SELECTION OF A WATER WHEEL UNIT.*

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(Continued from last issue.)

It is interesting to note, from Fig. 7, that where K = 20 with loads varying from 70 to 100 per cent. of full load, the per cent. of full load efficiency varies from 100 to 103 per cent. If therefore, the full load efficiency of this particular runner is 82 per cent., the actual efficiency between 70 per cent. and full load would be somewhere between 82 per cent. and 0.82 × 103 or 84½ per cent.

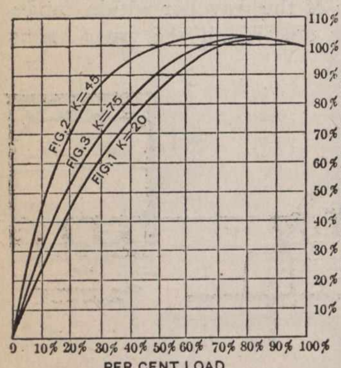

Fig. 7.
Comparative Efficiency Chart.

Let us consider Fig. 8. Here we have plotted the maximum actual efficiency against specific speed. It has been found by experiments which have been made by a number of manufacturing companies from time to time that the specific speed resulting in the highest efficiency is somewhere between K = 40 and K = 50.

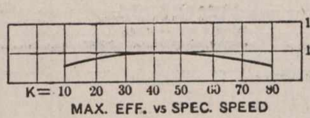

Fig. 8.

A consideration of the factors entering into the design of water wheel runners, and of tests which have been made on various designs, shows that it is not possible to secure as high efficiencies, even though the operating conditions be the most favorable, for specific speeds which are higher or lower than the specific speeds between K = 40 and K = 50. Experiments have also shown that there is a certain best speed for each particular type of runner, which speed gives 100 per cent. power. At all other speeds, either higher or lower, the power is not so great. The variation of power for changes in speed, however, is different in magnitude for different types.

Fig. 9 shows this for two different runners, one where K = 45, the other where K = 75. In this diagram the best speed is shown at the centre ordinate as occuring at 100 per cent. full power, and it will be noted that as the speed is made higher or lower than this best speed, the power drops off for both types of runner. In the case of the runner K = 75, it drops off considerably more than for the type K = 45. For instance, an examination of the charts show that an increase in speed of a Type 2 runner, with K = 45, of 10 per cent. above the best speed, decreases the horse power 4 per cent. while a decrease of 10 per cent. from the best speed decreases the power about 2 per cent. For a runner with K = 75, the horse power is decreased 6 and 4 per cent. respectively.

In Fig. 10 is given a curve showing the relation between variation in head and equivalent variation in speed. This is really a graphical expression of the formula rev. per min. $\propto \sqrt{H}$ or the equivalent expression rev. per min. = (a constant) $\sqrt{H}$. It will be noted by examining this chart that for a variation in head of 20 per cent. there is an equivalent speed variation of 10 per cent. For a variation in head of 40 per cent. there is an equivalent speed variation of nearly 20 per cent. This curve will be of use later on in our discussion.

With information such as the foregoing at hand, we should be able to select the best speeds, power, ratings, etc., for use in any given installation.

Number of Units in the Plant.—In order that a plant may work to best advantage on the load it has to carry, it must be designed to accommodate the characteristics of that load. In making this determination, a careful study should be made of the load curve and the load factor. There are also a number of other matters of importance entering into this particular subject; for instance, the question of whether or not the plant being designed is to operate alone or in parallel with other plants, whether there is to be a spare unit provided, etc. It is not intended to enter into any lengthy discussion of this subject at this time. Unless the purchaser has reliable information for arriving at a decision on the number of units to be used in the plant, it it advisable for him to secure the assistance of an engineer familiar with such subjects.

Size of Generators.—The generator should have a rated output approximately the same as the most economical capacity of the water wheel. It is assumed that an effort will be made to operate the generator as near as possible to its rating. It must be remembered that the most economical point of the wheel varies for different specific speeds. Even though the rev. per min. may not be determined and the specific speed not yet calculated, it can be at once found out from the curve that the maximum horse power of the wheel divided by the kw. rating of the generator should vary from 1.5 to 1.9. This is obtained by dividing the maximum horse power by the horse power at the most economical point and then again by 0.746 to reduce kw. rating. It may thus be said that the maximum horse power of the wheel divided by the kw. rating of the generator will vary from 1.5 to 1.9, depending upon the type of runner to be used. Manufacturers could, therefore, make up a tabulation of the value of this coefficient for their different types of runners. In the first approximation the value of this coefficient might be taken as 1.75, about the average value, and the kw. rating of the generator determined. Later on this could be corrected. The matter of overload should be kept in mind when this point is being worked out.

Standard Speed of Generators.—The electric manufacturing companies can supply tables of speeds for standard generators. Generators with frequencies of 25 and 60 cycles are the most common in use. It is not necessary to give such a table in this paper as it would be altogether too large if it covered all of the standards in use by the electric manufacturing companies. In such a table furnished the writer recently there are to be found for some of the more common sizes of generators met with in modern plants as many as 5 or 6 speeds standardized for each size. For instance, one company has made and is prepared to make a 175-kw. generator of water wheel type for 150, 180, 300, 514, and 600 rev. per min, and for full load voltages of 600 2,300 and 11,000-volts. Several speeds would be considered by the designer before making a choice, and the reasons governing the choice will now be considered.

What Speed of Unit is Based Upon.—The following elements enter into the selection of the speed of the unit: (a) head, (b) characteristic efficiency, (c) runner balancing, (d) speed regulation, (e) variation in head, (f) durability of design. We will discuss these points in order.

(a) Head.—The head is a most important factor in the selection of the speed. Low heads and attendant low

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