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OPTIMIZATION OF OPERATIONS IN A STEEL WIRE MANUFACTURING COMPANY

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ABSTRACT

The project was conducted in a high quality steel wire manufacturing company with the production capacity of over 120,000 tones/annum. The wire drawn from the high speed wire drawing (KOCH) machine is fed as the raw material for BEKEART (zinc coating galvanization) furnace. The problem faced by the company is the variability in the amount of input to the furnace, which results from the breakdowns occurring on the KOCH machine resulting in low production. Apart from its speed, KOCH machines have other advantages due to their automation by which they can be set as per the requirements and different parameters of the company. From figure1 it can be concluded that any downtime in the process occurring at the KOCH machine adversely affects the productivity of the BEKEART furnace, as a result of which the total production on this line suffers and hence the profits of the company. Simulation study was done with the objective of increasing the throughput and ensuring smooth product flow through the system by finding the optimum arrival batch size.

1 INTRODUCTION

The preliminary study at the plant revealed the following characteristics, which were the basis for achieving the desired objective:

- All the KOCH machines are very costly, so obviously any downtime of these machines is going to cost the company heavily, both in terms of production as well as loss of revenues due to lost sales.

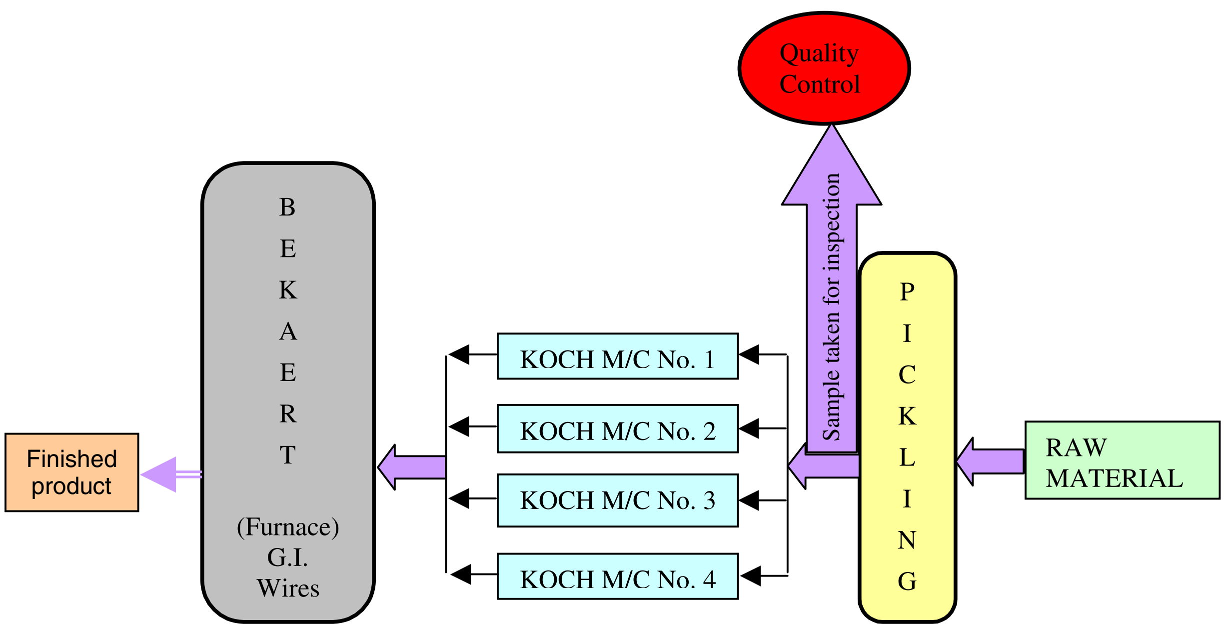

Figure 1: Process Flow Chart

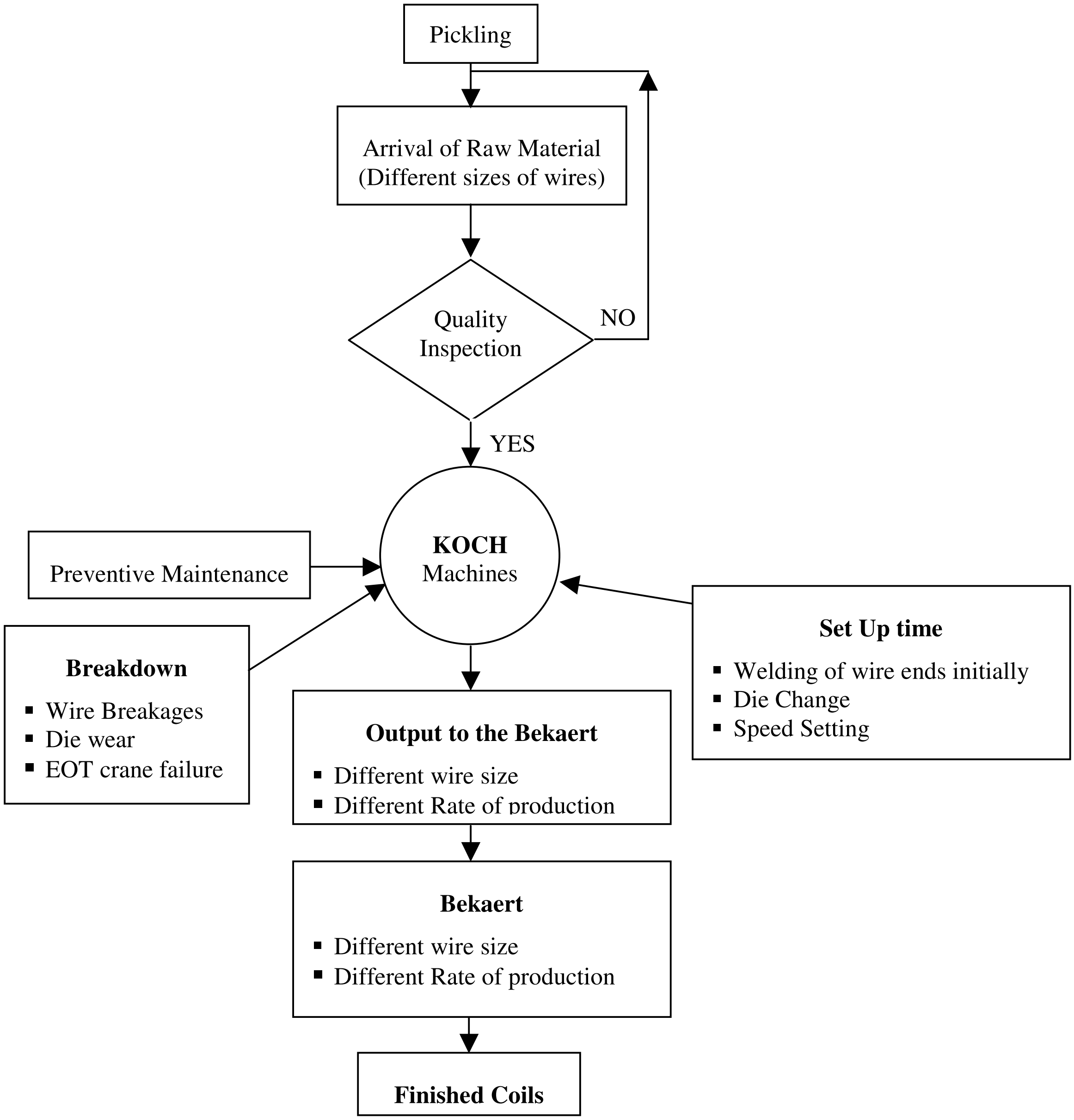

Figure 2: Flow Process Chart with Random Input and Output Variables

- From idle time study analysis of these machines it was observed that wire breakages and maintenance resulted in approximately 60% of the total idle time on these machines.
- Also rectifying the occurrence of wire breakages once, leads to downtime of the machine anywhere between 30 minutes to 3 hours, depending upon the pass number and the reason of occurrence.
- As seen from the flow process chart the wire drawn from KOCH machines is fed as the raw material for Bekeart, which finally produces the finished product. Therefore, downtime of any one of the KOCH machines will affect the productivity of Bekeart and, as a result the total production on this line would suffer, and hence the company's profits.
- No specific schedule was prepared for preventive maintenance.
- No specific efforts were made for analyzing each fault. The time consumed and the frequency of each fault was not studied.
- No specific task was taken to change or to revise subassemblies or machine members design which are giving trouble periodically.

