Analysis of Strategies for Productivity Enhancement of Wire Drawing: A Review

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Abstract— Productivity enhancement has become an important goal for improving the production performance in many manufacturing industries. We have attempted to present excerpts from the extant literature in the area of productivity improvement of different materials and substances. Our main work highlights the maintenance and productivity improvement with the help of root cause analysis of wire drawing process in context with steel wires which are used in manufacturing of tyres. So, here in this paper we provide knowledge of different methods and strategies adopted by many researchers and industries for enhancing the productivity of steel wires. The papers provide us a deep knowledge about the process, failure, methodology and overall details of wire drawing.

Key words: Productivity, Wire drawing, Root cause analysis

I. INTRODUCTION

Productivity is an average measure of the efficiency of production. It can be expressed as the ratio of output to inputs used in the production process. When all outputs and inputs are included in the productivity measure it is called total productivity. Outputs and inputs are defined in the total productivity measure as their economic values.[M. Telsang - 1998].

Wire drawing is the process used to reduce the cross-section of a wire by pulling the wire through a drawing dies. There are many applications for wire drawing, including electrical wiring, cables, tension-loaded structural components, springs, paper clips, spokes for wheels, and stringed musical instruments. Our work focuses on the wire drawing used for manufacturing of tyres. Drawing is usually performed at room temperature, thus classified as a cold working process, but it may be performed at elevated temperatures for large wires to reduce forces.[Byon & Lee-2010].

Root cause analysis (RCA) is a method of problem solving used for identifying the root causes of faults or problems. A root cause is a factor that caused a non-conformance and should be permanently eliminated through process improvement. Root cause analysis is a collective term that describes a wide range of approaches, tools, and techniques used to uncover causes of problems. A factor is considered a root cause if removal thereof from the problem-fault-sequence prevents the final undesirable event from recurring; whereas a causal factor is one that affects an event’s outcome, but is not a root cause.[Pal &Franciosa-2014]

II. LITERATURE REVIEW

A. Study Of Different Methods Used For Improvement Of Productivity:

Khalid S. Al-Saleh et.al [2010] works on the analysis of Motor Vehicle Periodic Inspection (MVPI) with the help of motion and time study techniques. The ARENA software is used in his work for simulation and analysis. Fig. 1 shows the diagram of Mean inspection time and Fig. 2 represents standard time for every inspection time.

Fig. 1: Mean inspection time for every inspection point

Fig. 2: Standard time for every inspection point.

The paper investigated the changes occurs by modifying the method and got success by increasing the output by 174.8% with no increase in fixed cost. [11]

Devi Prasad Mishra et.al [2013] focuses on improvement of productivity of coal mines. His work aims to identify the various problems affecting productivity in coal mine like side discharge loader (SDL) cable handling resulting in wastage of precious manpower resource and SDL breakdown. The case study of different problems and their effects like cycle of operations, machine efficiency, and manpower management were also discussed in his paper. He also concluded that many of their suggested changes are minimal affordable and shows a great effect on increasing a productivity. [8]
T. Czumanski et.al [2012] highlights the work on applied analysis of labor productivity with the help of state-oriented approach. The work here is applied to identify the different impacts on labor productivity for subsequent process enhancements. The work done by the researchers here concluded that with the use of this integral analysis on labor productivity the production manager can enhance the effectiveness and efficiency of their improvement activities. They also concluded that a high productivity potential with relatively low data acquisition achieved in their work. [17]

Tussatrin Wannagatesiri et.al [2015] conduct a quantitative survey on 357 local organization administrators views on training programs for the workers who are not working anywhere and do not have any skills. The programs conducted for the employment of these types of workers. Their short term training program was not effective as compare to long term program for providing employment. Fig 3 shows the graph of percentage of labor attended different training program as vocational and non-vocational. (SAO) Sub district administration organization and (SM) sub district municipality. [18]

Arawati Agus et.al [2011] presents their work on Total Quality management technique (TQM) by analyzing the importance of method in the Malaysian manufacturing industry. The authors investigate the relationship between TQM, production performance and customer related performance. The work done here is based on the explaining the importance of TQM and increase performance of company. Their methodology concluded that they got success as positive gains in improvement. The paper also concluded that with the use of their method of (TQM) analysis the manufacturing and management process of company greatly increases. [4]

Christoph Dobrusskin et.al [2015] focuses on Root cause analysis for estimating the chain analysis. Modern TRIZ is the technique which is used here as a tool to analyze the initial problem and concluded some advice that how the analytical tools can be directly used as input for the problem solving tools. Fig. 4 shows the Fishbone diagram investigating a problem with drilling machine. Fig. 5 shows the cause effect chain analysis and Fig. 6 shows the root conflict analysis. These figure represented above are used for explaining the overall methodology adopted in this paper.
Hamid Tohidi et al. [2011] provides a survey of research on teamwork productivity and effectiveness based on reward, leadership, training, goals, wage, size, motivation, measurement, and information technology. [9]

<table>
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<th>Research topics</th>
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<td>Reward systems</td>
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<td>Leadership</td>
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<td>Training &amp; learning</td>
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<td>Goals</td>
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<td>Intra group wage inequality</td>
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<td>Size of team</td>
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<td>Motivation</td>
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<td>Models of effectiveness</td>
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<td>Team measurement</td>
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<td>Information technology</td>
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Table 1: Gives the methodology and procedure of teamwork adopted in the paper for effective results.

