Impacts of the Characteristics of Unexpected Breakdowns on the Maintenance of Modern Printing Machines

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Abstract

The author outlined a model to examine unexpected breakdowns in modern printing machines. He was analyzing the different downtimes for years. The results of the researches help to organize the pro-active maintenance at the graphic arts industry.

During the study, the operation of characteristic printing machines was monitored in two steps, primarily to analyze unexpected breakdowns. From 1988 until 2004, i.e. for 17 years a database of unexpected breakdowns was structured with respect to 65 modern printing machines. The associated theoretical and practical conclusions drawn from the study were presented in 2008, in Valencia (Spain) at the 35th IARIGAI (International Association of Research Organizations for the Information) Conference. This publication is a summary of the observations of an additional period of 10 years (2005–2014). In this latter period, 71 mechanical printing equipment units were studied; some of them were identical to the machines investigated earlier, but a significant part of them were newly commissioned machines. Resulting from the study, the database of unexpected breakdowns was compared to the earlier results to highlight similarities, changes and development. One of the major conclusions of the study that is reflected from the results of the full-scale (27-year) monitoring effort is that in the world of printing machines a large proportion of unexpected breakdown, failures are technical or technological errors that can be quickly tackled.

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Introduction

Maintenance techniques have changed over time from correction (breakdown) to prevention to prediction and pro-active continuous improvement. Effective maintenance is a series of progressive steps to improve operational effectiveness and the key step in this process is the transition of pro-active working.

Companies that optimize their maintenance select and combine the techniques that match the needs of their equipment and operations. Moving up the maintenance stairway requires a planned approach that brings together the right procedures, tools, training and the knowledge the feature and history of our machines' breakdowns (Tsang, 2002).

The objectives of the research

The results of authors' survey – covering 25 leading Hungarian printing offices – suggest that the major cause (46%) of maintenance issues is events of unexpected breakdowns. Consequently, the high ratio is the most influential factor of the design and management of maintenance tasks. The objective of the research is to critically map and discover the characteristics of unexpected breakdowns of printing machines in order to facilitate proper maintenance management (Gaál, 2007).

Research methods - Operating maintenance model

Despite the possible big differences between printing machines we treat them with a united approach based on their fundamentally common characteristics. One of the major reasons for the synthesis originates from maintenance practice. Generally, the printing offices perform the maintenance duties with staff small in number. Consequently, there is a little chance to gain special knowledge and subdivide the maintenance approach and practice. The machines, which are different in structure and technological tasks, have a lot of common characteristics from the operational and maintenance point of view in case of printing office applications, which makes the united approach acceptable (Claypole, 2005; Wells, 2003).

The technological elements of modern printing machines unite two equally important operations. The major operation, which performs informational types of formation on the product, is based on a highly accurate transmitting operation of the processing material (mostly paper). Therefore, the input and the output units are very important elements of printing machines. These elements ensure the assembly of machine systems. Moreover, if the bigger systems were divided into elements we would always get division three, in the model. The units of operation, management and supply set the same claims up for the technological units regarding their structural form, complexity and especially their maintenance requirements.

The authors outlined a model (*Figure 1*) to examine the unexpected breakdowns of modern printing machines. The model reflects the general structure of printing machines, which is needed to analyse the features of maintenance and maintenance management. The modeling analysis focused on various types of downtimes of 65 different printing machines representing the previous, current and future generations.

The data of unexpected breakdowns were derived from an extensive period of time.