Because of the above reasons there were many wire breakages and maintenance problems occurring and they were consuming too much time. This lead to large differences between expected production and actual production (Todi 1997). The machine utilization was comparatively low and company used to fail to achieve the production target. Hence there was a major need to reduce the idle time which occurs due to wire breakages and maintenance.

2 GOAL: NEED TO IMPROVE THE PRODUCTIVITY

Productivity can be increased in numerous ways. It can be increased either by reducing the input for the same level of output or by increasing the output with the same level of input or by combining both (Todi 1997). There can be an increase in productivity by reducing down-time due to wire breakages, maintenance, reducing the material input, by using better quality of goods, improved utilization of resources, reduction in working capital requirements, and reduction in inventory. So, on Bekeart furnace the productivity can be improved by reducing the idle time resulting from wire breakages and maintenance on KOCH machines. In doing so the machine utilization will improve phenomenally.

3 METHODOLOGY / DATA COLLECTION

The basic medium of information that is circulated from one department is shift-to-shift detailed production chart of each machine. These charts are filled by the engineers from production, planning and control department on the shop floor, and are then circulated to the respective department head. Department heads or production control officers from respective department are required to fill production along with the reasoning for idle time occurrence per shift.

The major and important part of this chart is the ‘IDLE-TIME ANALYSIS’, which is at the back of the chart. This idle time analysis gives information to the Production, Planning and Control or to the chief production manager regarding the loss in production due to the idle time per shift. The possible reasons are tabulated and the production officers enter the time and reasons for idle time in the corresponding column in the table.

3.1 Data Analysis

These chart data regarding idle time lost due to maintenance, wire breakage and die changes on the KOCH machines, were studied in order to model the downtime on the machines. Wire breakages were basically due to defective raw material, improper pickling and welding. It was observed that most of the times the faults occurring repeatedly are of the same nature and the time consumption for each fault was studied as per the ‘ABC Analysis’. From the data collected it was concluded that some faults are occurring rarely but the time consumed by these faults are very high, whereas some faults are occurring regularly but time consumed by them are very less comparatively and some faults that lies in the corridors of uncertainties whose time consumption is also moderate.

4 DESCRIPTION OF THE SIMULATION MODEL

In the simulation model using ProModel software (Harrell et al 2002), the raw material arrives in the stores as per the order requirement. The forklift then transfers the raw material to pickling for cleaning, coating and lubrication. The pickled raw material is then stored at a location (Loc1) after pickling from where the forklift takes it to railing of the four KOCH machines. The railing is used to support the coils. We have one crane for 2 KOCH machines on either side; one is for the loading and the other at unloading side of the 2 KOCH machines. As the raw material from Loc1 is brought and is kept at the railing, the loading crane loads the coil on the spooling and the coil is fed in to the machine, the coil passes through several passes each varying the diameter of the coil and then the crane at the unloading side unloads the processed coils at the cage store. The processed coils are transported to the Bekeart furnace by forklift. It unloads the processed coil at the Bekeart and then the Bekeart does its processing to produce the finished coils ready for packing and shipping.

The downtime for the KOCH machines is modelled as exponentially distributed deduced by the output using Crystal Ball 2000 Professional Edition software, shown in table 1, moreover there is no certainty about the duration and time of the next occurrence of the breakdown. The mean of the exponential distribution has been arrived at by the historical data obtained from the ‘IDLE-TIME ANALYSIS’ chart.

Table 1: Output from Crystal Ball

Distribution:	0
Best fit:	Exponential
Normal	4.89444E-06
Triangular	1.37993E-06
Lognormal	0.000965143
Uniform	1.33178E-07
Exponential	**0.658019649**
Weibull	0.351456581
Beta	0.000339292
Gamma	0.000339292
Logistic	0.027604931
Pareto	2.90823E-05
Extreme Value	0.005301619

The processing times at the KOCH machines have been modeled as uniformly distributed, this is because of the high degree of automation of the KOCH machines. This is so because the wire drawing operation involves a minimum amount of complexity once the KOCH machine is setup for a particular run of the diameter of the wire. The setup times are modeled as normally distribution. This is because it has the maximum amount of human involvement. The present scenario shows the base model on which future scenarios and conditions have to be developed.

