WORK SIMPLIFICATION FOR PRODUCTIVITY IMPROVEMENT

A case study: Kaliti Metal Products Factory

Daniel Kitaw
Mechanical Engineering Department
Addis Ababa University

and

Tibebe Belachew
TBA Engineering PLC Addis Ababa

ABSTRACT

The tools and techniques of work simplification are used increasingly in industries, utilities, private and government institutions, and in all process involving tasks including paper works. Articles in the popular press concerning the work simplification techniques state that ***Productivity shall improve upon intelligently developed and improved work methods by elimination of waste of any kind in a process.***

This article introduces the tools and techniques of work simplification, implementation strategies for productivity improvement and its application in Kaliti Metal Products Factory. The outcome of the research has indicated an encouraging result. ***The probable annual net profit gain by use of the simplified work method developed, as applied to tube production only, is estimated to be Birr 3 million.*** *This profit gain would have increased the 1993 E.C. declared profit by over 55%. Application of the same principles for other types of production, Secco profile, Cut-to-size plates, etc., is likely to generate more profit gain.*

INTRODUCTION

For many years, productivity has been a key issue for all government and private companies. This is because of the impact of productivity on economic and social development and its importance as a source of income and an integrative objective, encompassing as it does improved labor-management cooperation, workers' participation, the criteria for enterprise competitiveness and the formulation of a long-term strategy for governments, employers and employees in alleviating poverty and promoting human rights and economic democracy [1].

It is a well-known fact that the most productive companies and government productivity-oriented policies are strongly committed to the promotion of a better quality of working life, participation, market economy principles, individual initiative and creativity, and human-oriented management styles and practices.

The manufacturing industries in Ethiopia whose establishment dates back to the 1950 are using the early 20^{th} century techniques with slight renovation and slow build up of recent technological know-how. The productivity has not improved significantly, and in some cases it was observed that there is a decrease in productivity further aggravating to "unproductive" situation. The effect of such "unproductive" situation in some sectors and reduction in productivity improvement in almost all manufacturing industries have been reflected through failure in competitiveness due to high cost of production, less quality and limited output.

To improve productivity in general, one has to be aware of all the critical factors (forces or impacts) that change the productivity level and its rate of growth, such as inputs-related factors: Capital, Plant, Technology, etc.; Process-related factors: Work methods, Organizational style, etc., in order to influence them by adopting different sets of actions.

One approach in productivity improvement requires high investment in renovation of the old plants and introduction of new equipment, technology, and qualified manpower. But due to the economic and financial problems encountered in the local industries the need for productivity improvement using this approach is none too practicable.

The alternative approach to productivity improvement is the promotion (strengthening) of the impacts of the positive productivity factors and the elimination (reduction) of the impact of negative productivity factors (barriers) at minimal expenditure.

Mostly considered productivity barriers are the uneconomical and inefficient work methods, loss of energy, materials and manpower. Productivity improvement gains are certain, as justified by records of those who implemented the principles, techniques and tools of work simplification.

This article covers work simplification and productivity issues and provides current technological findings, the state of the art in work simplification concepts, theories, techniques and tools in general, its application and results of implementation of the techniques in the Metal Industries like the Kaliti Metal Products Factory.

PRODUCTIVITY IMPROVEMENT & WORK SIMPLIFICATION CONCEPTS

Productivity in its broad sense is a measure of how efficiently and effectively resources are used as inputs to produce outputs, products or services of the quality needed by society. Productivity means creating more benefit for consumers, workers, employers, enterprise owners and society at large from the processes and resources employed in the activities of the organization.

As an efficient measure, high productivity implies that production inputs are fully utilized and waste is minimized. Effectiveness, on the other hand, means that outputs (and activities and processes) contribute to the attainment of the organization's specific goals, whether these be meeting customers' demands, the achievement of business aims or a contribution to attaining the social, economic and ecological objectives of the society. ***Productivity Improvement*** is an increase in productivity and involves the use of high quality resources to produce outputs that are of constant or better quality [1].

Work Simplification is a tool of cost reduction and finding a better way, making the best use of existing tools, equipment and human energy. It is a systematic analysis of all factors that influence job performance, the application of principles of improvement, and the design of correct work procedures. Improvement results in the elimination of wasteful application of human effort, materials, equipment, and facilities as well as in the maximum return for each unit of effort, money, or time expended [2].

Work Simplification is an old tool. The name was actually given by Erwin H. Schell of M.I.T. Allen H. Mogensen (1930's) with his Lake Placid, N.Y. conferences popularized it [3].

A fundamental premise of Work Simplification is that any work that does not add value to material, or service is reducible waste. There are four types of reducible waste: transportation, delay-storage-idle, inspection, and failure to use known faster devices.

WORK SIMPLIFICATION PROCEDURES

The most important productivity factors in work simplification process are linked with: human resources (workers, specialists and managers); Product design; Technology; Plant and equipment; Materials and energy; Work methods; and Organization and management styles.

Improved *work methods*, involving scarce capital, intermediate technology and labor-intensive methods constitute the most promising area for productivity improvement.

