Time-study of Rotary-Screen-Printing Operation

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Abstract
Improving operations-efficiency is an on-going-need, for all-industries, including textile-manufacturing. Time-study is essential, for-both; planning and control, of industrial-operations. This-research used Time-study, of observational-design-type, and of element-scope-level. Classical-stopwatch-technique was-used, to-ascertain the-standard-time, for the-printing-operaton, on the Octrooi-Aangevraagd Rotary-Screen printing-machine, for 3 cycles. Performance-rating was obtained using the-speed-rating-technique. The-machine-operation was-divided into 4 distinct and repetitive machine-elements: machine set-up; color-impresion; drying; and pick-up. This-time-study established Standard-Second-Value of 18, 725.41, giving machine-utilization of 65%. The-most-time-consuming elements, requiring constant-operators’ attention, were found to-be color-impresion, and pick-up/curing. Hawthorne-Effect was also-observed, where machine-operators noticeably-changed their-behavior, when they know that their-work being-measured. The-study made several-recommendations for future-more broader and deeper-research.

Keywords: textile finishing, Hawthorne Effect, equipment, operator, allowances, standard time.

1. Introduction.

1.1. Work-study and Time-study
Work-study is the-systematic-examination of the-methods of carrying-out activities. It-is one of the-most powerful tools, that management can-use, to-improve-productivity. Work-study is divided in two-groups: (1) method-studies, which are-used-to-simplify the-job, and develop more-ergonomic-methods, of doing it; and (2) work-measurements, which are-used-to-find the-time, required to-carry-out the-operation, at a-defined level of activity (Russell & Taylor, 2005). There-are also a-number of work-study-techniques, such-as: ergonomics, operations-research, time-study, and time and motion-study.

According to the-British-Standard-Institute, time-study is the-technique of establishing the-time, to-perform a-given-task, based-upon-measurement, of work-content, of the-prescribed-method, at a-defined-level of performance, with due-allowance for fatigue, and personal and unavoidable-delays. Time-study is a-direct and continuous-observation of a-task, using a-timekeeping-device (e.g., decimal minute stopwatch, computer-assisted electronic-stopwatch, and videotape-camera) to-record the-time-taken to-accomplish a-task (Bon & Daim, 2010) and it-is often-used when (Kulkami et al., 2014): there-are repetitive-work-cycles of short to long-duration; wide-variety of dissimilar-work is performed; or process-control-elements constitute a-part of the-cycle.

Time is the-most-meaningful and useful-measure of work; it-is quantifiable; objective; and universally-understandable. Accumulative-time-study is made for-determining time-standards, to: Establish reasonable-productivity-targets, for experienced-workers; Provide productivity-goals, for-training-purposes; Eliminate waste; Make processes more-consistent; and Reduce variability, while improving-quality (Aft, 2000). Meyers (2002), defined time-standards as: “the time required to produce a product at a work station with the three conditions: (1) a-qualified, well-trained-operator; (2) working at a-normal-pace; and (3) doing a-specific-task”. Minakshi (2016) also pointed-out, that an-industrial-activity includes mental, manual and machining-operation, where: (1) Mental time includes time, taken by the-operator, for-thinking-over some-alternative-operations; (2) Manual time consists of three-types of operations i.e. related with handling of materials, handling of tools, and handling of machines; and (3) Machining time includes time-taken by the-machines, in performing the-requisite-operations. Thus, time-study standardizes the-time, taken by average-worker, to-perform these-operations. Time-study is fundamental, for-both; planning, and control of industrial-operations.

1.2. Types and scopes of time-study
There-are three-types of time-studies: Observational, Experimental, and Modeling-study; they are not mutually-exclusive.

In an observational-study, also called descriptive-study, variables are not controlled (Magagnotti & Spinelli, 2010). This-study-type describes the-current-state of a-machine, its-operation, operator-tasks and performance, or system-function. This-is the-simplest-study-design, as it does not require comparisons with other-machines, operators or systems, and where variables, around the-machine or systems-function, are not controlled. Besides, the-analysis is likely to-be-quicker and easier, to-conduct, than experimental and modeling; besides, it matches-well ‘real-life’ situations. On-the-other-hand, weaknesses of this-type are: it cannot be used
to-compare against other-machines, operators, etc.; not statistically-rigorous; gives a-scenario for one machine/operator, in-one-set of conditions; results, however, might-be drastically different, in other-conditions (Ackerman et al., 2014).