The processing time on the KOCH machine varies from 40 minutes to 60 minutes depending upon the size of the diameter to be processed. Therefore the processing time on the KOCH is uniformly distributed according to the diameter size. The processing time on the machines are modeled as follows with the mean and half range (Bowden et al 2000).

- Diameter 1 – U (45,5),
- Diameter 2 – U (50,5), and
- Diameter 3 – U (55,5).

The setup time on the machines includes the die changing time on the KOCH machines and the time required for welding of the wire from the spool to the wire that is already fed in the KOCH machine. This time depends upon the size of the wire to be processed and is assumed to be normally distribution. The average time for the setup is normally between 20 – 30 minutes, that includes all the activities from changing of the dies in all the passes of the machine, loading the wire from the spool into the KOCH machine and then welding it. Therefore the setup time is normally distributed and is N (25, 5).

4.1 Verification

The simulation model is running as per the real scenario, the processing has been accomplished in the sequence of the operations on the shop floor. All the process routings have been appropriately defined in order to ensure the smooth running of the simulation model as described in the Notes on ProModel by Houshyar (2002).

4.2 Validation

The variables have been appropriately defined in order to keep track of the similarity of the model compared to the actual production rate in the plant (Houshyar 2002). The throughput in the simulation model is in accordance with the present production rate of the plant.

5 COMPLETE LIST OF COMPONENTS OF MODEL

5.1 Entity

There is only one entity in the entire system i.e. 'coils'. Initially coils act, as the raw material for the processing operations and the final finished product is also the coil with value adding processing operations.

5.2 Attribute

The attribute of the entity coils is the different diameter sizes of the wires.

5.3 Activity

The time for operations performed on the coils at each processing location viz. pickling, KOCH machines and the Bekaert are the activities in the entire system.

5.4 State of the system

The variables required to define the present system at any given time relative to the pre-defined objectives of the system are arrivals of the entity, WIP, Throughput, state of the KOCH machines and the resources.

5.5 Event

The events in the model are the arrival of the coils at the stores, loading and unloading of the coils from stores to the pickling by the EOT, start and end of pickling operations, inspection after pickling, transportation of the coils to the corresponding railings, loading and unloading of the coils by the crane from the railings to the spools, start and end of set ups , start and end of processing on the KOCH machines, unloading from the KOCH machines by the crane and storing it in the cage store, transportation of the coils by the forklift from the cage store to the Bekaert, start and end of processing at Bekaert and finally exit of the finished coils from the system.

5.6 List of decision variables

- The number of arrivals of the entity at the stores.
- The number of resources required
- Frequency and time of breakdown maintenance of the KOCH machines
- Utilization of the KOCH machines.
- WIP and Throughput of the system.

6 DETERMINATION OF WARM-UP PERIOD

The base model was run with the output mode as 'periodic' with intervals of one day for a time period of 1month and taking 25 replications. We find that the throughput of the system reaches a steady state after one day of operation as seen in figure 3 below.

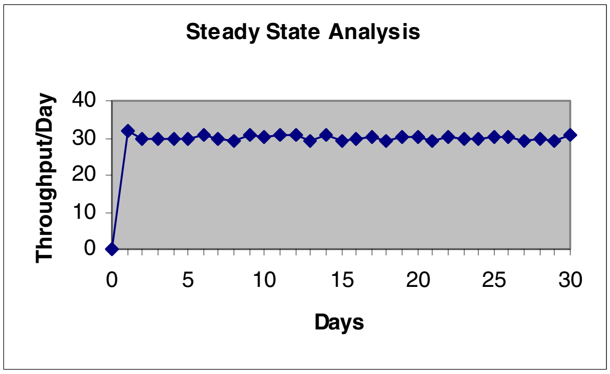

Figure 3

7 DESCRIPTION OF SCENARIO RUNS CARRIED OUT

The factors considered for optimizing the throughput were number of resources required, optimum arrival quantity for maximum throughput and minimum work-in-process and the idle inventory. Description of the simulation runs with the five scenarios having a warm up period of 24 hours are as follows:

7.1 Scenario 1

Depicts the present system with the number of coils arriving at the stores equals to 30, with no preventive maintenance. Downtime on each of the four KOCH machines is based on actual historical data and with the number of forklifts being one operating between pickling and 4 KOCH machines and one between cage store and Bekeart.

