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# MAINTENANCE OF DRILLING MACHINES USING PARETO ABC METHOD

*Abstract*. Under the pressure of global competition, production facilities have seen their performance grow steadily. The machines are highly demanded, the speed of rotation and the operating time increase. This results in increased damage and breakdowns, which lead to unscheduled shutdowns. The costs of downtime are in these cases significantly higher than the costs of repair and overhaul. The prevention of machine damage is therefore of great economic significance to every business. Preventive maintenance leads to ensuring the continuity of industrial production by controlling the anticipation of the consequences of faults and by ordering their repair in a timely manner so that they do not affect the functioning of rotating machines. The objective of this work is to statistically analyze failures in the machine shop with ABC method and to select the critical machine. A maintenance plan has also been drawn up for the development that addresses the major problem that is the optimized reduction in downtime of the radial drilling machine (NKH45), given the importance of this production equipment to level of manufacturing activity. This method of reliability-based maintenance (RBM).

*Keywords:* Maintenance, Radial drilling, reliability, history of interventions, Pareto ABC method.

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# ТЕХНИЧЕСКОЕ ОБСЛУЖИВАНИЕ БУРОВЫХ СТАНКОВ С ИСПОЛЬЗОВАНИЕМ МЕТОДА ПАРЕТО ABC

*Аннотация.* Под давлением глобальной конкуренции производительность производственных мощностей неуклонно растет. Машины пользуются все большим спросом, увеличивается скорость вращения и время работы. Это приводит к повышенным повреждениям и поломкам, которые приводят к внеплановым отключениям. Затраты на простои в этих случаях значительно превышают затраты на ремонт и капитальный ремонт. Поэтому предотвращение повреждения машин имеет большое экономическое значение для любого бизнеса. Профилактическое обслуживание приводит к обеспечению непрерывности промышленного производства за счет контроля упреждения последствий неисправностей и своевременного заказа их ремонта, чтобы они не влияли на функционирование вращающихся машин. Целью данной работы является статистический анализ отказов в механическом цехе методом ABC и выбор критической машины. Также был составлен план технического обслуживания для разработки, направленный на решение основной проблемы, заключающейся в оптимизированном сокращении времени простоя радиально-сверлильного станка (HKX45), учитывая важность этого производственного оборудования для уровня производственной деятельности. Это метод технического обслуживания, основанного на надежности (RBM).

*Ключевые слова:* Техническое обслуживание, радиальное бурение, надежность, история вмешательств, метод Парето ABC.

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**Introduction.** The world of industry and transport has increasingly efficient and complex machines and installations. The rotating machine is the major element of an industrial environment. From pumps to compressors, fans, turbines, motors, and mixers, all are rotating machines working under different operating principles to ensure continuity of the production chain. Indeed, a defect in bearing, fixing or alignment can compromise production and lead to the technical and economic decline of the company. The high security requirements, the reduction of operating costs and control over equipment availability play a major role in system maintenance. It must make it possible to intervene only in the presence of defective elements, to minimize repair time, reduce raw material losses and provide a reliable and easily interpretable diagnosis despite the complexity of the equipment [1].

The evolution and complexity of production systems, as well as the need to produce quickly and well, have forced manufacturers to structure and organize maintenance workshops. Above all, they created new organizational concepts and new ways of intervening in production structures for manufactured products [2].

Today, upkeep has given way to maintenance. This change does not lie solely in a complete upheaval in the way of doing and conceiving of what used to be called upkeep and which is now called maintenance.

A good maintenance strategy is one that looks and focuses on preventive action to reduce intervention times and improve the life of parts [3].

The objectives of reliability-based maintenance (RBM) are [4, 5]:

– Define and justify in design the scheduled maintenance actions to be implemented;
– Define in operation the scheduled maintenance actions;
– Ensure and increase the performance of the production tool in terms of operational safety;
– Determine the recommendations relating to the techno-economic issues (investment, renovation, procedure, justification).

In different industry sectors, many reliability analysis methods have been developed separately and some more specifically for a development phase. Controlling the dependability of hydro-electro-mechanical systems requires simultaneously taking into account, the different technologies and methods of analysis on the reliability of the development cycle [6]. The Activity-based costing (ABC) Pareto method, which consists on classifying the problems in order of importance into three categories in order to treat each of them in a different way, and the Failure Mode Effect and Criticality Analysis (FMECA) used to analyze faulty hardware. This technique is considered the most rigorous due to detailed research into the causes of failures.