In-contrast, experimental-study involves greater-control of variables, and produces results that are more-statistically-rigorous. Experimental-designs compare different-variables, in-order-to-determine differences, or establish cause and effect. Because more-control of variation is required, these-designs are, typically, more-complex. Different-techniques are-used to-control bias (i.e. systematic-error) including randomization and blocking. According to Pretzsch (2009) and Clewer & Scarisbrick (2001), there-are different-types of experimental-design, based on the-techniques, namely: Mono-factorial Random-Design; Multi-factorial Random-Design; Mono-factorial Block-Design; Multi-factorial Block-Design; Mono factorial Latin-Square-Design; Multi-factorial Latin-Square-Design; and Split-plot-Designs.

Modeling differs, mainly, in-the-purpose of using the-empirical-information, to-create a-model, for a-given machine, operation or system, and, later, simulation (computer-implemented-modeling). Similar-to observation-studies, modeling-studies are done to-observe machines, operators, or systems and create a-production or cost-model, based on a-series of input-factors. These input-factors must be measurable and, preferably, are continuous, meaning they-are quantitative. Examples of continuous-variables include DBH, slope (%), speed, etc. (Ackerman et al., 2014).

Moreover, there are six-different-scopes of time-studies, ranging from-wide to-narrow. These-studies are: shift-level; plot-level; cycle-level; time and production-count; working-sampling; and the-element level. Each-study has different-strengths and weaknesses, and requires a-specific-technique, which is discussed.

A shift-level-study examines production of a-machine, operator, or system, with the-observational measurement being a-completed work-shift. This-technique is commonly-used for long-term observation, monitoring, or follow-up studies (Magagnotti & Spinelli, 2010). A plot-level-study examines production of a-machine, operator, or system, with the-observational-unit being a-completely-ploted. A plot-can-be designed, specifically, to-meet the-study’s objectives; for-example, printing of 4,000 meters of fabric. The-unit therefore is a-completed-plot, and time is cumulative for the-entire-plot (i.e. how-long does-it-take Operator A to-complete a-plot versus Operator B) (Ackerman et al., 2014). A cycle level-study examines production, and the-observational-unit is a-completed-cycle. A-work-cycle is defined as a-sequence of tasks, which perform a-job, or produce a-unit of production (Kanawaty, 1992). Cycle-level-studies can-be conducted manually, or using automatic-data-acquisition, depending on the-objective of the-study, and the-equipment, available. The-major-drawback of a-cycle-level-study is that it lacks the-elemental-detail of the-work process; however, it provides a-quick-way of seeing the-variability, in-the-work-process and allows delay-information-to-be captured. One of the-simplest-techniques, for time and work-study, is time and production-count. The-observation-level is variable, and can-be anything from a-cycle, series of cycles, or a-shift. Time and Production-Counts are designed-to-be very-quick and, typically, are-done-manually, with an-observer, in-the-field, only over a-few-hours (Ackerman et al., 2014). An-element-study breaks-down the-work-cycle, of a-machine, or system, into individual-functional-steps, called elements (Magagnotti & Spinelli, 2010). An-elemental-study is, typically-conducted-manually, and tools can-range from basic-clipboard and stopwatch, to complex-handheld personal-computers, with detailed-time-study software, to video-recording. Particularly-when, individual-elements are very-short, in-duration, computer-software, and video-recording, can-make capturing, these-elements, much-easier. The-main-advantage of an-element-study is the-fine-level of detail, regarding the-work-process, it provides. Element-studies allow for greater-understanding of the-functional-steps, and can-help directly-pin-down inefficiencies. However, they-are time-consuming and can-become-costly, for acquiring large-data-sets. Experimental-design has-to-be-done, to-minimize-replications, and keep the-overall-number of observations, feasible. Furthermore, element-studies require the-observer to-be-well-versed, in-the-element-breaks, and understand what they are, specifically, looking-for. Finally, work-sampling (Instantaneous Observation, and/or Activity-Sampling), is considered, not a true-time-study-technique, per-say, however, work-sampling is an-important-method of work-measurement. Similar to an-element study, work-sampling also records element-level-data. Unlike time-study; however, work sampling determines the-relative-frequency of the-elements, over the-total-time, observed. During work-sampling, a-series of instantaneous-readings of an-activity is taken, over a-period of time. Ideally, the-readings are not taken, in-time with the-cycle, as irregular-sampling-intervals (Ackerman et al., 2014). This research used time-study of observational-type, and of element-scope-level.

4.3. Criticisms of the-time-study-approach

Time-study received strong-criticisms and reactions. Professional-Unions, for-instance, regarded time-study as a-camouflaged-instrument of management, designed to-standardize and intensify the-tempo of production. Likewise, Gilbreth, Cadbury and Marshall profoundly-criticized Taylor (the-inventor) and pervaded his-work with-subjectivity. Taylor’s critics condemned the-lack of scientific-substance in his-time-studies (Caldari, 2007) in the-sense, that they relied heavily on-individual-interpretations, of what workers actually-do (Wrege, 2014).
Perroni, 1974). However, the value in rationalizing production is indisputable and supported by academics, such as: Gantt, Ford and Munsterberg, and Taylor-society-members -- Renold, Jackson and Thompson (Cadbury, 1914).

