Extended operating maintenance model for modern printing machines

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Abstract

The authors outlined an extended model to examine the modern printing machines' unexpected breakdowns. They had been analisyng the different downtimemes for years. The results of the research helps to organize the pro-active maintenance at the graphic arts industry.

Keywords

breakdown, operating of printing machines, predictive and pro-active maintenace

1. 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.

2. 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.

3. 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.

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 .

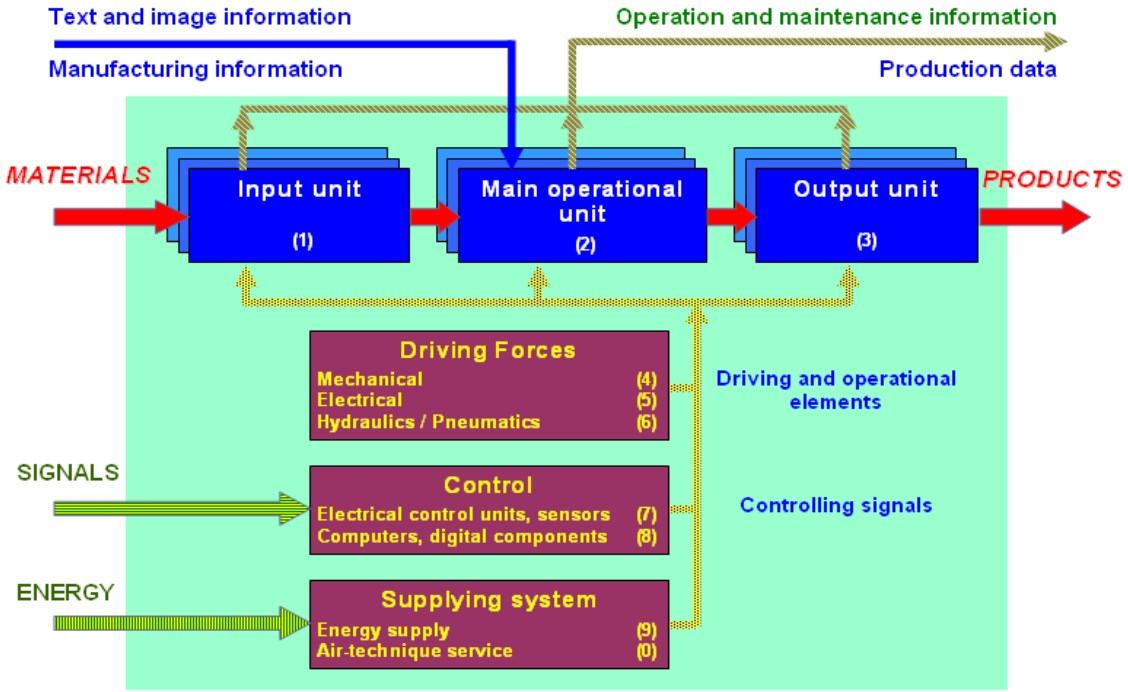

Figure 1: Extended operating maintenance model for the printing machines

4. Maintenece 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 centre 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.

Table I shows the major conclusions and the calculated characteristics. 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.

Table I: Most relevant data characterizing the unexpected breakdowns of printing machines (Examination period: 1. January 1988 - 31. December 2004)

The calculated mean values	**Mean**	**Standard deviation**
Restoration time	**1.80 hours**	0.47 hours
Reparation 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

The development of maintenance efficiency obviously has a great impact on unexpected breakdowns. The change in average values during the past few years show a slightly decreasing tendency as shown on *Figure 2*, conforming that the maintenance efficiency has also improved at Alfoldi Printing Plant. The slowly changing tendency of downtimes however proves that the fundamental maintenance characteristics are originated from structures and technological conditions. These are independent from the quality of maintenance. The number of machines used after 2000 did not modify the average values of downtime and reparation times significantly.

