Workload analyse of assembling process

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Abstract. The workload is the most important indicator for managers responsible of industrial technological processes no matter if these are automated, mechanized or simply manual in each case, machines or workers will be in the focus of workload measurements. The paper deals with workload analyses made to a most part manual assembling technology for roller bearings assembling process, executed in a big company, with integrated bearings manufacturing processes. In this analyses the delay sample technique have been used to identify and divide all bearing assemblers activities, to get information about time parts from 480 minutes day work time that workers allow to each activity. The developed study shows some ways to increase the process productivity without supplementary investments and also indicated the process automation could be the solution to gain maximum productivity.

1. Introduction

The assembling process could be considered the most important part of a technological process because it will put the manufacturer in position to go into the free market and take from it the monetary value of lot of work and resources introduced in the product. Few specialists could think that technological process relates with engineering, but nowadays is intensively used the term procedure for all profit or nonprofit activities, covered by quality management system. Speaking about technology like successive steps leading to fulfillment objectives, the humankind development could be seen in connection with technology starting with i) primary technologies till the first industrial revolution, ii) strong development of mature technologies that build modern society and finally with iii) emerging technologies, trying to solve the great problems of humanity. Technologies could use a great degree of automation but always the decisions and the control would be attributed to human that will have a great influence on efficiency of managed procedure for maximum efficiency in proper conditions for workers.

In this communication the work delay study method will be presented together with some results, obtain when it was applied for assembling radial bearings with cylindrical rollers made by teams of two or four qualified workers. This method of workload study has been introduced by L.H.C. Tippet [1] for textile industry in England and it is also known as: work sampling, random sampling, activity sampling, and ratio delay or observation ratio.

The mechanical shop where work sample study have been developed it is presented in figure 1 and here the technological process of bearings assembling it is carrying for a monthly figure around one million united states dollar and main type of bearings are radial and oscillate with small to big cylindrical or convex rollers, in steel or brass cages, in specific configuration like: NUP, NU, N type E for steel cage or type M for brass cage, dimensions related to radial cylindrical bearings or type C or M for oscillate bearings start with 50 mm inner diameter to 500 mm (example NU 210 E cylindrical
rollers radial bearing with steel cage till NU 4100 M big cylindrical rollers radial bearing with brass cage) and for oscillate bearings from 22210 C with two steel cages to 22500 M with one brass cage). The production series had less than one thousand assembles for each shift and where no longer than two days of work, like a rule of the shop each assembling team is changed after a day of work to offer equal opportunity to all bearings assemblers in the shop.

![Figure 1. Bearings assembling sector where the workload study took place.](image)

The work-sampling method has been applied in the cylindrical rollers radial bearings sector for the bearings type presented in figure 2.

![Figure 2. Bearings Radial bearings with cylindrical rollers type NU 210 E with steel cage (left side), N 210 M with brass cage (upper part of figure), NJ 214 M with brass cage (down part of the figure).](image)

The structural difference between same number of cylindrical radial rollers bearings is presented in figure 3 and consists in type of materials for cage that is manufactured in steel or brass.
2. Phases of Workload Analyses

As method to analyse workload, work-sampling could be imagine that have been used by F. W. Taylor [2] the mechanical engineer considered founder of scientific management which used the observations in the mechanical shop he was leading, writing his communication at American Society of Mechanical Engineers titled The Shop Management and soon after that the fundamental book The Principles of Scientific Management. Taylor school of job description states these ideas: 1 eliminate idle times for workers and machines; 2 eliminate duplication of effort; 3 streamline the flow of work through the firm; 4 rearrange task sequences for more efficiency; 5 reduce jobs to short cycle, repetitive ones higher productivity and eventual replacement humans with machines; 6 systematic reduction of skill requirements for each job. Could be considered that Taylor's knowledge have been used by Ford in his automotive plant to manufacture the T Ford and to introduce assembling line and horizontal integration of parts production. In the 1930's Tippet based work-sampling techniques on the theory that percentage of observations for a particular activity, could reflect the average percentage of time spent accomplishing studied task.

The work-sampling study consists in a large number of observations made by an instructed technician, at random times, following a specific displacement trajectory and registering workers activities in predefined categories. Richardson [3] identifies utilizations of this measurement method as: 1 analysing an indirect or service activity that is largely unmeasured; 2 aiding in manpower requirements; 3 identifying problems within a work function; 4 establishing equipment usage problems; 5 aiding in supervision of employees; 6 identifying cycles within works and determining peak load variations. Smith [4] presented in 1978's main phases used in the majority of workload analyses based on work-sampling technique as follows: 1 determine objectives of the study; 2 define the scope of the study; 3 selection of the quantitative measures of output that reflect the condition being study; 4 establish the activity categories; 5 determine the number of observations needed; 6 schedule the randomized time for observations; 7 design the form for data collection; 8 decide who will conduct the study; 9 conduct an orientation meeting with workers to be observed; 10 conduct the study.

