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Cost accounting in the tool steel industry

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FEBRUARY 15, 1923

COST ACCOUNTING IN THE TOOL STEEL INDUSTRY

Such a multitude of departments and operations exist in a plant producing tool steels, that the writer has deemed it advisable to discuss each of these in the order in which the steel passes through them from the time the composing materials are melted until the finished product is shipped.

This article does not describe a cost system which can be used without alteration in any steel mill, but merely outlines the fundamental principles which should be used in designing such a system. Local conditions in a plant where a cost system is to be installed usually make it necessary to design a system suitable to fit these conditions.

There are numberless varieties of tool steels, each differing from all the others in the nature of its composition, such as the amount of carbon and the percentages of the various alloys. The percentages determine its grade and the uses for which it is suitable. Tool steels are produced in all sizes from the smallest gauge of wire that can be drawn, to bars 8 inches in diameter, and in some cases even larger, and while the greatest quantity of it is produced in the form of round and square bars, it is also frequently made into hexagonal and octagonal shapes, and in special shapes made to order. Much of it is also converted into ball bearing rings, discs, blocks, and slabs for use in the making of dies and other tools. Bars of the larger sizes are produced by hammering or rolling, depending on the use the steel is to be put to, and the smaller sizes are produced by hammering, rolling, or drawing.

Melting Department

The figuring of accurate, useful and practical melting costs is one of the most vital parts of costs accounting in a tool steel mill, since it is the first actual manufacturing operation, and unless the costs of this operation are handled correctly, it will be impossible to secure accurate costs on the steel in more advanced stages of manufacture. For this reason the entire attention of the cost man should be devoted to this department until he is sure that the costs being figured for its production are absolutely correct.

The melting departments of most mills producing tool steels only consist of from one to three melting furnaces, and in the most modern plants these furnaces are operated with electric power as the fuel for melting. These furnaces are usually of five, ten, or twenty-five ton capacity, the furnaces of ten and twenty-five tons

capacity having been found to be the most economical to operate. They consist of a steel shell built in elliptical shape, and lined with bricks composed of magnesite or some other non-conducting material, the electric power entering the furnace by means of graphite electrodes passing through the roof and forming an arc through the steel which is to be melted. These furnaces are so arranged that when the steel is ready for pouring they are tilted by an electric motor installed for the purpose, and the melted steel is poured into ladles of five tons capacity, from the bottoms of which it is poured into the ingot molds which have been set up for the purpose.

In most tool steel plants the ingots are made by melting scrap steel of various kinds which has been purchased in the open market from brokers who deal in this class of material, or purchased directly from manufacturing concerns. This scrap is purchased in quantities ranging from lots of one or more carloads in the case of the lower grades of scrap, down to quantities as small as one hundred pounds in the case of the tungsten steel scraps. Experience has proved that due to the fact that the prices paid for scrap of all kinds exclusive of that from tungsten steels, are so nearly the same that it is practical to carry the entire stock of all these various kinds of scrap together in one account on the perpetual inventory records, thereby using one average price for all low priced scrap. In the case of the tungsten steel scrap, the prices paid differ rather sharply, depending upon the shape the scrap is in and the percentage of tungsten it contains. Machine shop turnings of this quality of steel can be purchased in the open market for about one-half of the price of solid scrap of the same grade. It has been found advisable therefore, to carry two accounts for the tungsten steel scrap, one for solids, and one for turnings. In this connection it is necessary that the stock of scrap in these two shapes be kept entirely separate in the scrap storage bins.

The actual cost of each consignment of scrap received should be entered into the perpetual inventory when the weight of the shipment is entered, together with the freight on the shipment, and the cost of unloading it and delivering it to the scrap storage. By observations covering a long period of time, it has been determined that in a plant of this nature from fifteen to thirty per cent of the weight of the good ingots produced in the melting department has been scrapped by the time the steel reaches the shipping department, and that from three to five per cent of it has been lost in scale, the percentage of such losses being much greater on some kinds of steel than on others.