**B. Study of Papers Based On Analysis and Process of Wire Drawing:**

Sedat Karabay et al. [2008] represents the discussion and study of importance and application of predictive maintenance concept with the help of vibration measurements. The study based on the analysis of two manufacturing plants. Plant A is aerial conductor manufacturing plant and plant B shows detection of a ball bearing failure just in time. All the process and analysis is done by considering the plant of wire and tyre manufacturing. [15]

**Fig. 7:** The deformed spool with wires thrown.

Fig. 7 shows the deformation of spool with wire thrown out from the rotating tubular machine by locking of the ball bearing of the cradle owing to maintenance problem. The weight of spool is 150 kg and rotating speed of the tubular machine is 1000 rpm. The paper concluded that with the survey and study of different rotating and loading machines the problem of workers and material safety occurs. The problem of vibration also created a various problems so author also highlights a men-machine safety in their paper. They also concluded that for the better work and safe production the methods are used in proper a manner and due to this number of workers are increases this varies the fixed cost of company.

Adriana-Maria Mihu et al. [2016] presents the analysis with the help of 3D finite element simulation for the complex study of the drawing process with cassette roller die, of the round wires. The paper analyze the influence of various vibration process parameters like friction coefficient, radius of working roller, and initial and final diameter of the billet in the drawing process. The procedure used here is explained with the help of Fig. 8 given below. [2]

**Fig. 8(a):**

Fig. 8 (a): The device wire drawing in cassette roller disc.

**Fig. 8 (b):**

Fig. 8 (b): The device used for simulation.

The paper presents various conclusions which analyzes with the help of applying the simulations at various friction values, different roller radius, and various initial and final diameters.

K.K. Tang et al. [2011] presented the numerical based simulation of damage evolution in multi-pass wire drawing process and its potential relevance to manufacturing design is represented in this paper. The processes here adopted are Gurson-Tvergaard-Needleman model (GTN model) for mathematical simulation and three dimensional model of wire is generated with the help of ABACUS. The conclusions arises by using these methods shows that the damage accumulation in the 8-pass wire drawing process is rise steadily and the range of new damages decreases. They also analyze that the damage occurs in the wire during the drawing process is mainly occurs at fractured area. They performed a various number of simulations on the wire for their complete analysis and shown their deep discussion in the paper. [10]

Pavel Peterka et al. [2014] analysis and performance here is done on the actual wire ropes of damaged and non-damaged condition means an old rope and new ropes. The examinations performed on these ropes are analyze and noted with the help of screen which shows the amplitude and length ratio.
The paper concluded that when the author analyzes that the damage occurs on the rope during operation in the upper layer during manufacturing process. They also mention that the deformation and breakage of wires is caused by releasing the wire of lower rope grade as well as by strong dint and abrasion when released wires are passing the hoist system. [13]

In the study of S. M. Byon [2011] based on wire drawing test for four different coating materials with two different lubricants. Plain carbon steel and ultra low carbon bainite steel are used here as a material. They also performed a series of Finite element analyses and a SEM observation is also conducted for investigation of surface defect of deformed wire. Fig. 10 shown below gives the representation of dimension of dies and wires. [14]

The paper concluded that the behavior of drawing force with the lubricant-type at the initial stage of drawing. They also mention that the power-type lubricant with a large particle cause the retardation of full lubrication on the entire contact surface and the local delamination of coating layer on the wire surface.

L. Filce et.al [2013] the paper shows the study of multi-objective approach based on the optimization of a set of objectives is presented. [12]

They focus here on various parameters of optimization on wire drawing process like process force, die wear, material thinning, and damages by varying of semi cone die angle imposed strain. The graph presented above in Fig. 11 shows results of correlation between Force (Z1) and wear index (Z2). The paper here concluded that the solution are Pareto optimal and constitute the better trade-off when these various kinds of problem structure are taken into account.

C. Study of Papers Based On Root Cause Analysis Technique:
A.H.V. Pavan et.al [2013] the researchers here in this paper works on the metallurgical investigation on failed pinion shaft for analyzing the causes of failure. They focus their work by taking a shaft at high stress concentration torsional failure. They performed here an actual experimental analysis which was shown in Fig. 12 below.

The tables presented below, Table. 2 show tensile testing results and Table. 3 shows impact testing results.