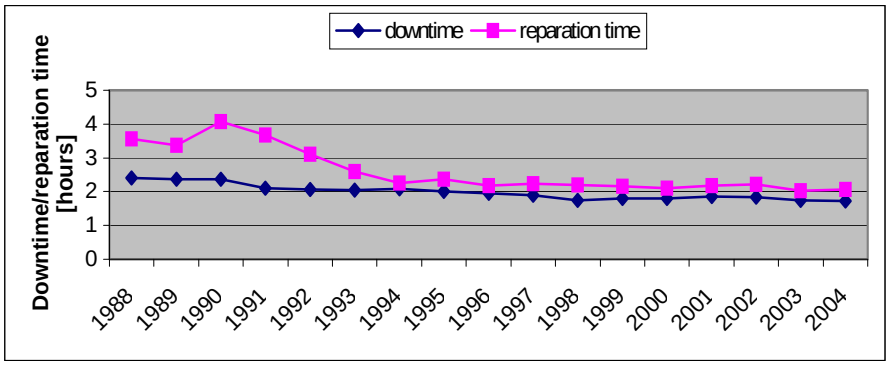

Figure 2: Time dependence of the average downtime and reparation time

The data also shows that the maintenance characteristics of pressing and bounding machines don't differ significantly. The values (shown at *Table II)* confirm the correctness of the principle; these should be treated together, like I haven't distinguished them in the maintenance model either.

Table II: Characteristics related to the troubleshooting of unexpected breakdowns for different types of printing machines

Calculated mean values	**Pressing machines**	**Bounding machines**
Time of troubleshooting:	***1.84 hours***	***1.77 hours***
Reparation time of a breakdown:	***1.97 hours***	***2.38 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.

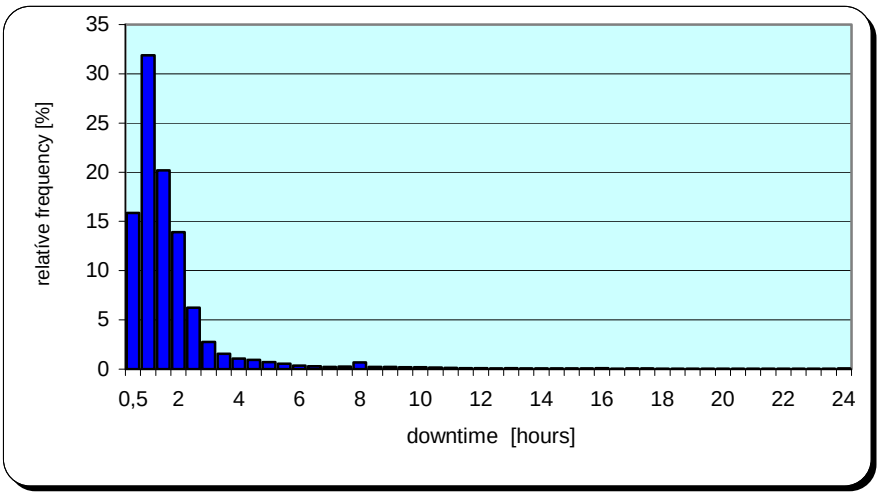

Figure 3: Histogram of the relative frequency of time needed to troubleshoot the unexpected breakdowns of printing machines

5. Typical breakdown 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.

There is another important approach in this chain of thoughts. What breakdowns are typical for printing machines? The classification of breakdowns is carried out according to the 10 big structural groups characterizing the printing machines mentioned in the maintenance event log system, based on the previously presented model.

Figure 4 shows the breakdown proportion of the distinguished parts.

The input and output units - the units of the above-mentioned transmitting machines - give the 39% of all breakdowns.