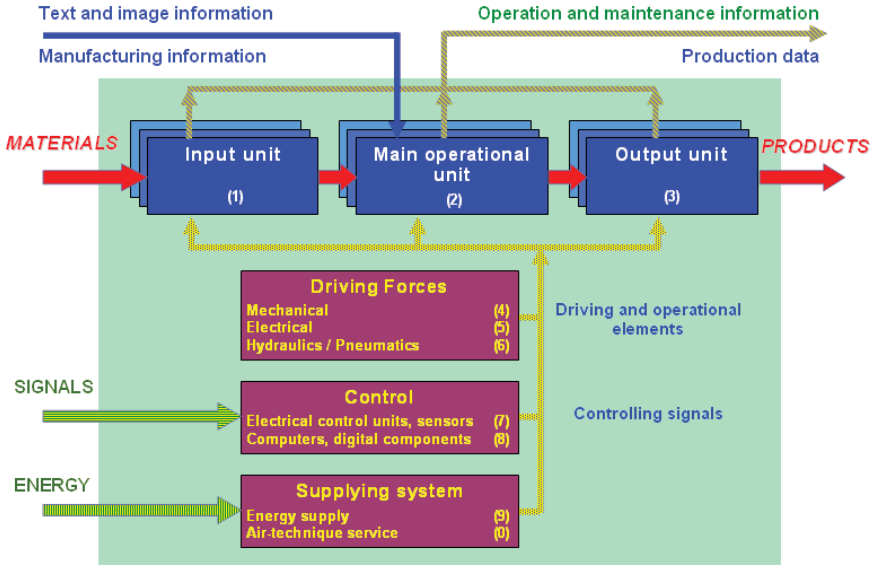

Figure 1: *Extended operating maintenance model for the printing machines*

Maintenance features of printing machines

While providing analysis for the typical features of the troubleshooting and detailed information of repairing operations, the results of the researches outline the maintenance characteristics of the modern printing machines' unexpected breakdowns.

The similarities between the manufacturing processes, raw materials and products of printing machines result in similar defective, corrective and maintenance features, which should be considered during management and organizational tasks. Therefore, thoroughly analyzed those sources of faults and damaging processes, with which we struggle during the operation of printing machines.

The authors collected data on unexpected breakdowns of printing machines for a long period of time at Alfoldi Printing Plant Plc., Hungary's largest book printing plant. A computer-assisted system could continuously record the basic data of the important processing machines. The historical datasets were set as the starting point for our analysis. The continuous data collection was carried out on the most important processing machines of Alfoldi Printing Plant Plc. During the monitoring the machines were replaced from time to time following the technological development. We monitored 65 printing machines. These represent the previous, current and following generations. Their age varied between 1 and 27 years and 22 completely new machines were purchased during our monitoring. Every machine was operated at a specific site, the center site of Alfoldi Printing Plant.

The data of unexpected breakdowns what they used are from a wide period of time (data of 17 years of full operation between 1988 and 2004).

The extent of generalization based on the characteristics of printing machines might obviously raise a few questions from the reader. The printing machines and the relatively complex technology of Alfoldi Printing Plant and their loading give an extensive cross-section of today's typical printing machines. It was a limiting factor that there were only a few similarly detailed and accessible historical databases even for a shorter period of time. However we could make a comparison with the data of similar Hungarian printing plants; like Szikra Lapnyomda, Revai and Petofi Printing Plant. The data on downtime and reparation time showed similarities with the calculations from our database.

Figure 2 shows the major conclusions and the calculated characteristics.

The calculated mean values	**Mean**	**Standard dev.**
Restoration time	1.80 hours	0.47 hours
Repair time of a breakdown	2.24 hours	0.54 hours
Characteristic data of printing machine		
Operational time in a year	2 883 hours	617 hours
The expected number of unexpected breakdowns during the operational period (rounded values)		
yearly	87 occasions	24 occasions *
monthly	7 occasions	3 occasions *
weakly	2 occasions	1 occasions *

* Rounded values for the easier understanding

Figure 2: *Most relevant data characterizing the unexpected breakdowns of printing machines (Examination period: 1. January 1988. – 31. December 2004.)*

The 65 printing machines ran nearly 1.7 million operating hours, while 58317 maintenance events originated from unexpected breakdowns were recorded. The reparation of the machines caused more than 105,000 operational hours of dropout in the production and more than 130,000 reparation hours.

The unexpected breakdowns of printing machines are quickly reparable; these generally require small maintenance events. The downtime, which is not more than two hours, caused by operational failure is more than 80%, which generates more than 50% of this kind of troubleshooting. The originated reduction of losses requires concentration to details and predictive organization. The relatively low average value might just well have a great influence on the future developmental concepts of maintenance systems. The relatively short reparation times typically contain several elements that are not actual professional work (reaction time, approaching the reparation scene, information transfer etc.). The relative frequency of values characterizing the reparation times of unexpected breakdowns is shown on a histogram of *Figure 3*. These data contain extremely important information for maintenance managers.