The systematic approach to work simplification involves seven steps. They are described as follows.

Step 1 Identification of the Problem

Locating work problems and properly identifying the various factors involved is the only reliable method of determining where improvements can be made, how much effort is justified in developing an improved work method that can most effectively be developed.

Defining a problem in precise terms, and identification of the various factors involved is extremely helpful. Finally, the critical factors will be identified and listed. These factors will be used to judge the worth of the proposed solutions to the problem.

The proper identification of work problem may be facilitated by a preliminary survey. As a guide in determining the type of job to select consider jobs that:

- Involve the greatest cost (labor, material, burden);
- Are continually behind schedule (bottlenecks);
- Will be running for several months or years;
- Is time consuming (red tape);
- Involve hazardous condition,

Step 2 Method Analysis

Getting the facts of the problem requires objective thinking in terms of functions. Determine the main objectives of the work under study, and how these objectives can be attained.

The flow Process Chart helps to reduce a complicated operation or process to a comprehensive word picture [ANNEX 1].

With a detailed description of each step in chronological order, the possibilities for improvement become obvious. Rules and definitions to follow in using the chart, in order to obtain the best results are indicated below [3]:

- Determine the job and decide on the subject selected for analysis. In most instances an operation involves a person, a product, and/or a paper form. One of the three is picked as a subject and every entry on the chart refers to that specific subject.

- Record every detail as it occurs. Avoid the tendency of leaving out details even they seam to be minor. All details are important and should be recorded in the same order as they occur.

- Make several short charts than a long single chart. Make sure you have a fixed starting and stopping place.

- Understand the symbols used in the flow process chart properly. The action-taking place must fit the description of the symbol applied on the chart.

Step 3 Challenge Every Detail & List all Possibilities for Improvement

The third step in the work Simplification pattern is when the job is put on the witness stand and questions are asked that lead to possibilities for improvement.

Knowing what questions to ask of the job or its details is crucial. The six questions used in work simplification are what, why, when, how, where and who. Each of these questions is vital to the complete understanding of the situation. The question "why" especially has been credited with effecting the greater improvements. Applying these questions to each detail of the job maintains an open mind in order to visualize the possibilities for improvement [4]. The open-minded approach requires to looking for reasons and not excuses.

Step 4 Develop a Better Method

The many possibilities for improving the individual work steps and the entire task, which have been developed in step three, should be carefully re-examined. With clear thinking one can assess the merits of the individual possibilities, and with imagination can visualize how these individual possibilities can be utilized and related to the overall job.

This detailed consideration of each and every possibility for improvement should lead to the selection of the several most meritorious and promising suggestions for improvement.

Applying the questioning attitude with an open-minded approach reveals many possibilities for improvement. When an improvement is made on a shop or an office operation, the improvement is made by: *Eliminating* unnecessary jobs, *Combining* jobs wherever possible and *Rearranging* sequence of operations for more effective results and *Simplifying* the operation.

Record only the necessary steps in the operation. Once all the possibilities for improvement have been considered, it is ready to reconstruct the job in a way that will produce the best results.

Step 5 Review the Problem and Analysis

If one or more improved methods have been developed, the next logical step is to subject these proposals to a critical review and to evaluate the effectiveness of the proposals as solutions to the original problem. The most advantageous proposal can be selected as a result of this examination and evaluation if more than one proposed method has been developed.

The final selection of one of the alternative proposals may be deferred until after the validation of the proposals by trail under typical conditions of work. The soundness, accuracy, and completeness of all work done up to this point should be checked. Any errors, or omission should be rectified by appropriate corrective action.

When the proposed method or methods have been thoroughly checked, then one is ready to evaluate these proposals. This evaluation is made in terms of the same considerations made in step one when the problem was defined and the factors involved in the problem identified.

A balanced sheet listing the pros and cons for each factor for the present and the proposed methods may be prepared. This may take the form of a cost reduction report based on the concepts of engineering economy.

Step 6 Validate the New Proposal

The previous steps have been designed to ensure the development of sound and workable methods for improvement. These methods must now be tested to make certain that they are feasible. This testing should be done in such a manner that any and all assumptions are verified.

Validation may involve extensive experimentation and research to test assumptions or to develop equipment, processing, or materials, or it may involve a simple trail run for the proposed methods. The main objective of the testing is to gather information about the workability of the proposed methods and to supply verification for the information presented in the comparative analysis of step five.

Step 7 Install the New Method Effectively

This is the final step, armed with the facts and ready to face the challenge. How to do it? How to get people to accept the change? How to get cooperation? There are three common ways of getting results: telling, selling and consulting. Tell them about the change, without a show of authority. Sell them by explaining why, and consult them for their opinions on how further improvement can be made [4].

Effective and complete use of the improved method is the only way to achieve any of the benefits associated with the improved method. One must make certain that the improved method is properly installed, that it functions as predicted, and that it continues to function as intended.

