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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-impression; 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-impression, 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 (Kulkarni *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 can*not* 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-fully-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-fully-completed-plot. 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 &

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, Labor-Performance, 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. Materials and Methods.

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 acoompanied by explanations on each-step.

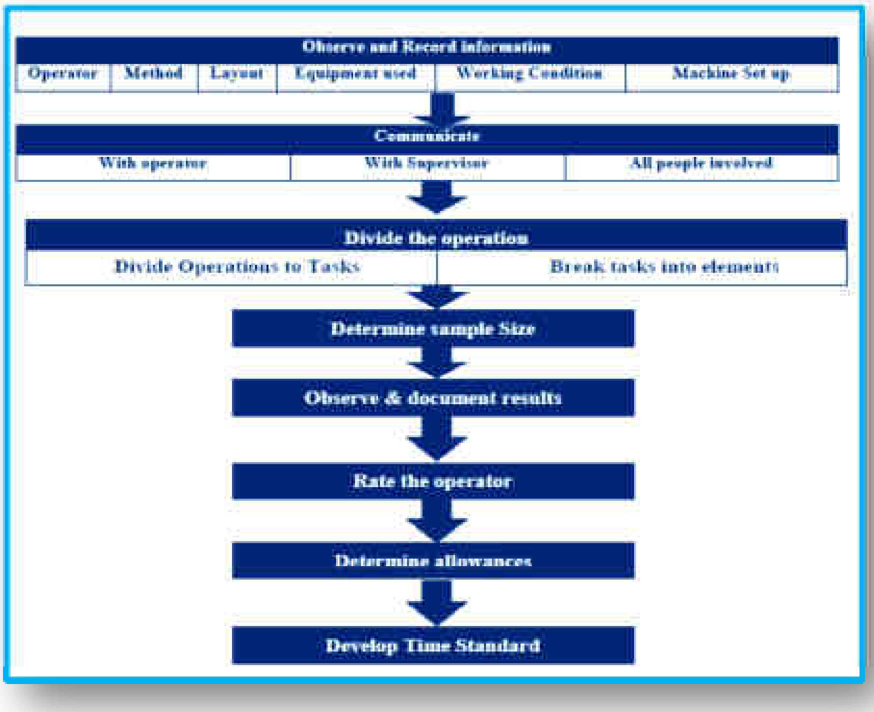

Figure 1: Time-study steps.

(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).

Minutes Per Cycle	To 0.10	To 0.25	To 0.50	To 0.75	To 1.0	To 2.0	To 5.0	To 10.0	To 20.0	To 40.0	Over 40
Number of Cycles Recommended	200	100	60	40	30	20	15	10	8	5	3

(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 can*not* 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 can*not* 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 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.

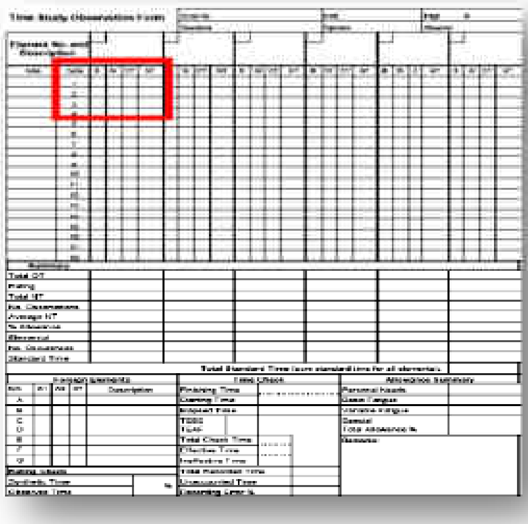

Figure 2: Standard-time-study observation-sheet

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.

$$\text{Machine Utilization (\%)} = \frac{\text{Productive Work Time (PW)}}{\text{Workplace Time (WP)}} \times 100$$

Or alternatively,

$$\text{Machine Utilisation (\%)} = \frac{\text{Productive Machine Hours (PMH)}}{\text{Scheduled Machine Hours (SMH)}} \times 100$$

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.

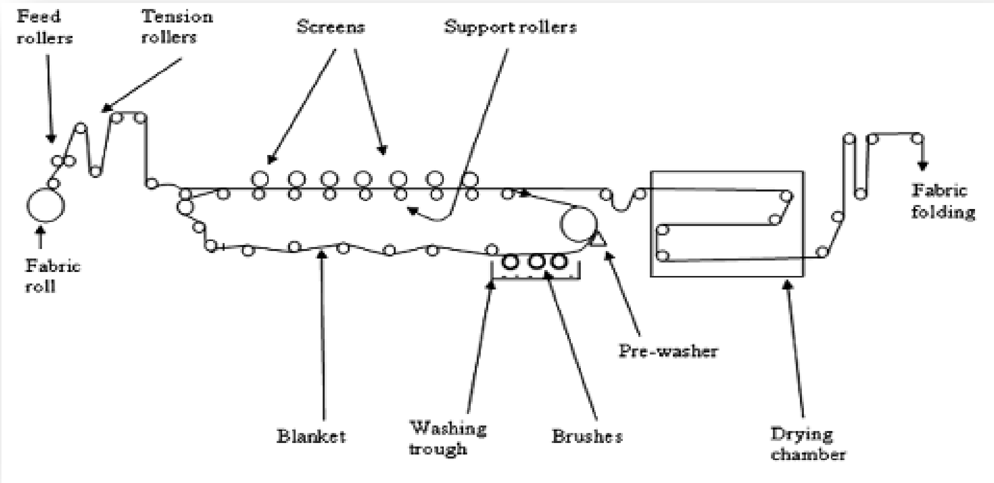

Figure 4: Schematic-Diagram of the *Ooctroi Aangevraagd* Screen-Printing-Machine.