**Methodology**

Our study will focus on a subsystem of the machine, under the recommendations made by the maintenance department at the agricultural equipment construction company a decision support tool is used which is the Activity-based costing (ABC) Pareto method and the Failure Mode Effect and Criticality Analysis (FMECA) method. These methods allow the identification of the main causes of functional equipment failures and the classification of these failures in order to establish an optimal maintenance action plan to minimize downtime, which penalizes production.

***Principle of the ABC method***

The ABC method is an objective means of analysis, it allows classify the elements, which represent the most important fraction of the studied characteristic, by indicating the percentages for a determined characteristic. The ABC method provides an answer. It allows the investigation that highlights the most important elements of a problem in order to facilitate choices and priorities [7]. Events (failures for example) are classified in decreasing order of costs (downtime, financial cost, number, etc.), each event relating to an entity. A graph is then drawn up corresponding to the percentages of cumulative costs to the percentages of types of failures or cumulative percentages of failures [8]. In the diagram (Fig. 1), there are three zones.

1. Zone A: 20% of breakdowns causing 80% of costs;
2. Zone B: the 30% additional breakdowns only cost 15% more;
3. Zone C: the remaining 50% of breakdowns concern only 5% of the overall cost.

It is obvious that the preparation of the maintenance work must relate to the breakdowns of zone A.

***Principles of the Failure Mode Effects and Criticality Analysis (FMECA)***

The Failure Mode Effect and Criticality Analysis (FMECA) is an a priori inductive risk prevention method that aims to identify the potential failures of a system. As it was developed in the 1940s by the American army, then implemented in the sectors industries, aeronautics and nuclear power, in France and in other European countries after 1970 [9–11]. This method can be applied to a product, a process or a means of production.

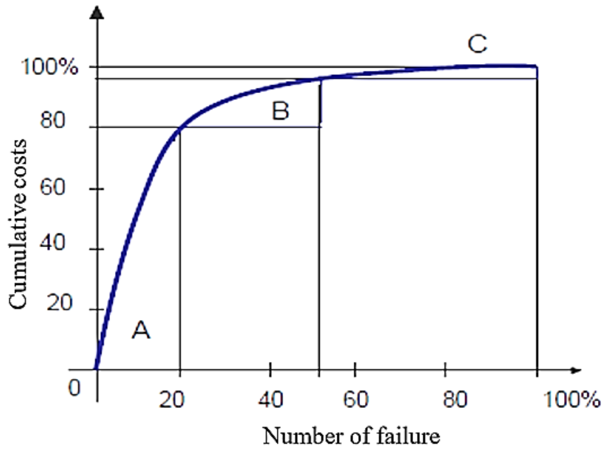


Fig. 1. Pareto diagram or ABC curve

Today, the FMECA method has been applied in the following industrial fields: space, armaments, mechanics, electronics, electrical engineering, automotive, nuclear, aeronautics, chemistry etc. Failures are analyzed to specify their criticality, identify the main causes and ultimately, define appropriate risk reduction actions [12].

*Objectives of criticality in FMECA*

• Evaluate the effects and consequence of events caused by each known mode of component failure regardless of the origin at the various functional levels of the system.

• Determine the importance or criticality of each failure mode taking into account its influence on the normal operation of the system or on its level of performance and assess the impact on the reliability or on the safety of the process considered.

• Classify the known failure modes according to the ease, with which they can be detected, diagnosed, simulated, change a component, and according to the means implemented to deal with them and keep the system in working order (repair, maintenance and logistics, etc.) as well as any other relevant characteristic.

• Establish the scales of significance and probability of failure, provided the necessary information is available [13, 14].

There are several types of the Failure Mode Effects and Criticality Analysis (FMECA). Among the used are: Products FMECA, organization FMECA, processes FMECA, resources FMECA, service FMECA, and Security FMECA [15].

**Case study and Results**

The designers in his definition drawing carry out machining for giving the blank part, the shape, required dimensions and the necessary precision, by chip removal on suitable machine tools [16].

A drilling machine is used to drill or tap holes in various materials with drill bits. Modern drills are the culmination of centuries of technology.

The radial drill (NKH 45) is the most used in the machining workshop of the agricultural machinery complex of the CMA company in Sidi Bel Abbés (Algeria).

The radial drilling machine (NKH 45) is the most used in the machining workshop of the agricultural machinery complex of the CMA company in Sidi Bel Abbes (Algeria) because of its superior characteristics and its versatility.

The radial drill (NKH 45) machine is used in most maintenance work and especially for large parts, which. After positioning remains fixed, the tool spindle is moved from one machining axis to another. Table 1 shows main characteristics and machining Ability of this machine.