Some sort of standard operating procedure should be prepared to provide a record of the correct job method and conditions. This record will most likely be based upon the chart of the improved method as previously prepared in the preceding steps. Cost reduction reports may be used to check the operating effectiveness of the improved method.

APPLICATION OF WORK SIMPLIFICATION IN KMPF

For work simplification application a government owned metal industry, the Kaliti Metal Products Factory, KMPF, was selected. KMPF is one of the metal producing factories by making use of cold forming process with relatively old machineries and low level of technology.

Kaliti Metal Products Factory produces five distinct types of products. These include: the Square/Rectangular/Circular hollow tubes; the Cut-to-size plates; the EGA 300 roofing sheets; the Secco doors & windows frame profiles; and the Corrugated galvanized sheet.

Systematic data collection and analysis is required to improve the productivity of the existing plant using work simplification techniques and tools. This is the first step in work simplification.

In problem identification process evaluation of the work procedures, work site conditions, etc., of the existing factory are done based on group discussions, video motion pictures, and production records. Committees were organized to work in collaboration with the authors for identifying problem areas. Data sheets were prepared for data collection. The respective supervisors and foremen completed the data sheets as per the training given by the authors at site [5].

Identification and Selection of Productivity Improvement Problems (Work simplification step1)

A number of techniques[1] are in use for problem identification and selection. Weakness analysis is widely implemented and the relevant detailed questionnaire on workflow, workplace layout, work methods and procedures are used for screening possible problem areas.

Some of the identified major problems are: *high die change and machine setup time; improper market analysis; low performances due to old production machinery and quality of the raw feed stock; improper plant & machinery layout; lack of initiative in developing new service and products; machine breakdown; and improper materials management system.*

The production process for each type of production is studied and subsequently data was collected to determine the time consumed for "Make ready", "Do", and "Put away" operations. After problems have been identified, selection of critical problems and priorities of action are determined. For the selection of certain critical problems and setting priorities the work simplification techniques were utilized.

Accordingly, one of the selected problems for further analysis is the "High Die Change and Machine Setup Time". The selection of this critical problem is justified for the following reasons. [The remaining critical problems are not considered in this article].

Machine setup and die change in three types of products, the Tube, the Cut-to-Size Plate and Corrugated Sheet Production, is found to be about 77% higher than the production time. According to the principles of work simplification the "Make ready and put away" portion need to be minimized to the lowest possible time and increase the "Do" portion that add value to the product. Therefore, further data collection and analysis is done to minimize the "Make ready" and "Put away" operation and set a Break-Even-Point for each type and size of product.

The tube production in Kaliti Metal products Factory amounts to 60 % of the total production capacity of the plant. The broad categories of products varying in dimension, from the smallest 15 x 15 x 1.2 mm to the largest 100 x 100 x 4.5 mm tubes, dictates frequent change of dies and setting up of the machine.

As recorded in the 1993 E.C. budget year Annual Report, the down time due to the die change, miscellaneous set-up and machine trial of the tube production machine amounts to 1011.29 hours. The annual work-hours is estimated to be 3136. This indicates that over 30 % of work-hours was in wastage.

Analysis of the Identified Critical Problems (Work simplification step 2)

Among the classical techniques for detailed analysis of selected critical problem areas the Method study analysis technique is implemented for analysis of the "High Die Change and Machine Setup Time".

The relative time consumed by machine setup and die change time is considerably high because of, according to the authors' opinion, the small order quantity produced. Such manufacturing condition is not viable from the economic point of view. Thus, it is required to define the minimum order quantity, the brake-even-point, for each size of product to be used as a reference.

On the other hand, the time consumed in machine setup and die change operation involves unnecessary work/job components. These unnecessary job components were identified through motion study, by fractionating the job into smaller units, elements, the Therbligs, according to the function of those units and have been eliminated to reduce the total time [Annex 1 to 5].

Motion Study, the Flow Process Chart (Work simplification step 2 & 3)

In the survey conducted the tube-forming machine was producing 50x50 mm square hollow section tube. After the required quantity had been attained, there was a need to change the dies for the next scheduled production of 60x40 mm rectangular hollow section. Records were made on the die change and setup process breaking it down to 69 work components [ANNEX 1].

1 These include Weakness analysis; SWOT, Strength, Weakness, Opportunities and Threats analysis; Portfolio analysis; Pareto analysis; Sensitivity analysis; and Force-field analysis.

This case, for instance, indicates the smallest possible die change process time that involves changing five sets of finish forming dies. The largest possible die change time is observed when there is a change of up to 18 sets of roll forming dies, up to 20 sets of guide rollers, and 5 sets of finish forming dies (usually when there is a jump from smaller size to larger size tube production).

It is observed that, the time taken to complete the die change process was 225 minutes. Each step of activity with the corresponding elapsed time is recorded in the flow process chart prepared for such analysis.

Analysis is made, using the recorded flow process chart, to identify which step has consumed a lot of time, and for duplication of effort, backtracking, excessive handling, costly delays, hazardous conditions, fatigue, etc.