This study was based on repeated-observations, so that motions, performed on the-same-part, differently, from one-cycle, to the-other, can-be recorded, to-determine values that are truly-repetitive and measureable, under-the-study-scope.

1.3. Stopwatch-Time-Study.
Different-work measurement-techniques, used by industry-managers, are: Historical time-study; Standard-Data; Work-Sampling; Predetermined-Time Standard-System (PTS); and Stopwatch-Time-Study (Niebel & Freivalds, 2003; Meyers, 2002; Lawrence et al., 2000; Niebel, 1994; Barnes, 1980). Among them, stopwatch-study is one of the-most-popular (Nabi et al., 2015), as it determines accurate-time standards, and it is economical, for repetitive-type of work. When a work is measured with the-stopwatch device, it is known as stopwatch-time-study-method.

Stopwatch-time-study measures how-long it takes an-average-worker, to-complete a-task, at a-normal-pace. A so-called ‘average’ operator is defined as a-qualified, methodically-experienced-operator, who is working under-conditions, as they customarily-prevail, at the-work-station, at a-pace that is, neither fast, nor slow, but representative of an-average. The-actual-time, taken by the-above-average-operation must be increased, and the-time taken by the-below-average must be reduced, to the-value, representative of normal-performance. Performance rating is a-technique for equitably-determining the-time, required to-perform a-task by the-normal/average-operator, after the-observed-values of the-operation, under-study have been-recorded (Izetbegovic, 2007; Nakayama, 2002).

The-importance of stopwatch-time-study can be stated as follows (Shaw, 2003): (1) Determining schedules and plan future-production; (2) Formative standard-costs, and as an-aid, in-preparing-budgets; (3) Estimating the-costs of a-product, before manufacturing it. Such-information is of value, in-preparing-bids and determining selling-price; (4) Determining machine-effectiveness, the-number of machines, which one-person can-operate, and as an-aid in balancing-assembly-lines and work, done on a-conveyor; (5) Determining time-standards, to-be-used as a-basis for labor-cost-control; (6) Helps to-know the Labor-productivity, Labor-efficiency, and overall-time, required to-perform the-task; and (7) Helps to-improve the-process of operation.

In this study, time-study-technique (classical-stopwatch) was-used to-ascertain the-standard-time, for the-printing-operaton in the-Octrooi-Aangevraagd Rotary-Screen-printing-machine. The-standard-time is the-time, required by an-average-worker to-perform a-job, once. This-output-data is exceedingly-useful; allowing for the-creation of machine- or operation-standards, accurate-inputs to pre-existing costing-models, and, potentially, the-creation of models, to-predict a-machine, or operations-productivity, given certain inputs.


2.1. Workplace analysis
Workplace-analysis has been accomplished by-observing the-machine-operators, as they were doing the-task of fabric-printing. It is important to-appreciate, that work is not strictly a-set of disconnected-tasks, it is a-process. In-addition, people have different work-styles -- some are fast and industrious; others take their-time. There are many-opportunities for variation in conducting a-task, possibly-resulting in that the-time measurements are not precise, but estimates of how-long a-task takes. Over-time, or by measuring the-work of several-people, it is possible to-come to a-general-understanding of how-long the-work takes, which is good-enough-estimation.

2.2. Basic Procedure of Time study
Figure 1 shows the-basic-steps of time-study, followed in this-research. The-figure is accompanied by explanations on each-step.
(1) Selection of task to-be-timed: There are various-priorities on the-basis of which, task or job, to-be studied, is selected, such-as: bottleneck or repetitive-jobs, jobs with longer-cycle-time, to-check correctness of existing-time, comparison of two-methods, etc.

(2) Standardize the Method of Working: To achieve performance-standard-accuracy, it is necessary to record the-correct (routine)-method of working.

(3) Select the operator for study: Select the-consistent-worker, whose performance should be average, or close-to-average, so that observed-times are close to-normal-times. So-called, average-operator is assumed-to as: Adapted to the-work and has sufficient-experience; has coordinated-mental and physical-abilities; Maintains proper-use of equipment, and tools, related to-the-job; is cooperative; Performs a-pace best-suited for continuous-performance.

(4) Record the details: The-following-information is recorded, on observation-sheet: Name of labor, task/job performed, department, section of work-activity, and general-information, about activity, performed, etc.