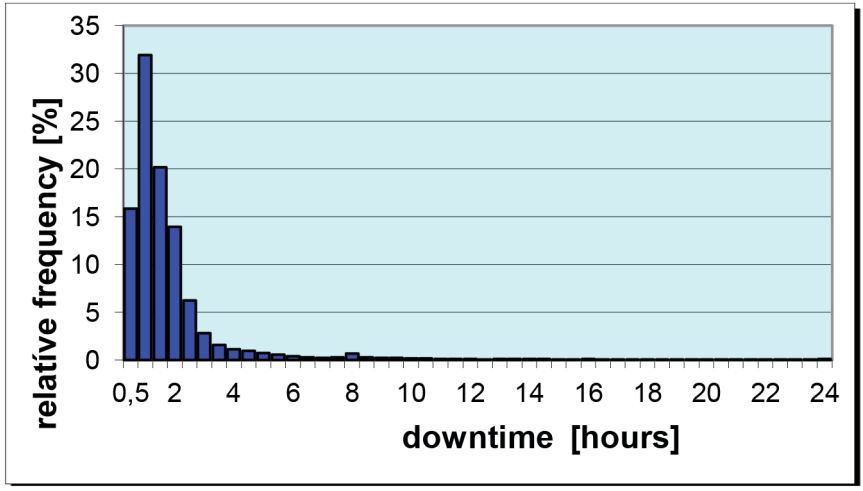

Figure 3: *Histogram of the relative frequency of time needed to troubleshoot the unexpected breakdowns of printing machines (Examination period: 1. January 1988. – 31. December 2004.)*

The „refurbished" monitoring and examination between January 1, 2005 and December 31, 2014

The finishing of the last investigation of the monitoring mentioned above was teen years ago. The monitoring of the printing machines of Alfoldi Printing Plant was continuously during this period of time. The "newer" 10 years is more than enough to repeat the investigation.

Even the company has partly changed its machinery and technology during the 10 years of examination. The average number of the running machine was 77. They have taken 38 machines out of order and have bought and took in operate 24 pieces new ones. The summary of the operating time was 611 326 hours while 18 585 maintenance events originated from unexpected breakdowns were recorded. It can be seen the number of unexpected breakdown was considerable reduced. The Figure 5 shows the character of the histogram hasn't changed, but the average time for the trouble-shot and repairing of the unexpected breakdowns increased. Only 60% of the breakdown is repairable within 2 hours.

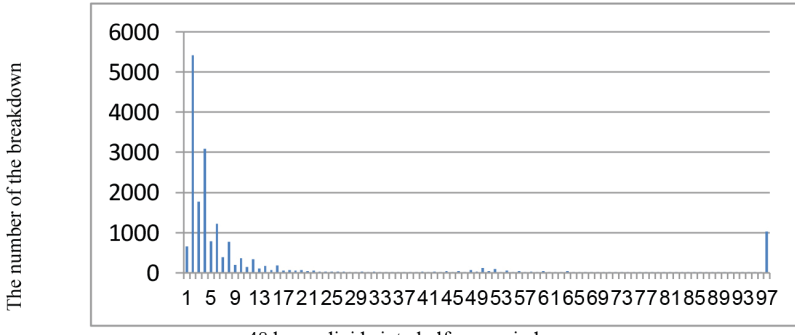

Figure 4: *Histogram of the relative frequency of time needed to troubleshoot the unexpected breakdowns of printing machines (Examination period: 1. January, 2005 – 31. December, 2014)*

Process integration efforts

The data provided by the machine monitoring system at Alfoldi Printing Plant allow us to explore the connections between operation and maintenance.

The experts of maintenance have a natural human relationship with the workers of the plants due to the smaller plant sizes of the printing industry. The routine and experience many times bridge over the failures, which occur due to unexplored correlations. It is essential for the maintenance management to clarify the reasons and the time periods of high occurrence of reparations and it is also important to know the time period and location of low occurrence of reparations.

The following analyses show that the breakdown events don't just depend on the technical condition of machines. Specific time dependence can also be recognised. We analysed the unexpected breakdowns of the printing machines of Alfoldi Printing Plant during the given two time period, and we also analysed the distribution of the resulting downtimes for a working day.

The results of the analyses are illustrated on *Figure 5*.

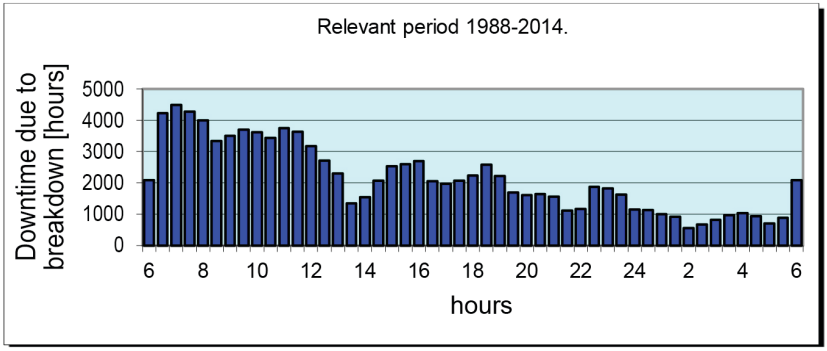

Figure 5: *Daily distribution of downtimes due to unexpected breakdowns*

There is a fundamental correlation in the number of operating machines. The proportions of the operating machines in the analysed period were the followings: 72% in the morning shift, 54% in the afternoon shift and 31% in the night shift. The proportions of downtimes reflect nearly the same result. While the proportion of operating machines hardly changes, a well-observed pulsation occurs (in the first and second halves of the shifts) in the downtimes.