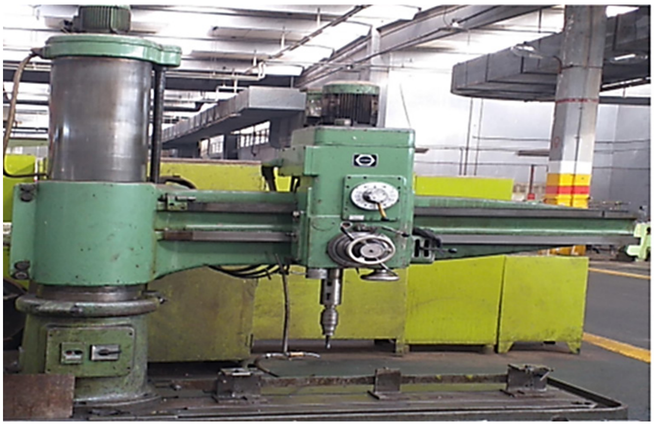

Fig. 2. Radial drilling machine (NKH 45)

Table 1

**Characteristics and machining capabilities of the NKH45 radial drill**

| Machining characteristic / capabilities | Value | Unit |
|---|---|---|
| Motor | 7 | KW |
| Spindle speed direction reversible | 1500–3000 | Tr/min |
| Advances | 0.12–1.25 | mm/t |
| Column diameter | 350 | Mm |
| Top column | 2800 | Mm |
| Drill axis distance | 325 minimums | // |
| Pinout and column | 1600 maximums | // |
| Spindle distance (chuck) | 0 minimum | mm |
| Table | 900 maximums | mm |
| Spindle-base distance | 375 minimum | mm |

***History of interventions on the drills of the workshop machining***

The following table presents the number of heavy curative interventions in 2021.

According to Fig. 3 which represents the history of the interventions and the results of the analysis by the method (ABC) for one year:

**Zone A**

It can be seen that the number of shutdowns / years on radial drills (5.4.3.7.10.1.6.) present (80%) of the shutdowns, in other words (80%) of the maintenance costs.

So this is the priority zone determine us to study in more detail the failures on its equipment, and then make the right decisions.

**Zone B**

Shutdowns on multi-spindle machines (9.12.13.) represent 5% of the total number of shutdowns for workshop equipment (drilling section). This machine requires little maintenance. From the intervention history and method analysis results (ABC) for one year.

**Zone C**

Stoppages of multi-spindle machines (9.12.13.) represent only 5% of the total number of stoppages of workshop equipment (drilling section).

The majority of failures are found on radial drills (.5.4.3.7.10.1 and 6).

– For these machines, a failure analysis study is necessary.


Fig. 3. The interventions on the drills of the machining workshop by the ABC method

– We prioritized the FMECA study for a subsystem of the machine (N°003505), serial number (n°5), because we noted that 70% of the failures are based on the electro-hydraulic circuit part, while the rest are mechanical s-system, engine, and cooling circuit.

Moreover, we used the ABC method aid tool in order to select the subsystem to be supported.

Table 2

**Cumulative number of shutdowns / years**

| Machine no. | Order no. | Number of critical shutdowns / years (ABC) | Cumulative number of Shutdowns / years | % cumulative number of shutdowns / years |
|---|---|---|---|---|
| 003505 | 5 | 214 | 214 | 15 |
| 003504 | 4 | 192 | 406 | 29 |
| 003503 | 3 | 180 | 586 | 43 |
| 003702 | 7 | 175 | 761 | 56 |
| 003706 | 10 | 153 | 914 | 67 |
| 003501 | 1 | 111 | 1025 | 75 |
| 003701 | 6 | 80 | 1105 | 81 |
| 003704 | 8 | 75 | 1180 | 86 |
| 003103 | 11 | 66 | 1246 | 91 |
| 003502 | 2 | 49 | 1295 | 95 |
| 003104 | 12 | 31 | 1326 | 97 |
| 003506 | 13 | 20 | 1346 | 99 |
| 003705 | 9 | 11 | 1357 | 100 |

***Statistics of the nature of interventions on the radial drill machine n ° (003505)***

In Table 3, we find the nature of the curative maintenance intervention carried out on the machine during one year.

Table 3 shows the results of the nature of corrective maintenance intervention. From these results, we make an analysis on these interventions by the ABC method.