(5) Break the-task into-elements: A-complete-job usually will-be too-long and variable, to-time and rate, in-one-go, so it would-be analyzed into several-smaller-parts (elements) which, separately, will each be-timed and rated. Each-operation, hence, is divided-into a-number of elements. This-is done, for easy-observation, and accurate-measurement. An-element is an-instinct-part of a-specified-activity, composed of one or more-fundamental-motions, selected for convenience of observation and timing. The-elements must-be long-enough, to be-accurately-timed (the-proper method should-be-used; Human and machine must be separated; The-end-point, of each-element, should-be consistently-detected. Types of elements are: (repetitive: occurs each-cycle; occasional: not every-cycle; foreign: not necessarily part of the-job; machine: the-time is fixed (no rating); manual: depends on worker (rating); and constant).

(6) Determine number of cycles to-be-measured: It is important, to-determine and measure, the-number of cycles, which needs to-be-observed, to-arrive at accurate-average-time. A-guide for the-number of cycles to-be timed, based on total-number of minutes, per-cycle, is shown in Table 1.
Table 1: Number of recommended-cycles for time study (Shaw, 2003).

<table>
<thead>
<tr>
<th>Minutes Per Cycle</th>
<th>To 0.10</th>
<th>To 0.25</th>
<th>To 0.50</th>
<th>To 0.75</th>
<th>To 1.0</th>
<th>To 2.0</th>
<th>To 5.0</th>
<th>To 10.0</th>
<th>To 20.0</th>
<th>To 30.0</th>
<th>To 40.0</th>
<th>To 60.0</th>
<th>Over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cycles</td>
<td>500</td>
<td>100</td>
<td>80</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>8</td>
<td>5</td>
<td>3</td>
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<td>Recommended</td>
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</table>

(7) Measure the time of each-element, using stopwatch: The time, taken for each-element is measured, using a stopwatch. The time measured from the stopwatch is known as observed-time. There are two-methods of measuring time, using a stopwatch, namely: (1) Fly back Method: Here the stop-watch is started at the beginning of the first-element. At the end of the element, the reading is recorded. At the same-time, the stop-watch-hand is snapped back-to-zero. Time of each-element is obtained directly; and (2) Continuous method: Here the stop-watch is started, at the beginning of the first-element. The watch runs, continuously, throughout the study. At the end of each-element, the watch-readings are recorded, on the study-sheet. The time, for each element, is calculated by successive-subtraction. The final-reading of the stop-watch gives the total-time, known as observed-time. This study used Fly back Method.

(8) Determine standard-rating: Rating is the measure of efficiency of a-worker. Different-workers perform their-job with different-efficiencies. Some-workers learn their-job quickly, and attain a very-high-efficiency, others, are, not. This is due to differing-speeds of movement, effort, dexterity and consistency. Thus, the time, taken for one-person, to do the work, may not be the same, as that for others. Rating is on a scale with 100 as its standard rating. Rating, therefore, is the measure of speed, with which an-operator works. Rating is the speed of an-operator, doing a-job, relative to the observer’s idea of standard-pace of work (Tanvir & Ahmed, 2013), and therefore, it is subjective. It is, usually, decided by the work-study analyst, in consultation with the supervisor. Various-rating methods used are: speed-rating, synthetic-rating and objective-rating. In this study, the speed-rating technique, was used to determine the performance-rating.

(9) Calculate the Normal Time: The observed-time cannot be the actual-time, required to perform the work, for a-worker. Therefore, Normal-time needs to be calculated. Normal-time is the time that a worker takes, when working at normal-pace. It is calculated as follows: Normal Time = Observed time x Rating.

(10) Determine the allowance: A-worker cannot work the whole-shift, or the whole-day, continuously. He/she will require time for rest, going for toilet, drinking water, etc. Unavoidable-delays may occur, because of tool-breakage, etc. Hence, some extra-time is added to the normal-time. The extra-time is known as allowance. In this study an allowance of 10% was used.

(11) Determine the standard time: The standard-time is the sum of Normal-time and allowances. Thus, it is calculated as follows: Standard Time = Normal Time + Allowances.

The following equipments were used to measure time, using Stopwatch time-study-method: (1) Digital-stopwatch; (2) Observation-board; (3) Observation-sheet; and (4) Stationary (pen, pencil, eraser, and calculator).

Observation-Sheet is printed-form, with spaces provided for recording the necessary information, about the subject-operation. Observation-Sheet (for each-element of the process) includes: Name of operation; Drawing number; Name of the worker; Name of the time-study person; Date and place of study. Spaces are also provided, in the form, for writing detailed description of the process (element-wise); Recorded-time or stopwatch-reading; Performance-rating (s) of operator; and computation, among others. Figure 2 shows the sample of standard-observation-sheet.
Figure 2: Standard time study observation sheet

Time Study Board— is a light-weight board/pad, used for convenient-holding the-observation-sheet and the-stopwatch, in-position. Its-size is somewhat-larger, than observation-sheet. Generally, the stop-watch is mounted near the-upper right-hand-corner of the-board; the-board has a-clamp, to-hold the-observation sheet.