It is apparent therefore, that large quantities of scrap steel are sent from the hammer, rolling, and other departments back to the scrap bins to be remelted. It has been found to be good policy in handling this scrap to establish from time to time standard prices to be used in crediting this scrap to the various operations when it is returned to the scrap bins, and for charging it into the perpetual inventory of scrap. In this connection the most prac-

tical method is to set one price for all the scraps that go into the low-priced scrap account, and two prices on the tungsten steel scrap, one for turnings, and one for solid scrap, although in a plant of this kind, it is a very unusual occurrence for any of this scrap to be in the shape of turnings. While this method may seem somewhat unfair in the case of the tungsten steels, it should be considered that it will give an average cost on all the steel in this scrap stock based on the average percentage of tungsten contained in the scrap. In some plants it may be found desirable to keep a separate perpetual inventory record account for the scrap in each bin, but the plan outlined above has been found very satisfactory in most instances.

The inventory account for each kind of scrap should show the numbers of the various bins in which the scrap carried in that account is stored. All scrap should be recorded when used by these bin numbers even though the name of the scrap is also used, thus making it doubly sure that the perpetual inventory clerk will deduct it from the proper inventory account. This procedure should also be followed in the case of recording the alloys used from the alloy stock to be discussed later.

Many of the materials used in making tool steels are alloys which are in combination with other materials in ores of various kinds, and it is vital that the analysis of each lot received of these ores be recorded on the perpetual inventory. In most cases the analyses of several lots of a similar alloy will be similar enough to permit of their being stored in one bin, and kept in one account in the perpetual inventory with an average analysis of all the lots of material in the bin. In other cases enough difference in the percentage of one or more of the composing elements of some lots exist to cause them to be carried separately.

On account of the great value of many of the materials used in making tool steels, it is advisable to keep in the melting shop proper stocks of materials in only a sufficient quantity for immediate use, but this small stock should be kept replenished at all times, in order that there may be no delays due to lack of materials at the furnaces. The man in charge of the material warehouse, by keeping continually informed a few days in advance, as to what brands of steel are to be melted, can judge for himself what kinds and quantities of materials should be transferred from the warehouse to the stock at the furnaces. This stock of materials should also be carried in the perpetual inventory.

For accurate cost work in this department of the plant, it is necessary to have a separate meter on each melting furnace if the melting is done by electric power, in order that a reading may be taken at the beginning and end of each heat, thereby securing a record of the number of kilowatts of power used in the melting of each heat. In the case of furnaces using oil or other fuel for melting, meters or some other means should be devised for securing an accurate record of the fuel consumed. A separate set of heat num-

bers should be arranged for each furnace, so that the number of any heat will automatically show on which furnace the heat was produced, and a printed form should be designed for heat record purposes, suitable for filing in a loose-leaf binder, with the idea of one sheet being used for each heat made. At the top of the sheet is a space for the entry of the heat number, the grade of steel, and the date of the heat. This form should be so designed as to provide a space for the entry of all materials melted in the heat, giving the name of the material, the number of the bin from which it was taken, in the case of materials where this is possible, and the weight used. The names and weights used of each of the various fluxes should be recorded in a space set aside for the purpose, and a square corner of the sheet should also be set aside for the recording of the time the heat was begun, the time it was poured, and the time consumed in charging the furnace and in making repairs or adjustments between heats. Any delays or special or unusual occurrences should also be recorded in this space, together with the time lost and the reason for the occurrence. In a separate section of the sheet the number and weight of each size of ingots produced, also any parts of ingots, or any ingots which are unfit for use, and any scrap caused by melted steel being spilled are recorded. The correctness of the figures reported on this sheet should be certified to by the foreman of the shop, and if a special man is employed for the weighing of the materials and production, he should be required to certify to the weights given. Some of the details recorded on this form are not absolutely necessary for the computing of costs, but are very vital for use in determining and improving the efficiency of the plant.

At the end of the cost period all of the heat-record sheets for successful heats are so sorted that all the heats for any one brand of steel are together. These heat-record sheets are then summarized on a large form which is designed especially for the purpose, of which one sheet is used for each kind of steel produced. On this sheet a space is provided for each kind of scrap which may have been used, and several blank columns, which are headed with the names of the alloys or other materials used in the kind of steel to be summarized on that particular sheet. There are also spaces for the heat numbers, the weight of ingots produced, the number of kilowatts of electric power used, and the number of hours and minutes the furnace was in operation in producing the heat. By this method all information pertaining to the good heats of any one kind of steel for the month are summarized on one sheet.

The heat-record sheets for heats that have been made and all the ingots which have been rejected and scrapped, are also summarized in exactly the same manner as the good heats, but on another set of summary sheets. The data assembled on these sheets are then transferred to the Melting Cost card shown on page 7.