The Break-Even-Point Analysis (Work simplification step 3)

The break-even-point is defined as the quantity of products required to be produced to cover the costs of production and all factory and overhead expenses including depreciation, property tax, insurance, rent, etc. and any other related costs. The break-even-point is calculated as the ratio of fixed cost to the difference of the unit-selling price and unit variable cost.

Based on the information obtained form the financial department of the factory and the data from the observation made, the Break-Even-Point is calculated to be 650 Pcs. The amount produced while under study was 384 Pcs [5].

Flow Process Chart Analysis (Work simplification step 4 & 5)

For work simplification analysis each work component recorded in the flow process chart is studied separately considering the possibilities for Elimination; Combination; Rearranging; and Simplifying in sequential order. Based on this work simplifying procedure, recommended methods are proposed for each work component. The proposal for recommended work methods is done after a through study and analysis of possible alternative methods using Charts for Evaluation of alternatives.

Factor analysis[2], the most effective general method of evaluating alternatives has been employed for this purpose of alternatives evaluation. [ANNEX 5]. Due consideration is given to those functions that consumed relatively long time and alternative methods are generated.

In the process of the elapsed time analysis the time taken for each job component is, whether done sequentially or in parallel, added up to calculate the total time taken under both the present method and the recommended method for comparison purpose using the traditional Flow Process Chart. For more clarity and more accurate comparison the *gang flow chart* is developed [ANNEX 2] by dividing the whole process in five gangs working in parallel and found the result fairly identical to that of the traditional flow process chart [ANNEX 3,4]. This chart reflects the actual process done in the die change and set-up operations.

CONCLUSION

The new developed method for die change and set-up of the tube production process resulted in substantial reduction in time and effort of human energy expended in the process.

The recommended method:

- Saves about 59% or, in terms of actual work time, the improved die change and setup time runs for 92.25 min. (1.54 hrs.) instead of 225 min. (3.75 hrs);
- Thereby reduces the relative time consumed by "Make ready" and "Put away" operations to 48.5% instead of 87% [5].

One of the merits of the proposed method is envisaged in the possible saving of the downtime, disclosed in 1993 E.C. Annual Report, by proper implementation of the proposed improved method amounts to 596.66 hours.

[2] It follows the engineering concept of breaking down the problem into its elements and analyzing each one. The procedure involves

- Identifying the alternatives to be evaluated,
- Establishing the factors or considerations,
- Arranging a rating sheet,
- Determining the relative importance of each factor,
- Rating each factor for different alternatives, and
- Calculating the weighted value and total.

Assuming that "only" 50% of the saved time is utilized for the production of tubes, the amount of tubes produced, at the rate of 30 meters per min (This is the average capacity of the tube machine and that experienced during data collection.), shall be 89,499 pcs. The gross profit (sales-cost), for 89,499 pcs of tube amounts to Birr 4,547,444.19. Fixed cost payable while producing this product, at the rate of 2417.83 Birr/hr. (Data obtained from Break-Even-Point analysis) becomes Birr 1,442,622.45 [5].

The net profit gain by use of the simplified work method, as applied to the tube production only, is estimated to be Birr 3,104,821.74. This additional profit may have increased the 1993 E.C. declared profit of Birr 5,599,000.00 by over 55%. Application of the same principles for other types of production is likely to generate substantial profit gain higher than the indicated figures.

Here it is to be noted that in the application of work simplification steps the first five steps were considered. The authors hope to see the validation and implementation of this new method, Step 6 and 7, for the benefit of the employee and management of KMPF in particular and the country as a whole.

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ANNEX 1 DIE CHANGE AND SETUP, FLOW PROCESS CHART

	METHODS ANALYSIS			
LOCATION: Kaliti KMPF	EVENT	PRESENT	PROPOSED	SAVINGS
ACTIVITY: Die change	OPERATION ○	8:13	3:41	4:32
DATE: April 15, 2002	TRANSPORT ⇨	0:18	0:05	0:13
OPERATOR: Abebe	DELAY D			
ANALYST: Tibebe Belachew	INSPECTION □	2:34	0:52	1:42
	STORAGE ▽			
REMARK: Average saving amounts to 58.2 %	TIME ANALYSIS			
	TIME (min.)	11:05	4:38	6:27
	PERCENTAGE		41.80	58.20