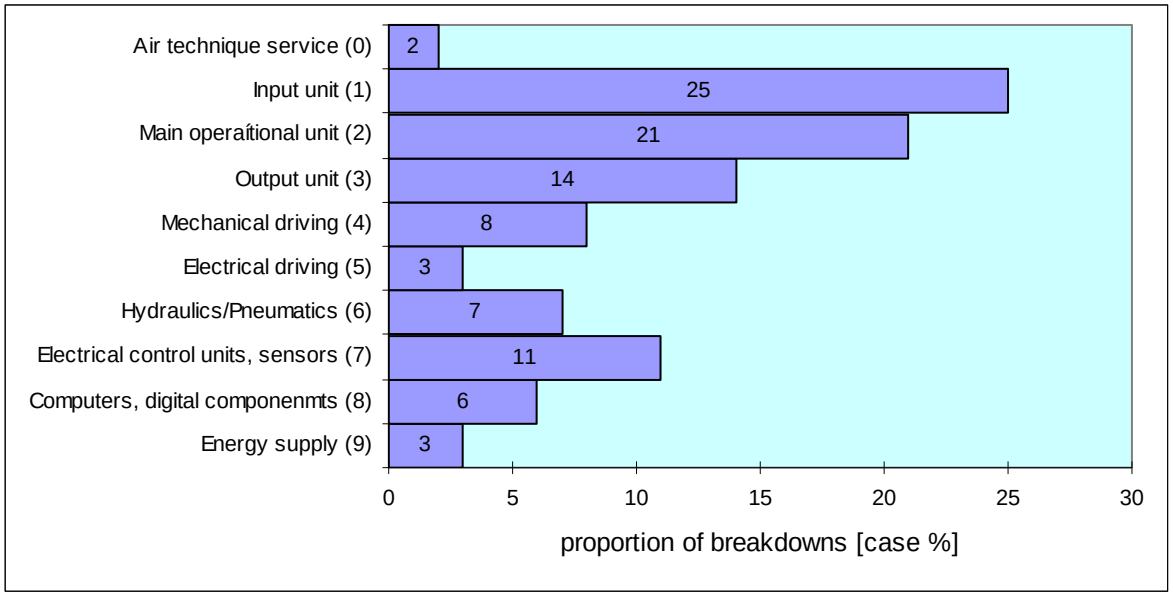

Figure 4: Distribution of unexpected breakdowns of printing machines between the given main units

There is a high occurrence of breakdowns due to failures of mechanical propulsion, sensors and beacons. Units performing technologically important operation have relatively smaller breakdown proportion compared to their importance in the machinery. The breakdown proportion of the electrical parts is 20% as shown on the diagram. The proportion of the electrical type of unexpected breakdowns is 29% including electrical faults of any part. The knowledge of proportions is especially important preparing for condition-assessment and modernization.

6. Reliability analysis

An adequately designed and managed historical maintenance database was needed to determine the above presented maintenance characteristics. In this part we wish to prove that the determination of breakdowns occurring in printing machines is possible through methods based on examples using databases. The methods of predicting breakdowns and the increase in reliability are also possible in the phase of application and operation.

The maintenance of high capacity production lines in the printing industry raises the issue of the application of maintenance-management from the reliability point of view. The user of several expensive machines (mostly magazine and newspaper printers) not only expects to have a fault-free system for a given time period, but also wants to have a lasting system complying with the instructions of operation, maintenance and reparation. This demand yet covers the complex understanding of reliability.

By definition reliability is the complex characteristic and the ability of an equipment that carries out a given function depending on its purpose and terms of operation for a given time period. It might include faultlessness, durability, and reparability respectively or all together [Tsang, 2002].

During the reliability approach of maintenance-management the type of maintenance strategy must be chosen based on the intended operational purpose, technical and economical characteristics of the machine, moreover the optimal tactical methods and activity system must be also determined. [19]

As a first step, the operational reliability of the maintained machines must be determined though. These reliability analyses are carried out on mathematical and statistical bases. It is only possible when possessing the number of maintenance events related to a given machine. We have only found one printing industry application of reliability theory in the literature. The authors [Malzhan, K. and Hofmann, S., 1972] published three summaries from their dissertation (Technical University of Dresden).

Maintenance strategy was developed for an offset roll printer following reliability theory basis. The actual analysis was carried out on an Zirkon Ultraset 72 printing machine. We have the historical data of 3 identical machines' event log. The distribution function of breakdown probabilities can be parameterised by Weibull distribution.

We took the aspects of reliability analysis into consideration when analysing the unexpected breakdowns of printing machines. The histogram of fault-free operation periods is illustrated on *Figure 5* calculated from the previously mentioned data of 65 printing machines. The expected value of the fault-free operational periods (Mean Time Between Failure) in case of continuous operation is 75.25 hours. The last column of the histogram represents 16% of the relative frequency of faultless operational periods exceeding 168 hours.