This card gives a summary of all heats of any one kind of steel produced in the month, showing the total amount, cost per unit,

MELTING SHOP COST RECORD			GRADE OF STEEL
FURNACE NO.	NO. OF HEATS	MONTH	

MATERIALS	WEIGHT	COST PER UNIT	COST	
TOTAL MATERIALS				
DEDUCT SCRAP VALUE OF STEEL SCRAPPED AT FURNACE				
NET COST OF MATERIALS USED				
LABOR HRS. @				
OVERHEAD HRS. @				
ELECTRIC POWER K.W. @				
TOTAL COST				
WEIGHT OF ACCEPTED INGOTS				
COST PER POUND.				
COST PER TON.				

and total value of each variety of materials used, and the same information for the total of all materials used. On the lower part of the card a space is provided for the entry of any scrapped ingots or other scrap, figured at the established scrap credit price for this kind of steel. This value is deducted from the total value of materials used. Spaces are arranged for the entry of the labor and overhead costs of producing the steel. These items should show the number of furnace hours consumed, the labor cost per furnace hour, together with the total labor cost. The overhead cost is entered in the same manner as the labor cost on the furnace hour basis. The number of kilowatts of electric power used, the cost per kilowatt hour, and the total power cost are next entered in the spaces provided for the purpose. The total weight of good ingots produced is entered, also the total cost of making them, and in the right margin are spaces which are continued the full length of the card, in which may be figured the cost per pound or per ton of ingots produced for labor, overhead, materials, and total cost.

LABOR

All labor in the melting department is paid on a day work basis, for the reason that while there are a few men on each furnace whose work is connected with that furnace only, the work of the rest of the men in the department is very evenly divided among all the furnaces in operation. In order to expedite production, however, a bonus system has been established, which consists of a price per ton being paid each man for every ton produced by the department in excess of an established maximum, the price paid as a bonus to each man depending upon his branch of the work, the rate being determined by the degree of importance which his work bears to the production of the department. In the case of men whose labor is devoted to one furnace only, their maximum is determined on the basis of the production of their furnace, and for the other men the total production of the entire department is used as the basis. The regular hourly rates of the men are also determined on the basis of the skill required to do successfully the part of the work to which they are assigned.

One crew of men performs all the work in the department which can be classed as direct labor, inasmuch as the same men prepare the materials to be used in the heats, attend the furnace while it is melting, prepare the molds into which the steel is to be poured, heat the ladles to be used in pouring, pour the steel into the ladles, and from the ladles into the molds, together with all the other various work in connection with the heats. When two or three furnaces are in operation, each averaging a heat every eight hours, very efficient use of labor is obtained. The wages of this crew for the month is reported in one sum by the payroll department, and is distributed over the steel produced on the basis of the furnace hours consumed in the production of the steel of each brand.

The total wages paid the cranemen, repair men, and any other indirect labor men in the department are reported separately and are considered in the discussion of Overhead.

OVERHEAD

On account of the fact that occasionally a furnace has to be out of use for a time to be relined, or for other repairs, and also for repairs that have to be made to the other equipment, thus causing the overhead expense in a cost period when such repairs are made to soar very high, and because in periods when such repairs are lighter, a much lower overhead expense results, it has been found that the most practical way of handling the overhead expense is by means of a predetermined overhead rate. This rate should be revised from time to time, as the actual expenses of the department show that it is too high or too low. By this method the violent fluctuations in the cost due to repairs are avoided, and in addition the great differences in the costs caused by varying amounts of production, are avoided, thus producing uniformity without sacrificing accuracy.

However, the amount of overhead expense absorbed in the costs should be carefully considered each month in comparison with the actual expenses of the department. The predetermined rates should be revised frequently enough to take up any considerable difference in the departmental expense in either direction.

The overhead expense of this department, as in the case of all other departments in the plant, should be compiled on a Summary of Expense, arranged in such manner that the amount of money expended for each item of expense in each department can readily be compared from month to month.

The principal items of overhead expense to be considered are the depreciation for the current cost period on the equipment of the department, the interest on the investment in that equipment (if the policy of the company is to charge interest on the investment into the costs), the maintenance charges made against the department for work done by other departments, the labor of the cranemen, the department's own repair men, and any other indirect labor, salaries of the foremen and clerks, if any, fuel oil, electric power for any purpose except as fuel for melting, the charges for water used, mill supplies, the proportion of the general expenses of the plant which should properly go to this department, and any other charges of such nature.