2.3. Machine Utilization
Machine-utilization refers to-the-portion of workplace-time, when a-machine is used to-conduct the-function, intended for the-machine (Björheden & Thompson, 1995). It-is dependent on the-mechanical availability of the-machine, as-well-as on the-effectiveness of the-operating-method. Figure 3 shows the-formulas, used in this-study, for-calculating machine-utilization.

Figure 3: Formulas, for calculating machine-utilization (Pulkki, 2001).

2.4. A Pareto chart
This-study also used a-Pareto-chart, as one of the-instruments. It-is named after Vilfredo Pareto, is a-type of chart, that contains both; bars and a-line-graph, where individual-values are represented, in descending-order, by bars, and the-cumulative-total is represented by the-line (Wilkinson, 2006). The-purpose of the-Pareto chart is to-highlight the-most-important, among a-given-set of factors/parameters.

3. Results and Analysis.

3.1. Observations
3.1.1. Rotary-screen-printing-machine.
Time-study was conducted on the-Octrooi Aangevraagd rotary-screen-printing-machine (model-number 146590) in finishing-department, at Rivatex-East-Africa, Limited (REAL). This-machine was manufactured in 1975, by Stork-Boxmeer, Holland. Figure 4 shows the-material-path and main-components of the-machine.
This-type of printing, is called ‘roll-to-roll’ printing, where the-print-paste is transferred-through onto the-fabric-underneath, by the-action of the-squeegee, on the-print-paste, inside the-rotary-screen. The-support-rollers lift the-rubber-blanket, pneumatically, towards the rotary-screens. The-printing-paste is fed from the-pressure-tank, by pumping it, to the-machine. Flexible-stainless-steel-squeegees are used-to-wipe print-paste, against print-paste, to-allow transfer of paste to-the-fabric. The-amount of paste is varied, by-offsetting-the-point of contact of squeegee, and screen, relative to-the-contact, between the-screen and the-fabric. The-pastes are pumped via the-back of the-squeegee, and are controlled by an-electrical-probe. Each-screen prints its-color, on the-design, then the-fabric is guided-to-the-drying-chamber, where the-printed-fabric is dried, indirectly, by steam. The-fabric is then taken either for-development, in-case of dyes, or is cured in the-steam-ager, for pigments.

3.2. Task description

The-printing-process is a-laborious-process, which involves several-stages, in-order to-prepare: (1) the-machine; (2) the-fabric; (3) the-printing-paste; and (4) to-fix the-impression, permanently on the-fabric.

In-particular, before beginning of every-shift, an-operator should: (1) check the-entire inside-passage of the-printing-blanket, for foreign-objects, with a-hand-clamp. Before start of the-operation, the-operator must clean the-following: Dust-suction-device, dryer, fabric-guides, and color-pumps.

After engraving of the-screens (with the-design-pattern), the-printing-pastes are prepared in the-color-kitchen. The-printing-paste consists of the-following-ingredients: (1) Colorants - consists of dyes, pigments or dyestuff-precursors, used for printing. Reactive red, blue, green, yellow and black are mostly used in printing cotton-fabrics. Disperse red, blue, green, yellow and black are mostly used in printing polyester-fabric; (2) Wetting agents - these are surface-active-compounds, used-to-reduce the-surface-tension of water, so that it-can-wet-surface easily e.g. turkey red oil; (3) Solvents - solvents are used-to-prevent aggregation of the-dyestuff-molecules, in the-highly-concentrated-paste of the dye-molecules e.g. Diethylene-glycol; (4) Thickeners - they are high-molecular-compounds, giving viscous-paste, in-water. They impart plasticity and stickiness to the-printing-paste, so that it-can-be-applied to the-fabric-surface, without migration. They are essentially dispersions of inert-hydrocarbon-oil, in a-continuous-phase, e.g. starch; (5) De-foaming-agents, e.g. formaldehyde; (6) Oxidizing and reducing-agents e.g. hydrogen-peroxide and sodium-hypochlorite; and (7) Acids and alkalis e.g. organic-acids and sodium-hydroxide.

Duties of the-printing-machine-operators could-involve the-following: Preparing the-work-area, for-printing; Establishing requirements and specifications; Setting-up, starting, monitoring and completing the-printing-process; Monitoring and controlling the-quality of the-process; and Protecting the-quality of the-product, during-transfer or storage.