Steps	Event Description	○	⇨	D	□	▽	Start time	Ending time	Elapsed time	Recommended Method
1	Pipe cutting, manually, to disco- -nnect from production feed	X					4:30	4:35	0:05	Use power tools to be faster, less 50%
2	Removal of decoder	X					4:30	4:31	0:01	To be done after step 7
3	Cleaning machine bed for scale removal	X					4:30	5:05	0:35	Use high pressure, air washing tools, less 50%
4	Untightening bolts used to fix dies set	X					4:31	5:09	0:38	Use of pneumatic tools or wrachet spanner, less 50%
5	Measuring thickness of installed contoured roller dies set				X		4:31	4:40	0:09	Not required
6	Measuring 6 m length from finished pipe to cut				X		4:40	4:45	0:05	Eliminated by Alternative method, see attached sheet [1]
7	Cutting finished section of tube from cut out in Step 1	X					4:45	5:00	0:15	Eliminated by Alternative method, see attached sheet [2]
8	Positioning Cut off machine to remove cut out piece		X				5:00	5:05	0:05	No comment
9	Positioning gantry crane for lifting 1st roller dies set		X	X			5:09	5:14	0:05	Instal small size crane, the ideal one at mil plant
10	Hoisting of 1st dies set from roller stands, using crane, and placing it on machine bed	X		X			5:15	5:16	0:01	No comment
11	Removal of each roller dies from the 1st roller dies set	X					5:16	5:21	0:05	No comment
12	Removal of installed bearing from each die of 1st dies set	X					5:17	5:22	0:05	Arrange spare bearings Unnecessarily done task
13	Inspection of removed bearing, 1				X		5:18	5:26	0:08	Untimely done task
14	Hoisting of 2nd dies set from roller stands, using crane, and placing it on machine bed	X					5:16	5:17	0:01	No comment
15	Removal of each roller dies from the 2nd roller dies set	X					5:17	5:22	0:05	No comment
16	Washing and lubrication of 1st									Arrange spare bearings

Steps	Event Description	SYMBOLS ○	⇨	D	□	▽	Starting time	Ending time	Elapsed time,min	Recommended Method
	inspected bearing for next use	X					5:18	5:23	0:05	Unnecessarily done task
17	Cleaning of roller dies of 1st set	X					5:19	5:27	0:08	Use high pressure, air washing tools, less 50 %
18	Selection of new set of dies from various sizes of stocked dies				X		5:17	6:00	0:43	Use tagging and sorting procedures, less 50 %
19	Removal of installed bearing from each die of 2nd dies set	X					5:18	5:23	0:05	Arrange spare bearings Unnecessarily done task
20	Inspection of removed bearing, 2				X		5:18	5:25	0:07	Untimely done task
21	Hoisting of 3rd dies set from roller stands, using crane, and placing it on machine bed	X					5:18	5:19	0:01	No comment
22	Assembling bearings into replacement dies of 1st set	X				X	5:19	5:27	0:08	Arrange spare bearings Unnecessarily done task
23	Removal of each roller dies from the 3rd roller dies set	X					5:19	5:25	0:06	No comment
24	Washing and lubrication of 2nd inspected bearing for next use	X					5:19	5:25	0:06	Arrange spare bearings Unnecessarily done task
25	Removal of installed bearing from each die of 3rd dies set	X					5:20	5:25	0:05	Arrange spare bearings Unnecessarily done task
26	Inspection of removed bearing,3				X		5:20	5:28	0:08	Untimely done task
27	Cleaning of roller dies of 2nd set	X					5:20	5:28	0:08	Use high pressure, air washing tools, less 50 %
28	Hoisting of 4th dies set from roller stands, using crane, and placing it on machine bed	X					5:20	5:21	0:01	No comment
29	Assembling bearings into replacement dies of 2nd set	X					5:21	5:26	0:05	Arrange spare bearings Unnecessarily done task
30	Removal of each roller dies from the 4th roller dies set	X					5:21	5:27	0:06	No comment
31	Removal of holding dies of the cut-off machine	X					5:21	5:35	0:14	Use new crane as in 9 above, less 50 %
32	Washing and lubrication of 3rd inspected bearing for next use	X					5:22	5:27	0:05	Arrange spare bearings Unnecessarily done task
33	Removal of installed bearing from each die of 4th dies set	X					5:22	5:26	0:04	Arrange spare bearings Unnecessarily done task
34	Inspection of removed bearing, 4				X		5:22	5:28	0:06	Untimely done task
35	Cleaning of roller dies of 3rd set	X					5:22	5:31	0:09	Use high pressure, air washing tools, less 50%
36	Hoisting of 5th dies set from roller stands, using crane, and placing it on machine bed	X					5:22	5:23	0:01	No comment
37	Assembling bearings into replace-									Arrange spare bearings