This phenomenon is a bit better observable on *Figure 6*, where the probability of downtimes due to the breakdown of at least one printing machine out of all during a day is plotted. In this case the way of calculation was the following: we related the data to operating machines at a given time. Therefore, the probability of downtimes related to breakdowns is independent of the number of operating machines. It is observable that the proportions of reparation needs in given shifts are different but not in a bigger extent. The critical time period is the beginning of morning- and nightshifts. The double hump or maximum peaks clearly appear in the 2-3rd and the 5-6th hours of each shift. It is important, without further analysis, for the maintenance managers to know these results for the sake of uniform loading of the workers and for the requirements of the reparation.

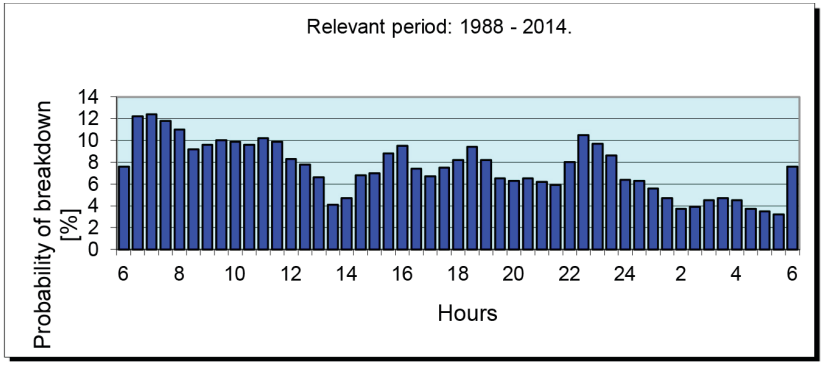

Figure 6: *Frequency of downtimes due to the breakdown of at least one printing machine during a day referring to the operation of printing machines*

It should be also informative to carry out an analysis on each working day of the week, as shown on Figure 7. The tools of work psychology can explain the low breakdown rate in Monday mornings and Friday evenings. It is well observable that the week starts with reparations and the number of breakdowns is relatively high even in the second shift. The operators want to "bring a good machine together" in the beginning of the week.

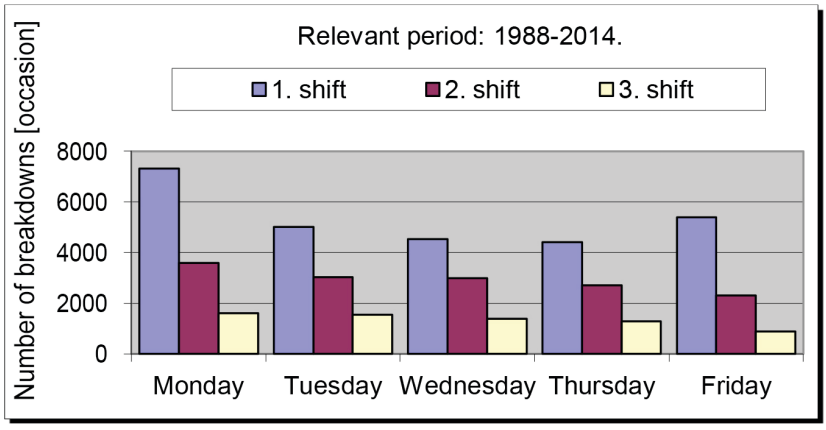

Figure 7: *Distribution of unexpected breakdowns projected to working days of the week*

The number of breakdowns, after the reparation, during the week is continuously decreasing. The Friday morning is the "time of preparation" for the weekend overtime, but that night, if it is possible, they don't bother with reparations.

The proportions, the demands of afternoons and nights during a week, the occurrence and the handling of demands are also useful information for the maintenance manager.

6. Conclusions

For maintaining the productivity of printing machines, the detailed knowledge of relations between failures is crucial. Aversion of unexpected breakdowns generally requires short/reactive reparative action. The knowledge about the typical failure rates of major parts of printing machines is the fundamental pillar to apply pro-active maintenance management. The strategy of the maintenance in Alfoldi Printing plant has also been changed to prefer the pro-active management.

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