Monitoring and controlling the-quality of the-process entails the-following: Ensure constant free-batching, with uniform-width of fabric, meant for printing; Checking screens for any-faults; Checking the-uniformity of lapping, cleanliness and smooth-surface of blanket, and proper-threading of back-grey, before mounting the-screens for printing; Ensuring cleanliness of furnisher-brushes and color-troughs; Selecting
appropriate-gauge, of doctor-blade, to-commensurate with type-printing; Ensuring proper-filling and polishing of doctor-blade; Checking for proper-mounting, with appropriate-angle of doctor-edge and pressure, using different-weights for the-purpose; Checking for the-proper-setting of the-lint-doctor; Ensure proper-feeding-cloth, alignment of the-screens, and through-cleanness of various-contact-parts, before commencing actual-printing; and checking for efficient-drying of the-printed-cloth, for faulty-free-printing.

After using the-color-pump, the-operator should-clean it, for 5 minutes, with water only; any faulty-blades must-be rectified, without-delay; Checking, constantly, on print-viscosities; Adjusting of screen-pressures; Startup of new-designs, and color-ways, must-be done, in-presence of the-supervisor. The-operator stops the-printing-operation, immediately, if quality laid-down-standard is not obtained, through soiling, insufficient-hydrophilicity, or any-other-phenomenon. Lastly, the-operator ensures no mixing of articles.

3.2. Time Study
From preliminary-observations of the-machine-operation and from the-Table 1, 3 cycles were-selected for the-stopwatch-time-study; this was-done on-three consecutive-days, with the-same machine-operators. On-average, a-fabric-roll of 4,000-meters-length (per-average-cycle) was being-printed, during the-study, with the-main-drive motor-speed of 20m/min. The-machine-operation was-divided into 4 distinct and repetitive machine-elements: machine-set up; color-impression; drying; and pick-up. Several-assumptions were-made, for the-study, such-as: the-number of observations determined, the-rating, and the-times, measured with stopwatch, are accurate and valid.

The-supervisor and the-machine-operators were contacted, in-advance of the-time-study. Supervisor was requested to-help, in-selecting average-operators: competent, with adequate-job-experience; and to-sign the-original-copy of the-time-study, on-completion. Workers were briefed on the-purpose and procedure of the-experiment, and asked to-cooperate, fully, with the-time-study-analyst, in-breaking the-job, into-elements; work at a-steady/normal-pace; and use the-exact method, prescribed. Table 2 shows the-summary of the-results.

<table>
<thead>
<tr>
<th>Table 2: Summary of the-results.</th>
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<tbody>
<tr>
<td><strong>Cycle</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td><strong>Summary</strong></td>
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**KEY:** T = Time in second, R = Performance rating, W = Watch time, OT = Observed time, NT = Normal time.
Normal time = performance-rating x observed-time
Standard time = normal time + allowance time
Performance-rating was obtained using the-speed-rating-technique. Speed-rate considers the-rate of work, per unit-time. The-operator was rated by 10s (80, 90, and 100) then moved to 5s (75, 85, and 95) and finally to 1s (86, 87, 88...,). according to ...
The-Standard-Second-value was found to-be 18,725.41, giving a-machine-utilization of 65%. Some-of-
the-contributing, to such-relatively-low utilization, could-be the-maintenance-mode(s), practiced, at the-factory. In-the-view of the-above, this-study suggests further-research on the-prevailing-mode(s) of machine-maintenance, particularly, at the-finishing-section.

Secondly, this-study, done according to the-standard-procedure, therefore, the-delays/allowances were not recorded; an-allowance of 10% was-used. Allowances/delays are extremely-important, as they assist the-analyst in establishing a-situation, much-more-precisely, than with no delays, recorded. Knowing the-exact-delays, such can-be addressed or eliminated, as-nonproductive-activities. Preoccupation, errors, too-much-motion and travel, during performing the-tasks, are examples of nonproductive-activities and it wasted the-production-time.

3.3. Pareto Chart

Figure 5 shows the-Pareto-Chart, for this-study.

The-lengths of the-bars represent time, and are arranged with longest-bars, on the-left, and the-shortest, to the-right. In-this-way the-chart visually-depicts which-processes are more-time-consuming. From this-Pareto-Chart three-specific-elements clearly-showed to-consume more-time to-perform, namely: drying, color-impression, and pick-up. Drying of the-printed-fabric is conducted in drying-chamber, with no physical-involvement, of the-operator, hence, the-most-time-consuming-sections, requiring operator’s attention are: color-impression and pick-up. Moreover, during the-entire-time, the-operators supposed to-be constantly-monitoring the-printing-process. This can-lead to-development of Musculoskeletal-Disorders (MSDs); as was-observed, mostly, the-operators monitor printing-process, in awkward-postures. Color-impression and pick-up had the-highest-time and attention-demand, and this-is where the-operator concentrates the-most, to monitor the-quality of printing. In-this-regard, the-study recommends further-research on machine-operator’s postures, during-printing, and possible-work-related MSDs, due-to such-postures.