The expense of operating the laboratory should be recorded on the Expense Summary in detail in a separate account, and a proper part of the total charged into the overhead of the melting department for the work done in analyzing the molten steel while in the furnaces.

Many of the supplies used in the department, such as the electrodes for the furnaces, cooling pots, molds, bricks, and various

other items, are stored in the warehouse where all the supplies for the entire plant are stored, and are issued from there only on a requisition signed by the foreman of the department. They are charged into the overhead expense and deducted from the perpetual inventory. In some plants, however, it may be found desirable to keep these supplies in the warehouse with the alloys and other materials, but the procedure for requisitioning and charging them would be the same.

The overhead expense is distributed over the costs on the basis of the furnace hours consumed in the same manner as the labor is distributed, as it has been found by careful observation over a considerable period of time, that the only difference that exists in the cost of producing ingots of the various kinds of steel, exclusive of the difference in the cost of the materials used, lies in the difference in the amount of time and fuel expense used in melting the heats. For this reason the most logical way to distribute the labor cost and overhead expense over the steel produced is by the use of furnace hours as a basis for distribution. In this way the heats which are more expensive to produce, because of the greater amount of time required, will receive their proper share of the labor and burden.

Electric Power

The electric power used as fuel for melting is charged to the cost of the steel direct by means of the melting cost card, and is charged at its actual cost per kilowatt hour, whether the power is generated in the plant or purchased from a power company.

Perpetual Inventory

In this industry it is necessary to operate a perpetual inventory of work in process in which an account is carried for each brand of steel in the form of ingots, one for each in the form of billets, and another in the form of bars. The weight and total cost of the ingots represented by each melting cost card are entered into the perpetual inventory account for that particular brand of steel, and an average cost computed including the ingots already shown in the account as on hand.

Chipping and Grinding Departments

Before being hammered or rolled, all ingots are either chipped or ground, in order to remove any external defective spots in the surface of the steel. The harder varieties of steel are ground, while the softer grades are chipped. These two departments are maintained entirely separately, and the costs while figured in a similar manner in both these departments are entirely independent of each other in every respect.

Records are kept in each of these departments, showing the

weight of each kind of steel chipped or ground. This information is summarized at the end of the month and the labor, and predetermined overhead expense is distributed on the basis of the weight of each kind of steel. The cost thus obtained is added to the proper accounts in the perpetual inventory of ingots. If, as occasionally happens, some billets are also ground or chipped, the cost of doing so is added to the billet inventory.

COGGING

The first hammering or rolling operation, through which an ingot is put is called Cogging. In most steel mills this work is done both by hammers and by rolling mills, the brand of steel and the use it is to be put to, being the factors which determine in which manner it is to be done.

In order to obtain costs on this operation it is necessary to maintain records which will show for each lot put through the hammer or rolling mill, the order number, size of ingots, brand of steel, the weight of the ingots, of the resulting billets, and the scrap made in the operation. If the costs on this operation are to be computed on the basis of time consumed in cogging, the time of starting and finishing the lot must also be recorded. In plants where large lots of steel are produced, the time basis will be found to be the most logical, but in plants where small lots are the rule, in order to save detail work, it is advisable to compute the costs on the basis of the weight of steel of each brand produced. At the end of the month all lots of each separate brand of steel should be brought together in a similar manner to the summarizing of the work in the melting department, and the labor and overhead expense distributed on the machine hour basis.

FINISHING

Finishing the steel from the billet shape to that of finished bars is also done on both hammers and rolling mills, and the records kept are in exactly the same form as those for Cogging. The costs of Finishing are likewise computed in the same manner as those of Cogging.

In arranging the cost card forms for both Cogging and Finishing, the same form is used with the exception of the heading, and contains the date, brand of steel, a space for the weight and value of the ingots or billets used, as the case may be, a space for the crediting of the value of any steel scrapped in the operation and upon inspection after completion, a space for the overhead and labor cost of the operation, and one for the weight of good billets or bars secured from the operation, together with their total cost. The total weight and cost of the billets or bars thus obtained are added to the proper accounts in the perpetual inventory, and the weight and cost of the ingots and billets used in making them are deducted from the proper accounts.