Table 3

**Nature of interventions on the machine n° (003505)**

| Voucher reference | Order No. | Number of shutdowns / hour | Type of intervention (failure) |
|---|---|---|---|
| 11130313 | 1 | 3 | Mechanical |
| 11130365 | 2 | 5 | Electrical |
| 11130455 | 3 | 2 | Mechanical |
| 11130688 | 4 | 1 | Cooling circuit |
| 11130804 | 5 | 24 | Electrical / Hydraulic |
| 11130865 | 6 | 6 | Mechanical |
| 11130574 | 7 | 4 | Mechanical |
| 11120349 | 8 | 2 | Cooling motor |
| 11120412 | 9 | 48 | Electrical / Hydraulic |
| 11120484 | 10 | 5 | Mechanical |
| 11110038 | 11 | 42 | Electrical |
| 11110051 | 12 | 14 | Hydraulic |
| 11110080 | 13 | 8 | Mechanical |
| 11110359 | 14 | 7 | Mechanical |
| 11110459 | 15 | 3 | Cooling circuit |
| 11110505 | 16 | 40 | Hydraulic |

Table 4

**Number of shutdowns / cumulative hour of the radial drill n° (003505)**

| Order No. | Number of shutdowns / hour | Accumulated number of shutdowns / hour | % Accumulated number of shutdowns / hour |
|---|---|---|---|
| 09 | 48 | 48 | 22 |
| 11 | 42 | 90 | 42 |
| 16 | 40 | 130 | 61 |
| 05 | 24 | 154 | 72 |
| 12 | 14 | 168 | 78 |
| 13 | 08 | 176 | 82 |
| 14 | 07 | 183 | 85 |
| 06 | 06 | 189 | 88 |
| 02 | 05 | 194 | 90 |
| 10 | 05 | 193 | 93 |
| 07 | 04 | 203 | 95 |
| 15 | 03 | 206 | 96 |
| 01 | 03 | 209 | 97 |
| 08 | 02 | 211 | 98 |
| 03 | 02 | 213 | 99 |
| 04 | 01 | 214 | 100 |

According to Fig. 4, which represents the history of the interventions and the results of the analysis by the method (ABC) of the radial drill machine n° (003505):

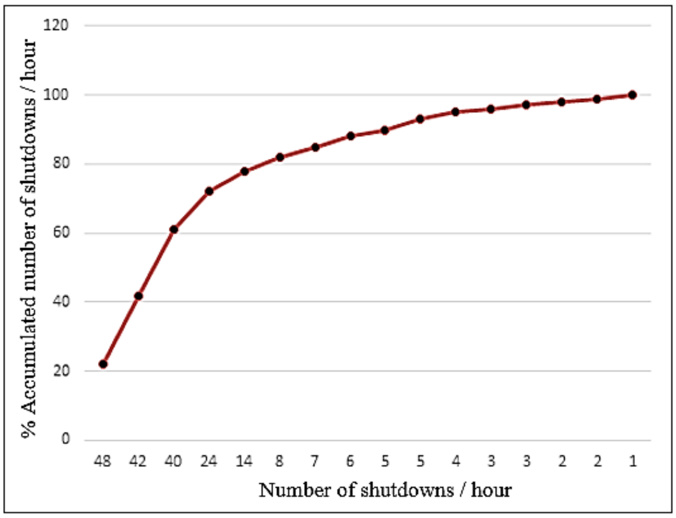


Fig. 4. Presentation of the interventions of the radial drill machine n° (003505) by the Pareto ABC method

**Zone A**

It can be seen that the number of shutdowns / hour of the electro-hydraulic box (9.11.16.5.12.) It accounts for 80% of the interventions, or in other words it represents 80% of the maintenance costs. This is therefore the priority zone, they challenge us to study in more detail the failures on this machine subsystem, and then make the right decisions.

**Zone B**

This zone amounts to 15% of the number of shutdowns / hour of mechanical nature (.13.14.6.2.10.7), we will be less demanding to maintain this subsystem.

**Zone C**

The number of shutdowns / hour for the rest (15.1.8.3.4.) Represents only 5% of the total number of interventions on the machine, i.e. the cooling subsystem. the cooling sub-system. This equipment requires little maintenance.

## Conclusion

The work carried out allowed us first to be acquainted with the industry, the environment of work and the various aspects that they can reveal. The progress of the project giving us the opportunity to discover the true purpose of the maintenance process. This work also allowed us to using a preventive maintenance plan for the radial drill and to define spare parts as well as the frequency of preventive actions.

The work carried out allowed us first of all to familiarize ourselves with the world of industry, the working world.

The following conclusions could be highlighted:

– The majority of failures on radial drilling machines (5.4.3.7.10.1 and 6.); for these machines it is necessary to carry out a failure analysis study;

– For the machine n° 003505 we noted that 70% of the failures based on the electro-hydraulic circuit part, and the rest, mechanical s-system, engine, and cooling circuit.

The problem posed in our work is that the T.R.T (Technical Repair Time) is high, due to the lack of diagnostic averages.

To this end, we propose to carry diagnostic and analysis methods on the electro-hydraulic subsystem to facilitate the diagnosis and to reduce the Technical Repair Time (T.R.T).

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