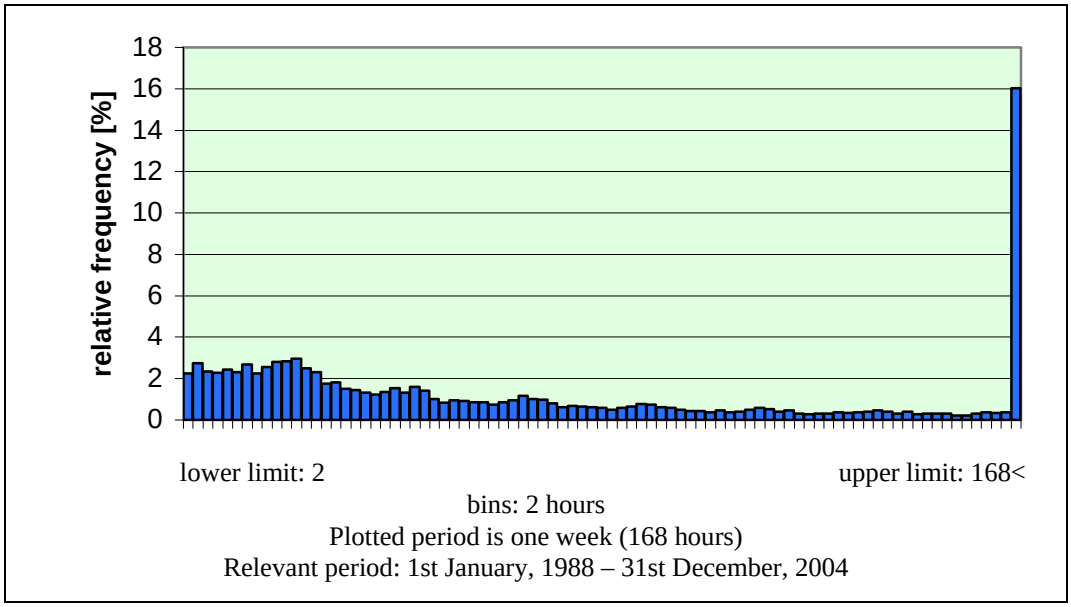

Figure 5: Histogram of relative frequencies related to fault-free operational periods of printing machines

The existing historical databases allow us to develop reliability models for several types of printing machines. Our main purpose was to assemble a toolbox of maintenance management, so we only presented the new ways of development after processing the results. The actual application of reliability analyses can only be expected after the wide use of computer-assisted systems, which we think is going to be one of the major professional challenges of future.

7. 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 above mentioned 65 printing machines of Alfoldi Printing Plant during the given 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 6.*

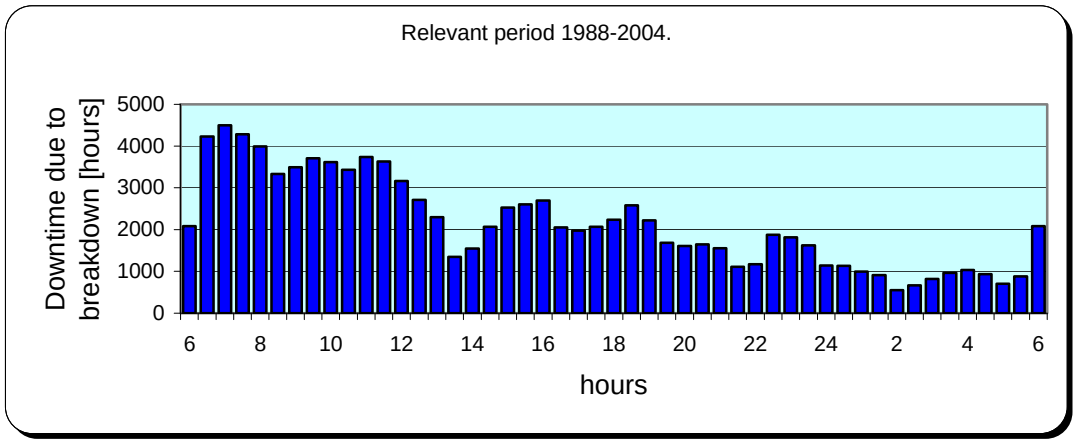

Figure 6: Daily distribution of downtimes due to unexpected breakdowns

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 7*, where the probability of downtimes due to the breakdown of at least one printing machine out of 65 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.

