Fatigue

Under the inadequate heading "fatigue" there has been rather generally included, apart from "necessary" or "unnecessary" delays, any variation between the actual time consumed in performing an operation and the sum of the unit times for its component elements, as indicated by observations over a period of one or more days. While, in some classes of work, such variation may in a large measure be due to fatigue, experience indicates that in many occupations fatigue is a negligible factor so far as it affects either the worker's performance or well-being. In the latter, fatigue is compensated for by the inherently diversified nature of suboperations or by periods of inactivity during which the worker is only required to keep an eye on machine operation and make an occasional adjustment. Typical of this is a large part of the work performed in general machine shops, in weaving, in knitting hosiery, in printing, etc. In some classes of work the method may be so devised that fatigue is offset by having the operator perform a useful incidental operation. An example of this was cited in my paper "Standards." Each girl folding handkerchiefs had to get up from her work-place after each twenty-five dozen, remove an empty tray and replace it with one filled with handkerchiefs to be folded; at another stage she was required to change a container filled with folded handkerchiefs for an empty one.

The theory that it is desirable to create conditions which will make it unnecessary for an operator to move from his or her working position for anything but personal needs is, in most instances, a mistaken one.

Muscular fatigue may occur in either heavy, laborious work, such as Taylor referred to in his description of handling pig iron, or in light, repetitive operations, such as he described in his example of inspecting bicycle balls. Taylor and Barth determined through their experiments at Bethlehem a law governing fatigue in heavy, laborious work. Taylor stated that a first-class laborer, suited to work such as handling pig iron, could be under load only 42 per cent of the day and must be free from load 58 per cent of the day. Practically, these men were made to take a rest, generally by sitting down, after loading ten or twenty pigs. This rest was in addition to the time that it took them to walk back from the car to the pile. If rests occurred after handling every twenty pigs, they would have come at the end of every 8.64 minutes during the day and have been of 1.77 minutes duration. Taylor further stated:

> As the weight grows lighter the man can remain under load during a larger and larger percentage of the day, until finally a load is reached which he can carry in his hands all day long without being tired out. When that point has been arrived at this law ceases to be useful as a guide to a laborer's endurance, and some other law must be found which indicates the man's capacity for work."

With regard to fatigue in the case of the bicycle-ball job, a careful examination was made of the way in which each girl spent her time. An accurate time study was undertaken, through the use of the stop watch and record blanks, to determine how fast each kind of inspection should be done, and to establish the exact conditions under which each girl could do her quickest and best work without danger from overfatigue or exhaustion. Even when the hours of labor had been shortened from ten and a half to eight and a half *a close observation of the girls showed* that after about an hour and one-half of consecutive work they began to get nervous. *It is wise to stop short of the point at which overstrain begins* and therefore ten-minute periods for recreation were arranged at the end of each hour and one-quarter. During these recess periods the girls were obliged to stop work, leave their seats and get a complete change of occupation by walking around and talking, etc.[45]

Here we have two concrete examples of determination of fatigue and provision to offset it, both of which are based on studies made over thirty years ago. It is interesting to note that H. L. Gantt was General Superintendent of the factory in which the "bicycle ball" experience took place and that S. E. Thompson made the studies in the course of reorganization work under Taylor's direction. One of the examples covers work calling for nothing but heavy muscular effort, while the other relates to the lightest kind of work in which concentrated attention of eye and mind, together with dexterity and speed are necessary. In the first instance, the allowance for fatigue or rest periods was 20 per cent of the active time, at intervals of 8.64 minutes, and in the second, the allowance for fatigue, strain

[44] *The Principles of Scientific Management, op. cit.*, p. 58.

[45] *Shop Management, op. cit.*, pp. 85-91. Also, *The Principles of Scientific Management, op. cit.* pp. 91-92.

or nervousness amounted to 13.3 per cent of the actual working time while the rest periods were only necessary every hour and a quarter.

From my own experience, I would cite a case in which girls performed light, repetitive work which called for speed, dexterity and keenness of vision. The operation consisted of twelve simple, elementary motions consuming one-tenth of a minute in all. It was here found that fatigue began to be apparent at the end of fifty-five minutes and that three minutes of rest offset it. Another instance involved making small molds on a machine in a foundry and required skill and speed, together with the handling of the finished mold weighing about thirty pounds. This operation consisted of forty-one elements and took 1.85 minutes to perform. It was found that fatigue became evident at the end of forty minutes and that five minutes of rest offset it. Time study in the two latter instances indicated fatigue unmistakably. For instance, it was found in the molding operation that, when the worker started a run of molds, the time for the first mold was about 15 per cent longer than the standard; each succeeding one was a little less until after about five molds he got into his stride and turned out mold after mold in the standard time until fatigue manifested itself. Then the time per mold fluctuated in a most erratic fashion. The fluctuation was obviously due to fumbling.

It would appear that fatigue, where it is a factor to be dealt with, does not gradually build up as the day progresses with a proportional slowing down in speed. My experience has indicated that operators engaged in the performance of properly set tasks under standardized conditions will work at the same rate during any period of the day.

The type of rest period referred to above is of undoubted importance in regard to both the attainment of high production and the worker's well-being. To date time study of each class of work done in each establishment seems to be the most practicable means of determining whether or not rest periods are needed and how frequently they should occur.

The value and necessity for general rest periods, or recesses, of ten or fifteen minutes in the middle of the forenoon and afternoon is, I believe, in many instances open to question. Too often they are inaugurated because someone thinks it would be the kindly and nice thing to do without any facts upon which to base such a conclusion or to prove its justification. If the work is of such a character as to require rest periods of the type discussed and if time is allowed for them, and for personal needs, it may be asked "What need can there be for these mid-morning and mid-afternoon recesses?" It would seem logical to assume that they are not necessary where an operator works on several different jobs during the day, especially where each job is of such a varied nature that neither fatigue nor monotony is a factor and where the worker leaves his machine to change his job time card after completing each job and to take care of bodily needs. On the other hand, it would seem that, if work is monotonous even though not fatiguing, or if it calls for a degree of concentration, or is performed in surroundings that induce nervousness, recesses might be necessary. Perhaps the best argument that can be advanced for them is that they may contribute to keeping the workers contented through the opportunity that they offer for recreation or social intercourse. In Japan I found the practice of having morning and afternoon rest periods almost general, and in a number of plants everyone, from the officials down, devoted a part of such periods to calisthenics in groups, under a leader.

As Mr. Stearns says in his paper to which I have previously referred: "Untold quantities of material have been prepared by innumerable authorities on the loss of productive power in the worker because of fatigue, the value of rest periods to offset this evil, and the effect of incorrect lighting, unsanitary working conditions, etc., in slowing down production." And yet, so far as I know, the laws governing fatigue have not been ascertained except as they may apply to individual cases, nor have results of investigation been so formulated as to be of help to the engineer and manager in dealing with specific, practical production problems.

Laboratory research in regard to fatigue, so far as I am acquainted with it, has not been of such a nature as to make results directly usable in the determination of allowances for fatigue. In this, as in the selection of workers, there is need for effective co-operation of the engineer and manager with specialists in other fields, to the end that results may be both more scientific and more practical. This is, however, management's problem primarily and the initiative in its solution must