Steps	Event Description	SYMBOLS ○	⇨	D	□	▽	Starting time	Ending time	Elapsed time,min	Recommended Method
	ment dies of 3rd set	X					5:23	5:28	0:05	Unnecessarily done task
38	Removal of each roller dies from the 5th roller dies set	X					5:23	5:30	0:07	No comment
39	Washing and lubrication of 4th inspected bearing for next use	X					5:23	5:31	0:08	Arrange spare bearings Unnecessarily done task
40	Removal of installed bearing from each die of 5th dies set	X					5:23	5:28	0:05	Arrange spare bearings Unnecessarily done task
41	Inspection of removed bearing,5				X		5:23	5:31	0:08	Untimely done task
42	Cleaning of roller dies of 4th set	X					5:24	5:34	0:10	Use high pressure, air washing tools, less 50 %
43	Washing and lubrication of 5th inspected bearing for next use	X					5:24	5:32	0:08	Arrange spare bearings Unnecessarily done task
44	Cleaning of roller dies of 5th set	X					5:24	5:32	0:08	Use high pressure, air washing tools, less 50 %
45	Installation of replacement dies on 1st dies set	X					5:25	5:30	0:05	No comment
46	Assembling bearings into replacement dies of 4th set	X					5:25	5:31	0:06	Arrange spare bearings Unnecessarily done task
47	Gauging and adjustment on 1st dies set				X	X	5:31	5:46	0:15	Use sample prototype for gauging, less 50 %
48	Installation of replacement dies on 2nd dies set	X					5:31	5:45	0:14	Train operators less 50 %
49	Gauging and adjustment on 2nd dies set				X	X	5:47	6:02	0:15	Use sample prototype for gauging, less 50 %
50	Changing of holding dies for cut-off machine	X					5:47	6:25	0:38	Train operators less 50 %
51	Assembling bearings into replacement dies of 5th set	X					5:47	5:53	0:06	Arrange spare bearings Unnecessarily done task
52	Installation of replacement dies on 3rd dies set	X					5:47	6:25	0:38	Train operators less 50 %
53	Installation of replacement dies on 4th dies set	X					5:47	6:25	0:38	Train operators less 50 %
54	Installation of replacement dies on 5th dies set	X					5:47	6:25	0:38	Train operators less 50 %
55	Gauging and adjustment on 3rd dies set				X	X	6:25	6:35	0:10	Use sample prototype for gauging, less 50 %
56	Gauging and adjustment on 4th dies set				X	X	6:35	6:45	0:10	Use sample prototype for gauging, less 50 %
57	Gauging and adjustment on 5th dies set				X	X	6:45	6:55	0:10	Use sample prototype for gauging, less 50 %
58	Positioning gantry crane for lifting 1st replacement dies set		X				6:45	6:53	0:08	Instal small crane, the ideal one at mil plant
59	Hoisting of 1st replacement dies									

Steps	Event Description	SYMBOLS ○	⇨	D	□	▽	Starting time	Ending time	Elapsed time,min	Recommended Method
	set on to roller stands, using crane, from machine bed	X					6:53	6:55	0:02	No comment
60	Assembling 1st replacement dies set on to roller stand	X					6:57	7:05	0:08	Use of pneumatic tools or wrachet, less 50 %
61	Hoisting of 2nd replacement dies set on to roller stands, using crane, from machine bed	X					7:05	7:07	0:02	No comment
62	Assembling 2nd replacement dies set on to roller stand	X					7:07	7:15	0:08	Use of pneumatic tools or wrachet, less 50 %
63	Hoisting of 3rd replacement dies set on to roller stands, using crane, from machine bed	X					7:15	7:17	0:02	No comment
64	Assembling 3rd replacement dies set on to roller stand	X					7:17	7:26	0:09	Use of pneumatic tools or wrachet, less 50 %
65	Hoisting of 4th replacement dies set on to roller stands, using crane, from machine bed	X					7:26	7:27	0:01	No comment
66	Assembling 4th replacement dies set on to roller stand	X					7:27	7:35	0:08	Use of pneumatic tools or wrachet, less 50 %
67	Hoisting of 5th replacement dies set on to roller stands, using crane, from machine bed	X					7:35	7:37	0:02	No comment
68	Assembling 5th replacement dies set on to roller stand	X					7:37	7:45	0:08	Use of pneumatic tools or wrachet, less 50 %
69	Reinstallation of decoder	X					7:44	7:45	0:01	No comment

ANNEX 2 DIE CHANGE AND SETUP, GANG PROCESS CHART

METHODS ANALYSIS

	GANG 1 Present	GANG 1 Proposed	GANG 2 Present	GANG 2 Proposed	GANG 3 Present	GANG 3 Proposed	GANG 4 Present	GANG 4 Proposed	GANG 5 Present	GANG 5 Proposed	Symbol
LOCATION: Kaliti KMPF											
ACTIVITY: Die change	122	67	150	70	156	66	138	68	154	65	○
DATE: April 15, 2002	13	0	8	0	0	0	8	0	0	0	⇨
OPERATOR: Abebe											D
ANALYST: Tibebe Belachew	75	22	65	22	61	22	64	22	61	22	□
											▽

REMARK: Average saving amou to 59.2 %	GANG 1	GANG 2	GANG 3	GANG 4	GANG 5
Pres. time (min)	210	223	217	210	215
Prop.time (min.)	89	92	88	90	87
Saving %	58	59	59	57	60