Inspection and Annealing

The Inspection and Annealing departments each furnish daily reports of the total weight of each brand of steel which passes through their departments, together with the weight of any steel which they reject and scrap. At the end of the month a summary is made up showing the total weight of each brand worked on during the month and the total weight of each brand scrapped. The overhead and labor of the two departments are then distributed on the basis of these weights and added to the accounts for the respective steels in the finished stock. The weight and scrap value of the steel scrapped in each of these two departments are also deducted from this part of the perpetual inventory, and an average cost figured on the finished stock.

Plant Administration Expense

Plant administration expense includes such items as the salary of the Plant Manager and any of his assistants, whose time is not chargeable to any definite department, the salaries of any general plant clerical employees, the rent, salaries, wages and other expenses of the production office, the finished stock warehouse, and any other expense which is chargeable to the plant as a whole, and which is actual manufacturing expense. In the amount thus distributed no part of the general administration expenses of the business is included.

As the plant administration would be a necessary expense in the manufacture of the production, and as it applies to the product in all stages of manufacture from the raw materials to the finished steel, it is deemed proper to distribute it over the steel at the time of its entry into the finished stock warehouse.

In the business of manufacturing tool steels, experience has shown that because the higher cost steels require more skill in producing, as well as more expensive materials, a larger proportion of plant administration expense should be charged to such brands, than to the lower cost steels, and that such increases are in direct proportion to the increased manufacturing cost of these brands. As these conditions exist to an equal extent all the way through the various processes, it was determined to be fair policy to distribute this administration expense on a percentage basis over the costs of the steel going into the warehouse. It will, therefore, be seen that should any of the products be sold, upon which fewer of the operations have been performed than on others, such products would by this method receive only their fair proportion of the Plant Administration Expense.

The man in charge of the warehouse where the steel is placed when finished makes a daily report to the cost department showing the weight of each kind of steel received into the warehouse. These reports are summarized at the end of the month, and on a form especially designed for the purpose the total cost of each of these

brands put into the warehouse stock is figured, using the average cost in the finished stock accounts as a basis. To this cost the administration expense of the plant is added on a percentage basis, and a total cost made for each steel including the administration expense.

From this sheet the entries to the perpetual inventory of finished stock and to the inventory of warehouse stock are made. The weight and value before adding the administration expense are used in making the deduction from finished stock, and the cost after adding the administration expense for making the addition to the warehouse stock, which accounts are also averaged each month.

Cost of Sales

At the end of the month the total weight of each brand of steel shipped during the month is entered on the cost of sales sheet. It shows the names of the various classes of steel shipped in the month, the total weight shipped, the cost per unit of weight, as taken from the warehouse stock record, the total cost, the selling expense, and the total of the cost plus the selling expense.

The selling expense is distributed on a percentage basis over the cost of the steel shipped during the month, and as in the case of the manufacturing overhead expense, a predetermined rate is used for this purpose. In some plants it might be found advisable to distribute the selling expense, and possibly the administration expense also, on a per pound basis, although ordinarily the basis of percentage of cost is the most practical, as in this way the higher cost steels, which as a rule should carry a greater selling expense, receive their due proportion.

The weight and total cost before adding the selling expense are deducted from the perpetual inventory of warehouse stock, and a balance made of the steel remaining on the record.

Sales Analysis

At the end of each month a sales analysis is made. It shows the names of the various kinds of steel, the weight of each brand sold in the month, the billed value, the average selling price per pound, the total cost of each brand, the cost per pound, the profit made or loss sustained on each brand, the gain or loss per pound, and in percentage relation to the cost of the steel. The footings at the bottom of this sheet indicate the total weight and billed value of the month's shipments, the average billed value per pound, the total cost, and cost per pound, and the total profit or loss per pound and in total.

Additional statistics could be added to this sales analysis should they be found to be of value to the management.

Conclusion

In outlining a cost system for use in a tool steel mill, the writer has attempted to describe only the important steps which it is

necessary to take in order to secure costs in this branch of manufacture. It is not to be assumed that these steps can be used successfully without change in any steel mill, as changes must be made to fit the local conditions in the plant where the system is being installed.

There are many steps of lesser importance than those discussed in this article, and many obstacles to be overcome in most plants, which it is impossible to foresee and to discuss here.

The writer has not attempted to discuss the steps necessary to "tie in" the cost system with the financial books, which is a necessary part of any cost system in any line of business. Neither has he attempted to outline an expense summary in which the overhead expenses of the various departments are assembled. All of these are matters, the principles of which are very similar in all cost systems, and the writer has deemed it unnecessary to take them up.

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