7.2 Scenario 2

In this scenario we changed the arrival quantity of the coils in the stores to 42 and a scheduled preventive maintenance is assigned to each of the four KOCH machines. This is scheduled to take place after every 35 coils processed by each of the KOCH machines, the time for preventive maintenance is calculated on the basis of the historical data by incorporating the non-preventive breakdowns into the actual machine breakdown time. The number of forklifts is unchanged.

7.3 Scenario 3

In this scenario we changed the arrival quantity of the coils in the stores to 42 and the number of forklifts operating between pickling and 4 KOCH machines was increased from one to two and one between cage store and Bekeart There was no preventative maintenance scheduled and the downtime on each of the four KOCH machines is based on actual historical data.

7.4 Scenario 4

In this scenario we changed the arrival quantity of the coils in the stores to 42, the number of forklifts operating between pickling and 4 KOCH machines was unchanged, and a preventive maintenance was assigned to each of the four KOCH machines which was scheduled to take place after every 35 coils processed by each of the KOCH machines. The preventive maintenance wait time is calculated after making allowance for the non-preventive breakdowns into the actual machine breakdown time.

7.5 Scenario 5

The preventive maintenance assigned to each of the four KOCH machines is changed, and is scheduled to take place after every 55 coils processed by each of the KOCH machines, instead of the previous 35 coils.

8 FINDINGS AND CONCLUSIONS WITH RESPECT TO THE FOLLOWING OBJECTIVES

8.1 Optimum Lot Size

The objective was to reduce the blocking of the coils in the process (i.e., to increase the product flow) and hence the optimum arrival quantity of 42 was decided upon after successive runs at different arrival quantities.

8.2 Preventive Maintenance

It can be seen from table 2 that the percentages down time of the KOCH machines decreases by assigning a scheduled preventive maintenance as compared to the downtimes based on the historical data with no scheduled preventive maintenance.

8.3 Throughput

Increasing the arrival quantity to more than the present value of 30 resulted in the 100% utilization of the forklift, transporting the coils from the pickling to the KOCH ma chines. The effect of adding an extra forklift was considered and it was found that the throughput increased by almost 500 units as shown in table 3 below.

Table 2

Decision Variables	Scenarios				
	Sn1	**Sn2**	**Sn3**	**Sn4**	**Sn5**
% down, KOCH1	6.6	1.4	5.7	1.8	1.6
% down, KOCH2	8.6	2.6	8.2	2.5	2.5
% down, KOCH3	8.8	2.8	8.6	3.8	2.9
% down, KOCH4	9.1	3.1	9.1	3.4	3.0
% Utilization of forklift1	99.9	100	79.8	79.9	80.0
% Utilization of forklift2	44.5	43.5	99.4	99.5	99.5

Table 3

Decision Variables	Scenarios				
	Sn1	**Sn2**	**Sn3**	**Sn4**	**Sn5**
% Utilization of Bekaert	53	53	74	74	74

9 REMARKS

After incorporating the above findings in the system we observed that the system had reached an almost optimum level of efficiency with respect to the objective of our project as seen from the different scenario runs (as seen in table 4 below). It is observed there is no significant change in the utilization of Bekaert, leading to the conclusion that the main constraint to throughput is operation of the Bekaert furnace.

Table 4

Decision Variables	Scenarios				
	Sn1	**Sn2**	**Sn3**	**Sn4**	**Sn5**
WIP	139	524	31	26	25
Through-puts	821	820	1313	1319	1319

It is recommended that the preventive maintenance be carried out every 5 days under the assumption that this would eliminate the breakdowns due to present lack of a scheduled preventive maintenance. However this assumption will have to be validated by observing the system with the new schedule and recording the frequency of the breakdowns occurring with the present preventive maintenance schedule. Further study needs to be done with respect to optimization of the operation of the Bekeart. The present capacity of the Bekeart is 10 coils. A cost benefit analysis should be carried in order reach at an optimum level of the capacity of Bekeart that could increase the throughput.

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