

HOW TO DEAL WITH THE VIEWS AND DIMENSIONS OF THE WORKING DRAWING

Prof. Dr. Tadashi SEIKE

Introduction

The views which have been produced in drawings heretofore belong to either of the following ;

1. Those in the condition convenient for the users after the construction
2. Those in the condition convenient for shop practice

and those in the category of the former have been predominant as the statistics show. But this is a mistake. The working drawings to be used in the engineering industry which performs all its work through drawings, should have the latter in view.

The working drawing is the guide of production and the foundation of factory management and has the most profound relationship with operations, as it directly affects work efficiency of operations proper in their routine, and it is strongly desired from the side of its users that a working drawing be made ;

1. In the form most suitable for working
2. With all the necessary information given clearly so that it can be got on the spot.

The drawings to be directly coupled with operations are to be made with a special view to meeting the requirements of work efficiency, especially the results of operations study which form the most important element in determining the projections. Little consideration, however, has been given to this, as the statistics on the drawings hitherto made show, and it is not too much to say that there has been no study attempted or no literature available in this field.

To rationalize the drawing on the foundation of motion study, the following must be synthetically brought into consideration ;

1. Working importance for the users of the drawing,
2. The results of motion study for the draftsman.

The author gives following four laws for setting the principal projection which represents the whole view of the working drawing.

1. How to deal with the views and dimension of the working drawings
2. How to deal with the principal center line of the working drawings
3. Which side of the principal projection is the most important
4. The law of true shape description.

There will be made no mention here about the problems of promoting technical work efficiency by improving working technique, and those problems of human work efficiency belonging to the field of psychological study such as aptitude test or posting a right man in the right place. The author is going to state how to improve work efficiency solely in relation to the drawings that directly affects operations.

1. The shape of machine parts and the kind of work most dependent on the drawing.

As the objects of operations research in the work performed by means of

drawings, "machine parts which most frequently appear on the drawing" and "the kind of work which most frequently uses the drawing" are to be considered first.

1.1 The fundamental forms of machine parts that appear most frequently on the drawing.

The shape of machine parts as the objects of machining in iron works is quite varied but "bodies of revolution" are quite predominant, as the following table shows, in which A is the data from the aforesaid examples taken at random and B from the most common 4 ft. gap lathe.

Shape	A: General machine parts (293 ex'ples)			B: Parts of 4 ft. gap lathe (130 ex'ples)		
Body of revolution			246 (84%)			89 (68.5%)
body of rev. with single principal center line		243			85	
shaft	25			15		
ring	60			15		
wheel	77			16		
body of rev. (general)	72			39		
body of rev. with multiple principal center line		12			4	
Body due to appearance			41			22
body due to app. (general)		15	(14%)		8	(16.8%)
flat body		8			7	
body of planing		10			7	
body with screen formed cross section		4				
Body due to cross section			6			
Built-up body			4			23

1.2 The kind of work in machine shops most in need of drawings

The kind of work in common machine shops that uses drawings most often is turning and planing and to those the objects of drafting the working drawings should be directed. The following data show the ratio of the turners' analyzed working hours to the daily average of their practical working hours, and show the result of time study extending for about half a year with several 8 ft. lathes in a factory that specializes in producing the dynamo-electric machinery, limited for new products, for each of which new drawings are used.

1. Time for preparation of works and putting things in order 3 to 8%
2. Time for reading the drawings before operations 10 to 20%
3. Time for fitting works and machine tools 5 to 20%
4. Actual cutting duration 30 to 50%
5. Time for indirect operation 10 to 20%
6. Time for measuring 5 to 10%
7. Waiting time 10 to 40%

Among these, the actual cutting duration is the time when chips are actually coming out of the work, and yet it is so short a time as to comprise only 30 to 50% of the whole working hours.

The time for indirect working is divided into the following four items; "time for machine" like the time for regulation of feed or change of revolution, "time

for tools" like the time spent in changing or in regrinding the cutting tools, "time for works" in fitting and removing the works, and last, "time for drawings" spent in reading the drawings and changing the operations at every tact. The time spent in measuring is part of the time for indirect operations. Stopping the machine at every tact, the worker usually proceeds to the next. Waiting time is the time when the worker is away from his working post and does not contain the inevitable time loss resulting from electric stoppage or materials shortage, and most of it is spent in fetching or returning the materials, tools or drawings as the occasion requires, and in asking questions about the doubts in the drawings, especially the latter.