### Table 2: Tensile testing results

<table>
<thead>
<tr>
<th>Specimen</th>
<th>0.2% yield strength (Mpa)</th>
<th>UTS (Mpa)</th>
<th>% elongation</th>
<th>% reduction in area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupling side</td>
<td>698 ± 37</td>
<td>1012 ± 35</td>
<td>9.81 ± 0.9</td>
<td>54.13 ±1.2</td>
</tr>
<tr>
<td>Specified value</td>
<td>785 min</td>
<td>1080-1320</td>
<td>8 min</td>
<td>35 min</td>
</tr>
</tbody>
</table>

### Table 3: Impact testing results of transversely prepared impact specimens

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Impact Strength (j)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupling side</td>
<td>56 ± 4</td>
</tr>
<tr>
<td>Gear box side</td>
<td>59 ± 4</td>
</tr>
<tr>
<td>Specified value</td>
<td>46 min</td>
</tr>
</tbody>
</table>
The research in this paper concluded that the pinion shaft had failed due to overloading despite the keyway. These failure and fractures are arises due to presence of limps which are not properly crushed. As we mention above that the failure arises is due to high stress concentration torsional failure although fatigue marks were not observed as the fracture surface rubbed against each other after failure. Hence the researchers mention that the failure here is a type of consequential failure. [1]

C. V. Sunil Kumar [2014] focuses on Root cause analysis technique by applying supplier development (SD) approach in a manufacturing company for increasing strength. In this paper the (SD) method is applied by using Interpretive Structure Modeling (ISM) – Fuzzy Matricide Impact Croises Multiplication Appliqueean Classement (FMICMAC) algorithm for systematic analysis. The software based methodology is adopted in this paper by using programmed MATLAB 7.10.0 software. The paper concluded that with the use of this approach a problem of aforementioned is resolved. They also mention that from ISM model, the PCF is the most influencing SDIs and can be considered as the strongest root cause for the other SDIs. [6]

Avishek Pal et.al [2014] the paper gives analysis with the help of Root cause analysis by applying a closed loop lifecycle modeling approach. The researchers here works on software based analysis by using a design software’s such as CAD, geometric dimensioning and Tolerancing (GD&T) etc for finding the critical geometric features of internal components. The actual methodology adopted here in this paper is easily explained with the help of Fig. 14 below.

![Fig. 14: Root cause analysis of product service failures Caused by dimensional variations.](image-url)

The conclusion presented in this paper mentions that the overall procedure surrogate modeling of dimensional variable of control parameters. The current work also focuses some methodologies like closed form representation of relation between product features and control parameters. Selection of critical control parameters and sensitivity analysis of product features with respect to control features. [5]

Amir Azizi et.al [2015] focuses on the evaluation of production productivity by continuously improved the equipment efficiency and process control in tiles manufacturing industry. Here the researchers used OEE method for improvement of equipment efficiency. The analysis and improvement was carried out by using Define, Measure, Analyze, Improve, and Control (DMAIC).

![Fig. 15: Process flow chart of the study.](image-url)

Here SPC is suggested as a monitor function for evaluating the process quality performed and the seven basic tools are used to tackle the manufacturing process and AM is applied as a glazing line to improve the machine efficiency. The Fig. 15 shown above presents the overall methodology and process adopted in this paper. As from the study of paper we see with the use of AM the defect rate reduced with 8.49% successfully and reduces 14.6% and 6.12% by using glazing line technique. They also mention that the Machine breakdown time has been decreases from 2502 minutes to 1161 minutes whereas OEE has been improved 6.49% from 2212% to 28.61%. [3]

Sherif Mostafa et.al [2015] suggested that the waste elimination is very much important for reduction purpose. So here the paper based on the analysis of nine waste types and waste identification tool are revised. The proper study is based on waste documentations, waste analysis and waste removal. The proper framework is shown in Fig. 16 given below.

![Fig. 16: Framework of waste elimination process.](image-url)
The paper mentions that the VSM method is considered as a common tool to visualize an activity flow. They also highlight that for non-complex manufacturing, traditional VSM could be sufficient to capture non-value adding activities. As we know the paper focuses on waste removal frameworks and they got success. They also present some future scopes as per their research like they recommended that the pre and post measurement should be conducted in order to conclude the effectiveness of waste removal in relation to manufacturing sustainability. [16]

III. CONCLUSION

Our paper based on the study and analysis of extant research on productivity analysis of different products in manufacturing industries. Our analysis based on review highlights the parameters affecting the productivity, the cycle of operations, machine efficiency and manpower management. We focus here on the papers of wire drawing analysis and Root cause analysis technique. Following are the salient findings of our research:

1) The use of software’s like ARENA, MATLAB, and CAD are very much effective for study and analysis of productivity and methods of increasing productivity.

2) The papers also present various analysis methods for wire drawing like Motion and time study technique, Integral analysis, Total Quality management (TQM), Chain effect analysis, information technology, and Finite element analysis.

3) From the study of these methods we find that work on Total Quality management (TQM) is best possible technique to work.

4) Work on wire drawing is our main work to do. The papers provide us a deep knowledge about the process, failure, methodology and overall details of wire drawing.

5) The papers also show the benefits of Root cause analysis which shows effectiveness for us to use in our main work.

6) The papers identify how simple method can be used to improve work and work process. By making simple changes to the process, it can reduce the time taken for each component to improve the flow and speed up the process.

REFERENCES


