a given process must be utilized. Wood waste is variable in the conditions affecting its suitability for chemical utilization so that certain wastes might command a fairly high price without coming into competition with other waste. The variability may be in chemical composition, in form, or in the supply available without transportation. For instance, beech, birch, maple, and oak, on account of their chemical composition, are especially suitable for hardwood distillation and have never suffered serious competition from other species. In this same waste utilization process the larger forms of waste have been used without serious competition from the smaller forms of waste, even though the latter could be obtained more cheaply. The effect of the available supply on suitability is exemplified by the process for making ethyl alcohol from wood. During the brief period of the commercial operation of this process it was only the largest sawmills that could furnish sufficient mill waste for successful operation.

These examples show that the variability in requirements of different processes may make possible the utilization of various types of waste without competition between types. This discussion of suitability variation also indicates that the utilization methods most likely to add considerably to the value of the waste utilized are those for which only narrowly limited types of waste are suitable.

Cost of Waste

It is not customary to discuss costs of waste because waste is commonly considered to be available for utilization without cost. Of course, costs of collection are sometimes discussed and they are especially significant in connection with wood wastes since there are two kinds, forest waste and mill waste, that vary greatly in cost of collection. Even aside from cost of collection there are costs to be paid, present or prospective, direct or indirect. Let us look at this subject from the standpoint of the technologist interested in developing processes for the chemical utilization of wood waste or in putting such processes into commercial operation, for he is the man that must consider costs. Even though the material is now running to the waste burner, he can not expect to set up a plant on the site of the burner and obtain the waste free of charge. The mill owner naturally wants to get a share of the profits made on the use of his raw material, and the waste utilizer expects to pay enough for the waste to obtain a contract for a continuous supply. So much for present costs. Now suppose that a 5- or 10-year contract is made at a fairly low price and the utilization plant operates apparently successfully until a new contract must be made. This time the sawmill man will get a larger share in the profit because he is in a position to bargain for it. The utilization plant is already built and perhaps the owner would prefer to pay more for his raw material rather than to move his plant elsewhere (or, as happened once, he might prefer to dismantle his plant and go out of business). The wood utilizer must therefore reckon on both present and prospective costs.

Suitable arrangements may often be made for obtaining at a reasonably low price all or a part of the mill waste that is actually waste, i.e., that which goes to the burner. As has been already pointed out, however, certain utilization processes may operate on such a narrow margin of profit that the difference in efficiency between a 100-ton and a 50-ton plant might be equivalent to the difference between a small profit and a small loss. If such a plant is operating at a mill that has only 50 tons of actual waste, it can not expand its operations to a 100-ton capacity without paying a higher price for its raw material. Here is a situation where everyone concerned, especially the sawmill owner, soon realizes that the wood used as fuel is not waste but has a value equivalent to the cost of other fuel to replace it. The wood waste utilizer may be able to obtain small quantities of wood at a low cost, but if he finds that larger quantities are required he must pay at least fuel value for it. It might be suggested that this difficulty could be remedied by collecting forest waste, but the cost of collection is likely to be higher than the fuel value.

It is recognized that this discussion of costs may seem trite and self-evident, but it is known that some of the points brought out have been overlooked in certain expensive attempts at wood waste utilization. The discussion is introduced here largely for the purpose of showing that the most promising chemical wood utilization processes from the standpoint of low cost of raw material are those for which sawmill waste is suitable and small quantities are sufficient.

Competition of Agricultural Wastes

The possibilities of future developments in the chemical utilization of wood waste are affected by a situation that is not commonly recognized as important. There is so great a similarity in chemical composition between wood and various agricultural wastes that the latter may be strong competitors in furnishing the raw material for a chemical utilization process. This is no place to discuss the details of this similarity; but it can be briefly and not inaccurately covered by the statement that the woody stems of most agricultural wastes, such as straws and stalks, are more closely related chemically to the hardwoods than the hardwoods are to the softwoods. In fact, this similarity is close enough so that much of the previous discussion of suitability, costs, effect on values, and availability of supplies applies more properly to wood and agricultural wastes combined than to wood waste alone.

Benefits of Chemical Utilization

It must be recognized that the subject has been discussed so far only from the standpoint of the probable effects of chemical utilization on the value of the waste. This point of view has been purposely chosen in order to correct any impression that the future profits of forestry are likely to be considerably increased by the chemical utilization of wood waste. Stressing this point of view may have given the incorrect impression that attempts to improve waste utilization by chemical methods are not worth while. Only a brief discussion should be necessary to correct such an impression.

While the previous discussion had indicated that chemical utilization is not likely to give a high value to a large amount of wood waste, it has shown that the opportunities are good for giving either a slight increase in value to a comparatively large amount of waste, or a comparatively large value to a small amount of waste. Furthermore, there is so much wood waste available that even a low value given to even a small part of it by chemical utilization would amply repay great efforts to develop the successful waste utilization processes. It should also be emphasized that the very conditions that are unfavorable for the attainment of high values for wood waste, such as the large supplies in comparison with the probable small demands, are extremely favorable for the future expansion of chemical utilization. A chemical manufacturer in these days of large-scale, low-price operations and severe quality competition will not look with favor on a prospective raw material that is not plentiful and cheap and certain to remain so.

What is perhaps the main beneficial effect of waste utilization can not be measured by the direct dollars-and-cents increase in selling price of the waste. As was previously pointed out, if the owner of the waste also operates the utilization process, he may or may not credit the profits of the utilization directly to the value of the waste, but there are still some increased profits that must be credited to the forest from which the raw material came. Even if the owner of the waste does not operate the utilization plant and obtains directly only a low price for the waste, yet there are many general economic benefits that must ultimately accrue to the credit of the forest -- valuable commodities are produced, labor is employed, and capital is profitably invested.

It should also be remembered that chemical utilization of wood waste is more promising in its beneficial effect on forestry than those methods that produce wood substitutes. When the by-products compete with the products, the utilization of by-products becomes a two-edged sword -- the increased profits from the utilization of the by-products may be more than counterbalanced by the loss of market for the main products. The production of chemicals, on the contrary, has no detrimental effect on the market for lumber.

We may confidently expect continued progress in the chemical utilization of wood waste. The chemical industries using cellulose as a raw material have developed very rapidly in the last few years and the opportunity seems good for wood cellulose to furnish an increasing proportion of this raw material. Lignin chemistry is still in a very early stage of development and the commercial utilization of lignin lies all in the future. Since it is so easy to be optimistic about the unknown (and to reason by far-fetched analogies) we should not be censured if we foretell that the eras of coal tar chemistry and cellulose chemistry will be succeeded by an era of lignin chemistry in which the forest will be called upon to furnish raw material for important new chemical industries.