2. Delay of operations due to the drawing

2.1 Delay of operations resulting from ambiguity of drawings

The delay of operations due to the drawing results, directly from reading the drawing, indirectly from measuring, waiting and so on. "The time for reading the drawing" has been indeed considered in time study, but what it is has not been explained. The real reading time is divided in two kinds, the first for reading and digesting the drawing before setting to work and is spent to decide

1. How to fix the work
2. What kind of tools and fixtures to prepare
3. How many revolutions to give to the machine
4. Where and how to begin working.

The second is included in the time for indirect working and measuring, and is spent separately during operations as the occasion requires, and though the drawing is used here also, "each very short separate time for reading the drawing" is very difficult to distinguish from the actual working duration, thus making it almost impossible to measure the time by a stop-watch in time study.

Besides these, as to the delay of operations due to imperfect drawings, time spent by a worker leaving his working post or asking his foreman or draftsman to come to him to clear away his doubts about the drawing, can also be counted as belonging to the waiting time.

Therefore, the length of time which a worker is obliged to spend in reading a drawing is considerably greater than that shown on the statistics, and according to the author's experiences, it amounts to at least over twice the net reading time on the average and comes next to the actual cutting duration. Moreover, as a loss due to imperfection of drawings, misreading often causes failure and necessitates remanufacturing.

2.2 Delay of operations the draftsman is responsible for

All the delay of operations caused by the drawing has hitherto been attributed to the workers alone and their illiteracy has been considered to be solely responsible for that; and no cure was thought possible for it without educating the workers. The author strongly against this opinion, and has long been insisting that the whole responsibility lies upon the draftsman. According to the author's experiences extending for many years, "incomprehensibility of drawings" has much to do with the situation, as a great many examples illustrate. The most important fact is that a lot of drawings are being made without any consideration of the users who are not "specialists" in drawing, but to read such drawings much knowledge of drawing, or all kind of technical and mathe-

mathematical knowledge is required.

2.3 Defects hitherto shown in projections and dimensions

Users' difficulty in understanding drawings can be considered as result from both projections and dimensions. As for projections, the following are the main points to take care of;

1. In case one projection can represent the whole view, other technically needless projections are often added, with the result that the users are not sure which one to use for their operation
2. No one of several projections conforms to the condition of the production in its normal working position
3. Though there are more than two projections described, no connection is shown between these
4. Because of illogical representation of the main object of description, the portions, for instance, which exist on different planes are piled up on the same view, irrespective of need for operations, or no indication is given to a projection to show the primary object of description or the relationship between the bases to represent the part described and the whole is also very difficult to make out
5. Though one of several projections described may conform to the normal working position of the production, the most important dimensions are placed elsewhere
6. Inseparable dimensions are placed on several projections separately
7. Many dimensions are placed in utter neglect of the **indication** which they should possess. Especially the dimensions for cylindrical parts are shown as diagonal diameters which have no "indication" and though they are not on the same plane are placed on the same view
8. Dimensions are not at all placed in good order.

3. Benefits gained by directly coupling the drawing with operations

With the drawing directly coupled with operations, logical measures must be taken for actual operations both with the "projections" and the "dimensions and notes". The author emphasizes "to build a correct principal projection and try to enforce it materially" as for the projections, and "to enforce the indication" as for the dimensions including notes.

In a drawing directly coupled with operations, following benefits can be obtained from the standpoint of production engineering.

1. Improvement of work efficiency
 - a. Decrease of the time for reading the drawing
 - b. Decrease of the time for indirect operations, including measuring
 - c. Decrease of loss through errors and failures as a result of misreading of the drawing
2. Benefits gained if the drafting room management through their rationalization
 - a. Uniformity of projections
 - b. Location of proper dimensions on the projections must be similar and be based on operations
 - c. Standardization based on operations
 - d. Logical comparative study
3. Benefits in production control

- a. Complete legibility of the drawing even for an illiterate is obtained through through-going simplification of views
- b. All the information except that pertaining the principal object is given in the heading or in the remarks of the drawing
- c. As a result, material and human arrangement is performed systematically and accurately
- d. Patterns and special tools necessary for operations are known at the time of issuing the drawing, and preparation can be started simultaneously.