4. Discussion.

This-section elaborates on the-important-issues, identified or raised, by the-study.

4.1. Types of allowances

Allowances are categorized as: Relaxation-allowance, Interference-allowance, and Contingency-allowance (Minakshi, 2016). Figure 6 shows main-allowances and their-contribution to the-Standard-Time.
Relaxation-allowances are established, to-allow a worker to-recover from fatigue. Relaxation allowance is an-addition to the-basic-time, intended to-provide the-worker with the-opportunity to-recover from the-physiological and psychological-effects of carrying-out specified-work, under specified conditions, and to-allow attention to-personal-needs. The-amount of allowance will-depend on-nature of the-job. Relaxation-allowances are of-two-types: fixed/constant-allowances and variable-allowances (Minakshi, 2016).

Constant-allowances are: (1) Personal needs (up to 5% for men, and 7% for women): restroom, smoking, drinking water, lunch, etc.; (2) Basic-fatigue: this-allowance is given to-compensate for energy, spent during-working (4%); Variable-fatigue, special-allowances; (3) Unavoidable-delays: interruptions from supervisor, material-irregularities, machine-interference; (4) Avoidable-delays: socializing, idleness other than rest; (5) Extra-allowances: attention-time, cleaning, tool-maintenance; and (6) Policy-allowances: new-employees, differently-able, workers on light-duty (Alev, 2011).

Variable allowance is allowed to-an-operator, who is working under poor-environmental-conditions, which cannot be improved, added stress and strain, in performing the-job. The-variable fatigue-allowance is added to the-fixed-allowance to-an-operator, who is engaged on-medium and heavy-work, and working under-abnormal-conditions. The-amount of variable-fatigue-allowance varies from-organization to organization (Minakshi, 2016). Interference-allowance- is an-allowance of time, included into the-work content of the-job, to-compensate the-operator, for the-unavoidable-loss of production, due-to simultaneous stoppage of two or more-machines, being operated by them. This-allowance is applicable for machine or process-controlled-jobs. Interference-allowance varies in proportion to-number of machines, assigned to the-operator. The-interference of the-machine increases the-work-content. Contingency-allowance is a small-allowance of time, which may-be included in a-standard-time, to-meet legitimate and expected-items of work or delays. The-precise-measurement of which is uneconomical, because of their-infrequent or irregular-occurrence. This-allowance provides for small-unavoidable-delays, as-well-as for occasional minor-extra-work. Some of the-examples calling for contingency allowance are: Tool-breakage, involving removal of tool, from the-holder and all-other activities, to-insert new-tool into the-tool-holder; Power-failures of small-duration; and Obtaining the-necessary-tools and gauges, from central-tool-store. Contingency-allowance should not exceed 5% (Minakshi, 2016).

Policy-allowances are not the-genuine-part of the-time-study and should-be-used with utmost-care and only in clearly-defined-circumstances. The-usual-reason for making the-policy-allowance is to-line-up standard-times with requirements of wage-agreement, between employers and trade-unions. The policy-allowance is an-increment, other than bonus-increment, applied to a-standard-time (or to some-constituent part of it, e.g., work-content) to-provide a-satisfactory-level of earnings, for a-specified-level of performance, under exceptional-circumstances. Policy-allowances are, sometimes, made as imperfect functioning of a-division or part of a-plant (Alev, 2011).

From above-narrative, it is apparent, that allowances are diverse, in-scope, nature, and timing. The-literature tends to-handle delays/allowances in-differing-ways, and the-suggestion is, often-made, that only delays greater than 15 minutes, be-recorded (Brown et al., 2010). Allowance-time is taken into account, during setting-up of Standard-Time. Tanvir & Ahmed (2013), for-example, pointed-out that, the-allowance-time ranges from 15 to 25%. This-study, instead advises that any-delay, greater than 30 seconds, be-recorded and classified, appropriately (see Ackerman et al., 2014). It is, hence, recommended to-record and to-classify all the-delays/allowances, taken by an-operator. This can-be done via Continuous-timing stopwatch-study.
4.2. The-Hawthorne-effect

The-Hawthorne-effect was observed, during this-study. This-finding is in-accord with time-study by Jannat et al., (2009). More-details, on the-same, is, hence, beneficial, to-both; the-comprehension of the-phenomenon, and relevant, to-it, issues.

