of the charge, the amount, pressure and temperature of the air blast must be controlled.

3. *Processes at the puddle mills.* The weight and proportions of the charge and the nature of the furnace lining all have an effect on the resulting quality of iron.

The temperature of the furnace must be controlled. Too high a temperature will result in an inferior quality of iron.

The atmosphere must be controlled. At different stages in the process alternate oxidizing and reducing atmospheres are required.

The method and amount of working while in the furnace and the timing of the various operations are important.

After leaving the furnace the amount of work or percentage of reduction in cross-sectional area in rolling into muck bar has a decided effect on the quality of the finished product.

4. *Processes at heating furnaces and rolling mills (skelp mill).* In the furnaces, temperature, time, atmosphere and materials used in the furnace bottoms must be controlled.

Iron must be brought to the exact welding temperature without overheating and delivered to the rolls at the right temperature. If it is too cold it will not weld; if too hot, quality will be impaired.

Here again, as in the rolling of muck bar, the percentage of reduction in rolling is important. Not only the total amount of reduction but the amount per pass and the particular manner in which it is effected are important.

The product of this rolling is called skelp, which is a flat bar or plate of correct thickness and width to form the required size of pipe.

5. *Processes at pipe furnaces.* At the pipe furnaces the same elements as in the heating furnaces—time, temperature, atmosphere and nature of bottoms—must be controlled.

In forming pipe from the skelp it is necessary to have the iron at the correct temperature at the moment of welding. The edges must be clean and brought together with sufficient pressure to form a sound weld.

The pipe must comply with strict specifications as to diameter, roundness, weight and thickness of wall.

6. *Finishing processes.* In threading, the precautions that are necessary for accurate threads of any type must be taken, but as pipe threads are tapered there is one additional element which is not encountered in bolt threads.

If the pipe is to be galvanized, accurate control of the pickling process is necessary. Pipe must be thoroughly clean and free from scale.

The spelter must be of correct quality and the bath must be at proper temperature when the pipe is dipped. The pipe must remain in the bath long enough to be raised to the temperature of the spelter or it will not take the coating.

All pipe regardless of nature of finish is given a hydrostatic test, the pressure depending upon the size and type of pipe.

Organizing for Standards

With the foregoing points, among others, for which standards might be set, it is obvious that they cannot all be undertaken at once, nor can the problems be handled by any single group. We are proceeding as follows: (1) to determine where and what to standardize; (2) to develop standards and reduce them to writing; (3) to apply and maintain standards.

Various agencies have been found helpful in indicating where standards should be set: market analysis, costs, yields, loss segregation reports by causes, complaints, suggestions, promptness of shipment of orders, accident reports.

Research

In determining points at which standardization should be undertaken we are making constant use of information furnished by the Sales Research Department. Through this department we are kept informed as to standards of finished product required by the trade and these are incorporated into our manufacturing standards as rapidly as possible.

When the need for a standard is established the responsibility for its development rests either with the Industrial Engineering Department or with the Research Department, depending on the nature of the problem.

The development of standards requiring preliminary laboratory research is assigned to the Research Department.

Industrial Engineering

The development of standards which do not require laboratory research is turned over to the Industrial Engineering Department at once. Others may be referred to them after laboratory research has been completed by the Research Department.

The Industrial Engineering Department has responsibility for developing standards and reducing them to writing in standard form. Among the subjects

covered are the following: (1) written standard instructions for responsibility heads; (2) standard specifications for raw materials and supplies; (3) specifications for finished products; (4) standard methods and processes; (5) standard equipment, tools, etc.; (6) standard crews; (7) standard rates of production; (8) standard yields; (9) standards of wage payment—class wages; (10) standards for maintenance; (11) standard costs; (12) standardization of forms, reports, etc.; (13) standard methods of handling and storing raw materials and finished products.

1. *Written standard instructions for responsibility heads.* We are developing written standard practice instructions to define the general responsibilities of each division of our organization together with the relation of one to another.

After the responsibilities of major divisions are clearly defined, we intend to extend these instructions to cover the minor sections, so that eventually each member of the organization will be fully acquainted in writing with his duties and relations to other members of the organization.

2. *Standard specifications for raw materials and supplies.* In order to control our manufacturing process and the quality of our finished product, it is necessary to set up definite specifications for our raw materials. These specifications are being so written that our testing facilities can determine whether or not material offered meets the specifications.

3. *Specifications for finished products.* As a guide for our inspection department, we are developing standard specifications for the quality of our finished products. These specifications when written are also useful as a guide in standardizing our methods, raw materials and rates of production, and consequently have an effect on standard costs.

4. *Standard methods and processes.* As each of our manufacturing methods is investigated it is reduced to writing to record the present approved practice for producing a finished product of standard quality.

As an example, in setting standards on pipe furnaces it is necessary to cover furnace design, preparation of material, furnace time, fuels, temperature, drawing speeds, furnace bottom, forming tools. As fast as better methods are developed the standards will be revised to conform.

5. *Standard equipment and tools.* As a result of standardization of equipment and tools we are decreasing our inventories of numerous kinds of spare parts.

Some of the items with which we are particularly concerned at the present time are electric motors and accessories, packings, taps, dies and chasers.

6. *Standard crews—labor standards.* Through our studies incident to the standardization of methods we are gathering data which are very valuable in determining standard crews for the various operations.

These are being expanded from individual operations to complete departments and eventually will embrace all plants.

7. *Standard rates of production.* Standard rates of production follow naturally from the establishment of standard methods, equipment, tools and crews.

We are building up standard rates of production for each operation. These may be expressed in units per man hour or per machine hour or tons per day, per hour or per turn, etc.

These standards are indispensable in planning and scheduling, and their establishment prepares the ground for a rational approach to a wage-incentive plan.

8. *Standard yields.* Standard yields are closely tied up with standard production. As we use the term it is the ratio of output to input or the percentage of finished product to the amount of material started in the process.

These yields are valuable in planning and scheduling, in the ordering of raw materials and, along with standard production rates, will be useful later in approaching wage incentives.

9. *Standards of wage payment—class wages.* We are giving special study to the matter of wage rates, with the object of adjusting rates of pay so that, as nearly as possible, work will be paid for in proportion to its difficulty, skill required and company value.

In the attempt to standardize wage rates, we found it necessary first to standardize the jobs, or at least their names, so that we should not have similar jobs with different names, or the same name for different jobs in different locations.

We are developing fair class-wage rates for each job, based on job evaluation.

10. *Maintenance standards.* Major repairs are carefully planned and scheduled in advance and estimates of cost are prepared. This, of course, cannot be carried out in emergencies, but such cases fortunately are exceptional.

Before starting on extensive repairs, such as the rebuilding of a pipe furnace, we carefully consider whether we should rebuild according to the existing design, modify the design, or replace with entirely new equipment.