4. The principal projection directly coupled with operations

4.1 Requirements of the principal projection viewed from the side of the users

What is most important for the users of drawings is that emphasis be focused exclusively on the proper projection that represents the whole view so that their need may be satisfied at a glance. The author calls this the **principal projection**.

The works in the normal position must completely correspond with one another in the same condition.

1. As for the practical problems regarding the position
 - a. Fit the center line that is to represent the principal projection, i.e. the principal center line, with the **normal working position**, and decide whether to describe vertically or horizontally,
 - b. Examine closely where to put emphasis, whether on the right side or on the left, in case the center line is horizontal, or whether on the upper side or on the lower side, in case it is vertical.
2. As for the dimensions
 - a. The dimensions must be arranged in the order that needs occur in the course of operation,
 - b. The actual positions that must be measured along with operations are to correspond with those in the drawing,
 - c. The position where the cutting tools, drills, cutters, etc. are to be applied, and the direction of feed must be clearly shown on the drawing.
3. All the tools and fixtures necessary for operations must be arranged through the drawing
4. Description must be made so that they may be of advantage also for the subordinate jobs to help operations.

4.2 Requirements of the principal projection viewed from the side of the draftsman

The following are the requirements of the principal projection ;

1. The principal projection must conform to the results of motion study made from the standpoints of the next three, i.e. general workers, users of drawings and draftsmen
2. The position of the principal projection described on a sheet of drawing must be quite logical from the standpoint of drafting room management
3. The shape of the principal projection must be as simple as can be
4. Concentrate everything on the principal projection
5. All the projections made from unavoidable necessity must be described to make up for the insufficiency of the principal projection
6. The indication of the depth of the principal projection must remain within the limit of the least necessity.

5. The numerical value and the indication of dimensions to make the drawing directly coupled with operations

In coupling the drawing with operations, there are two means according to their condition;

1. To couple the principal projection (including dimensions) with operations
2. To place dimensions (including notes) on the projection which takes a proper position in the drawing so that it may be coupled with operations.

The author's opinion is that for the former, **distance dimension**, and for the latter, **size dimension** must be used.

5.1 Distance dimensions

In this case, it is the method generally used to show the dimension of distance between two points that needs dimensioning by a dimension line with arrowheads on both ends containing the numerical value between the two extension lines drawn perpendicularly to the line that connects these two points. But these two points in the drawing made primarily for production rarely indicate the distance only between the two geometrical points, but, in fact, indicate almost without exception, points on a portion of a solid.

On the other hand, to decide the distance between these two points is to do dimensioning in anticipation of the machinist's skillfulness, if in this case some special machining procedure for mass production is not applied.

In Figure the numerical value l not only determines the distance between A and B, but also it fixes, as the basis of a solid, other conditions of dimensioning, as, e.g. in connection with the point A, it denotes

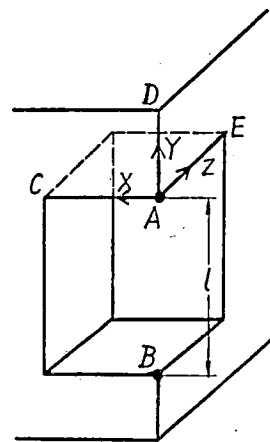
Through direction AX to limiting point C (opposite direction to the extension line)

Through direction AY to limiting point D (perpendicular to the extension line)

Through direction AZ to limiting point E (perpendicular to the extension line)

As for the point B we can say the same.

The author calls these three—**point, direction and limit—indication of dimensions** and maintains that they are the most important factors for dimension-setting, and also calls this kind of dimensions with indication which anticipates the machinist's skillfulness, the **distance dimension**, and wants to emphasize that the most important thing in dimensioning in the drawing that aims at improving work efficiency, is to show the "numerical value by the dimension lines" and the "indication by the extension lines".



5.2 Size dimensions

For example, in drilling, unlike in turning, the results of machining has nothing to do with the machinist's skillfulness, and one must be satisfied with the dimension that may be finished. The dimension of a hole is altogether different from that of distance as in the case of turning, and is a proper dimension naturally finished in so called nominal size, and worker's skillfulness has nothing to do with it. The author calls this size dimension and attaches special significance to it. In this kind of dimensioning it is difficult to couple the view with operations and so the dimensions must be coupled with operations.