Steps	Event Description	GANG 1	GANG 2	GANG 3	GANG 4	GANG 5
1	Pipe cutting, manually, to disco--nnect from production feed				5	
2	Removal of decoder	1				
3	Cleaning machine bed for scale removal	35		35		35
4	Untightening bolts used to fix dies set	38	38	38	38	38
5	Measuring thickness of installed contoured roller dies set	9				
6	Measuring 6 m length from finished pipe to cut				5	
7	Cutting finished section of tube from cut out in Step 1				15	
8	Removal of holding dies of the cut-off machine		14			
9	Changing of holding dies for cut-off machine		38			
10	Positioning Cut off machine to remove cut out piece		5			
11	Positioning gantry crane for lifting 1st roller dies set	5				
12	Hoisting of dies set from roller stands, using crane, and placing it on machine bed	1	1	1	1	1
13	Removal of each roller dies from the dies set	5	5	5	5	5
14	Removal of installed bearing from each die set	5	5	5	4	5
15	Inspection of removed bearing,	8	7	3	6	8
16	Washing and lubrication of inspected bearing for next use	5	6	9	8	8
17	Cleaning of roller dies	8	8	9	10	8
18	Selection of new set of dies from various sizes of stocked dies	43	43	43	43	43
19	Assembling bearings into replacement dies set	8	5	5	6	6
20	Installation of replacement dies on dies set	5	15	38	38	38
21	Gauging and adjustment of dies set	15	15	10	10	10
22	Positioning gantry crane for lifting 1st replacement dies set	8	8		8	
23	Hoisting of replacement dies set on to roller stands, using crane, from machine bed	2	2	2		2
24	Assembling replacement dies set on to roller stand	8	8	9	8	8
25	Reinstallation of decoder	1				

ANNEX 3 SINGLE DIE SET CHANGE, FLOW PROCESS CHART

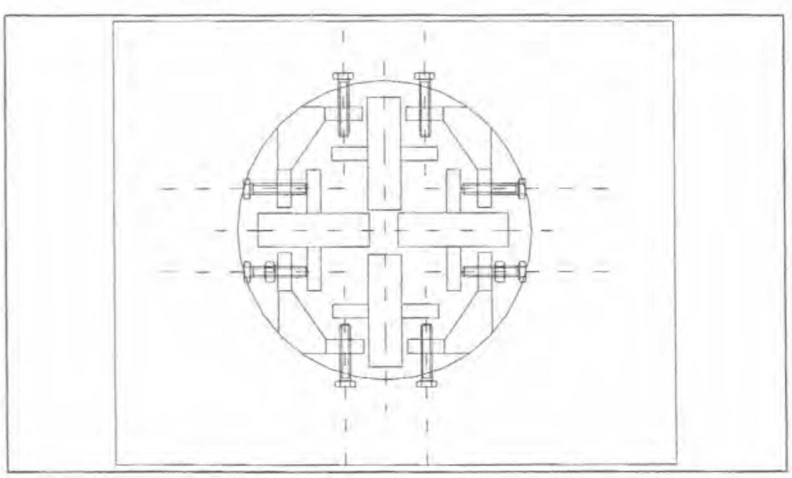
	METHODS ANALYSIS				
LOCATION: Kaliti KMPF	EVENT		PRESENT	PROPOSED	SAVINGS
ACTIVITY: Single Die set change	OPERATION	○	0:42	0:16	0:26
DATE: April 15, 2002	TRANSPORT	⇨			
OPERATOR: Abebe	DELAY	D			
ANALYST: Tibebe Belachew	INSPECTION	□	1:06	0:29	0:37
	STORAGE	▽			
REMARK: Average saving amounts to 58.3 %	TIME ANALYSIS				
	TIME (min.)		1:48	0:45	1:03
	PERCENTAGE			41.67	58.33
	OTHERS				

Steps	Event Description	SYMBOLS ○	⇨	D	□	▽	Start time	Ending time	Elapsed time	Recommended Method
10	Hoisting of 1st dies from roller stands, using craneand placing it on machine	X					5:15	5:16	0:01	No comment
11	Removal of each roller dies from the 1st roller dies set	X					5:16	5:21	0:05	No comment
12	Removal of installed bearing from each die of 1st dies set	X					5:16	5:21	0:05	Eliminate by evaluating Alternatives, less 100%
13	Inspection of removable bearing				X		5:16	5:24	0:08	Eliminate by evaluating Alternatives, less 100%
16	Washing and lubrication of 1st inspected bearing for next use	X					5:17	5:22	0:05	Eliminate by evaluating Alternatives, less 100%
17	Cleaning of roller dies of 1st set	X					5:17	5:25	0:08	Eliminate by evaluating Alternatives, less 50%
18	Selection of new set of dies from various sizes of stocked dies				X		5:17	6:00	0:43	Reduce time Evaluating Alternatives, less 50%
22	Assembling bearings into replacement dies of 1st set	X					5:19	5:27	0:08	Eliminate by evaluating Alternatives, less 100%
47	Gauging and adjustment on 1st die set				X		5:31	5:46	0:15	Needs further analysis
57	Positioning gantry crane for lifting 1st replacement die set	X					6:45	6:53	0:08	Eliminate by evaluating Alternatives, less 100%
58	Hoisting of 1st replacement dies set on to roller stands, using crane, from machine bed	X					6:53	6:55	0:02	No comment
59	Assembling 1st replacement dies set on to roller stand	X					6:57	7:05	0:08	Use alternatives to reduce time, less 50%