The-Hawthorne-effect, also-referred-to as the-observer-effect (Monahan & Fisher, 2010), is a-well-documented-phenomenon, that affects many-research-experiments, involving human-subjects. In-essence, it-is the-process, where participant-subjects, of an-experiment, modify an-aspect of their-behavior, in-response to-their-awareness, of being-observed (Fox et al., 2008; McCambridge et al., 2007). According to McCambridge et al. (2014), the-Hawthorne-effect ‘is any form of artifact or consequence of research participation on behavior’. For-instance, if a-group, or an-individual, is isolated, from their-work-colleagues, for the-purpose of research, the-individual-attention, and the-normal-human-impulse to-feel ‘chosen’, will, probably, distort their-behavior, and, consequently, the-results of an-experiment. Mostly, possible-effect manifests in temporary-increases in workers’-productivity (Chiesa & Hobbs, 2008; Gale, 2004; Wickstrom & Bendix, 2000). Other-changes, such-as maintaining clean-work-stations, clearing floors of obstacles, was also-reported (Bowey, 2011). Hawthorne-effect have-mutated, in-meaning, over-time, and across-disciplines, and been the-subject of much-controversy (Olson et al., 2006; Kompier, 2006).

On-the-other-hand, some-researchers argue, that the-Hawthorne-effect does not exist (Fernald et al., 2008; Fox et al., 2008; Ertem et al., 2001) or is, at-its-best, the-placebo-effect, under-another-name. Study by Steele-Johnson et al., 2000, of the-demand-effect, however, also-suggests that subjects, change-their-behavior, subconsciously, to-fit the-expected-results, of an-experiment, and to-please the-experimenter. Whatever the-legitimacy of those-claims, in this-study, the-effect was observed, leaving little-doubt that subjects can, and do, change-their-behavior, when under investigation. This-effect is one of the-hardest inbuilt unavoidable-biases, to-eliminate, or factor, into the-design of an-experiment, and hence, evaluation of the-Hawthorne-effect continues, in the-present-day (Levitt & List, 2011; Menezes et al., 2011; Cocco, 2009; Kohli et al., 2009; Leon, 2008). Some of the-studies are Randomized-Controlled-Trials (McCambridge et al., 2012; Evans 2010); Quasi-Experimental-Studies (Fernald et al., 2012; Ertem et al., 2001); and Observational-Studies (Fox et al., 2008; Maury et al., 2006; Eckmanns et al., 2006; Mangione-Smith et al., 2002), vast-majority of studies, however, is in medical-fields. In-the-view of the-above, the-study recommends conducting a-large-scale-research, to-ascertain whether or not, the-Hawthorne-effect exists, in-a-study on textile-manufacturing-sector, exploring its-extent.

The-Hawthorne-effect is, probably, also-correlated to-terror of job-loss. In the-mind of the-worker, being measured, the-time-study is done for improvement, of current-practices, and, hence, represents a-direct-threat to their-job-security. They, probably, believe if the-measurements show they cannot keep-up with an-expectation or standard, they will lose their-job, as management attempts to-eliminate inefficiencies. For this-reason, the-subjects have some-level of fear, when they are involved in work-measurement, and they will, often, attempt to hinder the-process, as a-result. Best (nd), for-example, stated, that during a-time-study, that he conducted, using a-computer, to-speed-up the-data-collection-process, an-employee pressed the-power-button on his-computer; an hour’s worth of work was lost. When someone’s work is observed by a-superior, the-person always has some-amount of fear, for their-job-security. This-fear is, often, greater, when a-stopwatch is involved. Frederick W. Taylor first used the-stopwatch, for analyzing labor-processes (see Taylor, 1910). Over the-past century, the stopwatch has developed into a-symbol of top-down-management, a-philosophy, which is, largely, rejected by today’s custom, high-skill-employee.

5. Conclusion and Recommendations.

5.1. Conclusion

This-time-study established Standard-Second-Value of 18, 725.41, giving machine-utilization of 65%. The-most time-consuming-elements, requiring constant-operators’ attention, were found to-be color-impression, and pick-up. Hawthorne-Effect was also-observed, where machine-operators noticeably-changed their-behavior, when they knew that their-work being-measured.

5.2. Recommendations

Due to-the-limited-scope of this-study, several-recommendations for future-studies were made, as-follows:

1) To-record and to-classify all the-delays/allowances, taken by an-operator. This-can be done via continuous-timing stopwatch-study.

2) To-examine the-prevailing-mode(s) of machine-maintenance, particularly, at-the-finishing section.

3) To-conduct a-large-scale-research, to-ascertain whether or not, the-Hawthorne-effect exists, via a-study on textile-manufacturing-sector, exploring its-extent.
4) To research on machine-operator’s postures, during-printing, and possible-work-related MSDs, due-to such-postures.

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