Assembling procedure is different and need teams with more members, just two for cylindrical roller radial bearings with steel cage (one to take rollers and cage to put them in a ring and other to press the assemble and stock products for future operations) and three for cylindrical rollers radial bearings with brass cage (one to take rollers and cage and put them in ring, other to introduce rivets to close brass cages and the last one to do hot forming of rivet head on a special press, for big cylindrical rollers bearings four members team are used because two people works to introduce rollers and cages into rings). The teams working for assembling cylindrical rollers bearings are specialized for each type and have lot of experience working together, in few cases when there lot of bearings in same type to made, the teams became larger generally working with two or three teams same bearing type. Assembling processes are very different for small and big cylindrical bearings and ask skills based on experience.
3. Workload study development and results

The first action in the workload study was to establish objectives, in a work meeting with assembling sector management when it was decided that method could give important information’s, have been established type of assembling activities, the pathway to be followed by observers, random time establishment method and the template for data acquisition. The material flows in the sector have been established and those are presented in figure 4.

The bearings assemblers activities to be observed at random times were established as: 1 effective bearings assembling; 2 constitutive bearing parts transportation; 3 cleaning (demagnetize) constitutive parts; 4 dismantling bearings with deficiencies; 5 setting or testing installations or devices; 6 transport of assembled part of bearings to final quality control; 7 waiting constitutive parts of bearings; 8 receiving instructions for his chiefs; 9 refreshing breaks; 10 other activities (will be named by observer). These activities have been recorded by trained observers which work with templates presented in figure 5 at twenty randomized times in 480 minutes of an assembler workers day, registering specific types of assemblers established together with department management, observers followed same pathway for all observations and register activities.

After five days of observations made with observers in all three shifts working during twenty four hours in the Assembling and Mechanical Manufacturing shop for radial cylindrical rollers bearings in a meeting with the staff of that department the activities recorded have been once again put in classes presented in table 3, that reflected management interests about workload of bearings assembling workers. The results of work-sampling method applied to small radial cylindrical rollers bearings have been a surprise for department management that decided some future needed actions to achieve a greater effective assembling time, in the view of management have been measures like: new positions for assembling desks so to minimize movement of workers, bigger series of elements for assembling process, utilization of elements existing in rollers and rings from department warehouses, improvement of assembling elements transportation platforms.

Symbolization in table same in all rows: 1 current number of random observation during the day; JJ identification of bearing assembler or assembling team member; M activity number 1 from list meaning effective assembling bearings; T activity number 2 meaning transporting elements (rollers, cages or rings); V activity number 6 meaning verification of own work done till then; 30 symbolize all activities recorded in observation tour with short specification for those not closed by the list activities.

Table 1. Template for data acquisition used by observers.

| No. | Names | Recorded activities from observations at fixed times | All obs/notes |
|-----|-------|------------------------------------------------------|---------------|
| 1   | JJ    | M T M T V                                            | 30            |
| 2   | KK    | T V M M T                                            | 18            |
| 3   | DG    | W O T M Q                                            | 27            |
| 4   | EF    | M T R C T                                            | 10            |
| 5   | AL    | O Q C T M                                            | 30            |
| ... | ...   | ...                                                  | ...           |
| 19  | TD    | M V T M T                                            | 29            |
| 20  | VW    | R T C M Q                                            | 29            |
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Table 2. Final data after observations ending.

| No. | Assembling activities            | Observation from 100 | Time from 480 min |
|-----|---------------------------------|----------------------|-------------------|
|     |                                 | Iron cage [%]        | Brass cage [%]    |
| 1   | Arrangement of ring and cages   | 10                   | 9                 | 28.8              | 25.9              |
| 2   | Taking roller                   | 8                    | 9                 | 23.4              | 25.9              |
| 3   | Arrangements of roller          | 33                   | 28                | 95.4              | 80.6              |
| 4   | Cage deformation                | 29                   | 15                | 83.5              | 43.2              |
4. Conclusions
This method used to study the workload have been used for the first time in that company and it underline an easy way to get important information about technological process and which way the work time is spend. It emphasizes some possibilities to increase productivity with low expenses. After this study between five to eight percent increase in productivity have been obtained with good collaborative suggestions from workers, also the problem of sorting rings operation have been solved totally, replacement of assembling shop was done and some improvements in warehouses for rings and rollers give a contribution to rise productivity cutting the waiting times.

This communication presents to readers and participants utilization of Tippet's work sampling method to estimate the workload of assembler bearings, also the data acquisition process and management appreciated results from Assembling and Mechanical Manufacturing sector from a big bearings manufacturing company.

References
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