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-cleanliness 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 2: Summary of the-results.

Time study observation form					Study No:				Date:				Page			
					Operation: screen printing machine				Operator:				Observer:			
Element No. and Description	Machine Set up				Color impression				Drying				Pick up			
Cycle	R (%)	W	OT	NT	R (%)	W	OT	NT	R (%)	W	OT	NT	R (%)	W	OT	NT
1	80	1920	1920	1536	88	9840	7920	6969.6	100	17760	7920	7920	90	25678	7920	7128
2	90	1680	1680	1512	85	6312	4632	3937.2	95	10945	4632	4400	78	15573	4632	3613
3	79	1688	1688	1334	81	6488	4800	3888	85	11326	4800	4080	99	16096	4800	4752
Summary																
Total OT	5288				17352				17352				17352			
Av. Rating	83				84.67				93.3				89			
Total NT	4382				14794.8				16400				15493			
No. observations	3				3				3				3			
Average NT	1460.6				4931.6				5466.6				5164.3			
Total NT													**17023.1**			
% Allowance	10				10				10				10			
Elemental Std. Time	1606.66				5424.76				6013.26				5680.73			
No. Occurrences	1				1				1				1			
Standard Time	1606.66				5424.76				6013.26				5680.73			
Total Standard Time (sum standard time for all elements)													**18725.41**			

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.

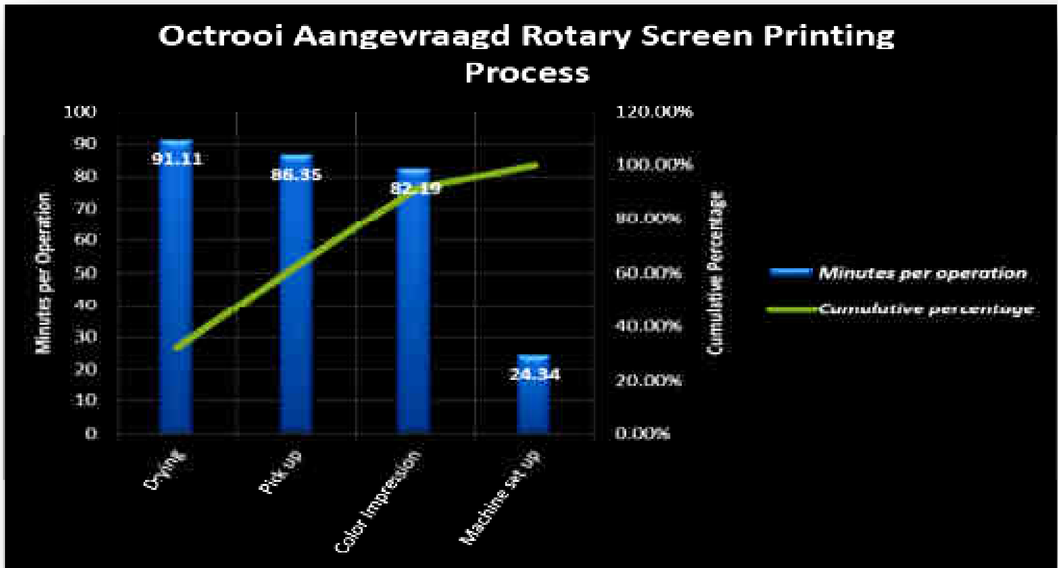

Figure 5: Pareto-Chart

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.

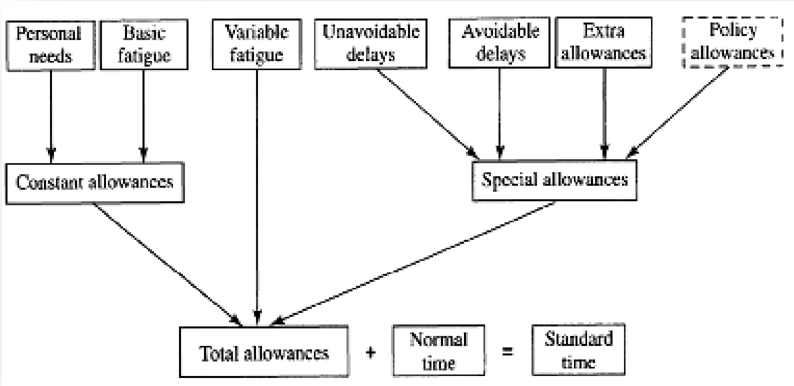

Figure 6: Allowances in time-study (Alev, 2011).

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 can*not* 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; McCarney *et al.*, 2007). According to McCambridgea *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; Leonard, 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-fear 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 can*not* 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 know 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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