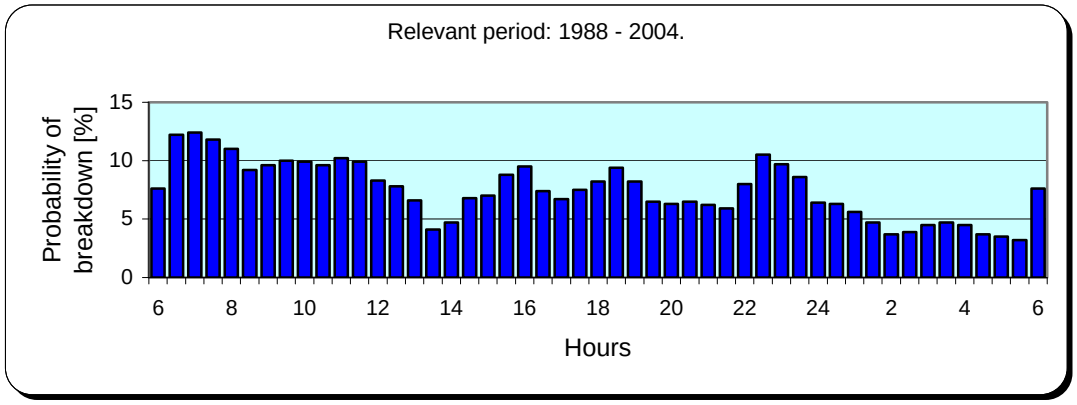

Figure 7: Frequency of downtimes due to the breakdown of at least one printing machine during a day referring to the operation of 65 printing machines

It should be also informative to carry out an analysis on each working day of the week, as shown on *Figure 8.* 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. 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.

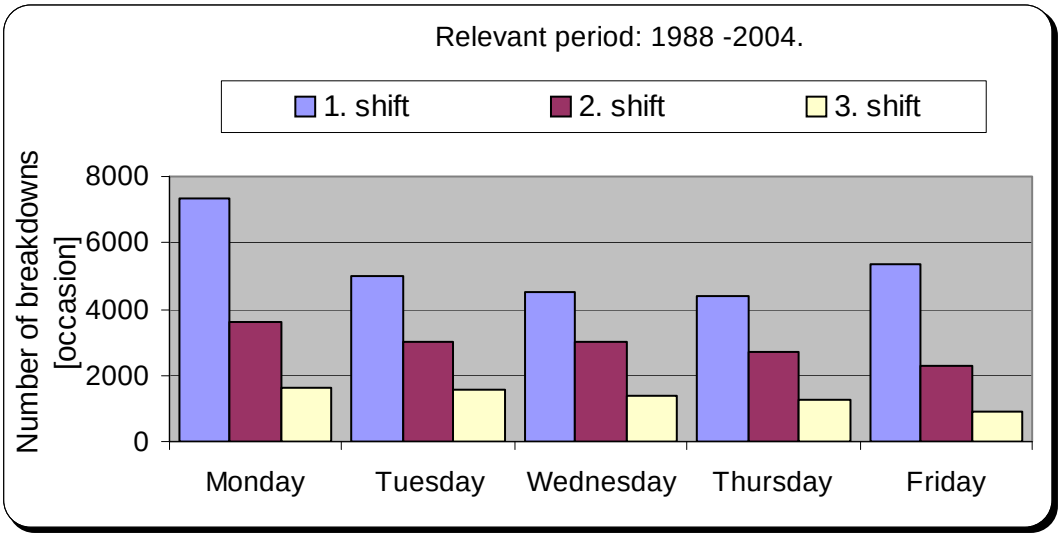

Figure 8: Distribution of unexpected breakdowns projected to working days of the week

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.

8. 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.

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