ANNEX 4 DIE GAUGING & ADJUSTMENT, FLOW PROCESS CHART

		ANALYSIS			
LOCATION	Kaliti KMPF	EVENT		Present	Proposed
ACTIVITY	Die Gauging & adjustme	OPERATION	○	0:10:20	0:05:20
DATE	April 16, 2002	TRANSPORT	⇨		
OPERATOR	Kelema	DELAY	D		
ANALYST	Tibebe Belachew	INSPECTION	□	0:04:40	0:01:20
		STORAGE	▽		
REMARK		TIME ANALYSIS			
For details refer to Annex 5.1		Time (min.)		0:15:00	0:06:40
		Savings (min.)			0:08:20
		Percentage			55.56

Steps	Event Description	SYMBOLS ○	⇨	D	□	▽	Start time	Ending time	Elapsed time	Alternative Method
47	Gauging and adjustment on 1st die set						5:31:00	5:46:00	0:15:00	Produce
47-1	Positioning dies	X					5:31:00	5:35:00	0:04:00	prototypes
47-2	Calibration of gauge tool using Vernier Caliper	X					5:35:00	5:39:00	0:04:00	fix same between
47-3	Checking clearnce of slot in three spots in line using calibrated tool				X		5:39:00	5:40:40	0:01:40	dies and tighten
47-4	Tightening the bolts to reduce clearance between slot and gauging tool	X					5:40:40	5:41:00	0:00:20	bolts. For clearance
47-4	Checking clearnce of slot in three spots in line using calibrated tool				X		5:41:00	5:42:20	0:01:20	use filler gauges as
47-5	Untightening the bolts to increase clearance between slot and gauging tool	X					5:42:20	5:43:00	0:00:40	required. Reduce
47-6	Measuring clearnce between die shaft side				X		5:43:00	5:44:00	0:01:00	time by minimum
47-7	Tightening the bolts to reduce clearance and gauging tool	X					5:44:00	5:44:50	0:00:50	of 50 %
47-8	Checking clearnce of slot in three spots in line using between slot calibrated tool				X		5:44:50	5:45:30	0:00:40	
47-9	Finish tightening bolts and counter nuts to make ready for assembly onto stands	X					5:45:30	5:46:00	0:00:30	



ANNEX 5 SAMPLE CHART FOR EVALUATING ALTERNATIVES

	Alternatives	A	B	C	D	E	Best alternative
Plant: KMPF		A	B	C	D	E	Best alternative
Project: Removal, cleaning, inspect and reinstallation of bearings for each die Date: April 15, 2002 Analyst: Tibebe Belachev		Do not remove, but clean	Do not remove, Store	Do not remove, Clean, inspect, store	Remove clean, inspect & store	Remove clean, inspect, reinstall bearing	Alternative A Score 56.13

Factor/Consideration	Wt	Ratings and Weighted Ratings					Comments
		A	B	C	D	E	
Time, shortest	[40]						Rules applied
Removal	6.56	6.56	6.56	6.56	0	0	Score =
Cleaning	6.56	0	6.56	0	0	0	(Max.time−Actual
Inspection	11.8	11.8	11.8	0	0	0	time)/(Max.time),
Reinstallation	11.8	11.8	11.8	11.8	11.8	0	in percentage
Sorting ready die	3.28	0	0	0	0	3.28	
Total	7.5	30.16	.59 6.72	5.51 8.36	5 11.8	3.28	
Cost, (Birr 0.56 per change)	[30]	9.3	.96	20.1	28.2	6 30	
Skill requirement	[10]						
Highly skilled	3.33			3.33	3.33	3.33	
Moderate	6.67	6.67	6.67				
Equipment availability	[10]						
Standard tools	6.67	6.67	6.67				
Special tools	3.33			3.33	3.33	3.33	
Morale Benefits	[10]						
Full satisfaction	6.67			6.67	6.67	6.67	
Partial satisfaction	3.33	3.33	3.33				
Totals	100	56.13	54.35	51.79	53.33	46.61	

Remark:

Cost include arrangement of spare bearing and shaft. Shaft fabricated in the workshop and bearing bought Birr 200.00. Expected lifetime 3136 hours operation, records, depreciation cost amounts to Birr1.40 per hour, for 20 bearings. For a die change time of 24 minutes, max, saving by reinstalling removed bearing and shaft is Birr 0.56 per change.

Legend

Subject: Dies are removed from dies holders. Each die consisits of a bearing and a shaft. Removed dies will be stored and new replacement dies are installed in the die holders for the next operation. The usuall method is to remove die with bearing and shaft and dismantle, clean and inspect, store die, replace bearing and shaft into replaceable die.

Alternative processes proposed for die and bearing change

A Clean and store die as assembled and install replaceable assembled die readily prepared.
B Store die as removed from die holder and install replaceable assembled die readily prepared.
C Clean, inspect and store die as assembled and install replaceable die readily prepared.
D Disassemble die, clean, inspect, store and install replaceable assembled die readily prepared.
E Disassemble die, clean, inspect, store and install replaceable die with bearing fixed.