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Management of Efficiencies of Mining Equipment

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Abstract

Some practitioners classify delays during operations in the waiting time classes, others say that changing shifts times are standby times. In this article, we define in practical way all the terms entering into account in determining the availability, utilization, working and efficiency of mining equipment. We also give a very simple method of recording data necessary for their determinations. We give a brief treatment method accessible to all and available without much trouble at all practitioners of the mining industry to determine the different rates required for the management of mining machines.

Keywords: Availability; Utilization; Operation; Efficiency; Maintenance rate

Introduction

The availability and utilization of mining equipment differ from one practitioner to another, from one author to another, from one supplier to another, as well as an engineer to another. Vorne defines the time available as the planned production time less downtime [1]. He defines downtime as all time during which the equipment is supposed to work but is not a result of unplanned shutdowns (e.g., breakdowns) and planned outages (e.g., job changes). What is not at all the case with Hustrulid et al. that categorize changing shifts in the available time, under the working time and the waiting time category [2]. In what follows, we give definitions that we will consider in this article. These definitions are used to reduce the confusion that may exist taking into account several books and practices in the mining industry (Table 1).

Time Distribution Flowchart

Figure 1 shows the distribution of total time. This is a series of nodes which time is divided into productive and non-productive streams from a production standpoint.

The ratio between the outgoing productive flow of a node and the total flow entering a node is the efficiency ratio of the node or efficiency ratio, we can also call the efficiency rate of the node.

Node 1: Availability rate

$$Avaiblility = A = \frac{up\,time}{Total\,time} \quad (1)$$

It is the ratio between productive time resulting from the total time which stops are removed. Practically, this is the time during which the machine is available to the production department.

***Node 1:** Mechanical availability rate

$$Mechanical\ Avaibility = MA = \frac{Working\ hours}{Working\ hours + Downtime} \quad (2)$$

Practically, this rate represents the availability of a viewpoint of the maintenance department. Wait times are removed from the available time.

Node 2: Rate of utilization

$$Utilization = U = \frac{Working\ hours}{up\,time} \quad (3)$$

Practically, this ratio gives a value of productive time resulting from the availability to which expectations are extracted.

Node 3: Operating rate or walking efficiency

$$Working\ Efficiency = WE = \frac{Operating\ time}{Working\ time} \quad (4)$$

Working time has regulatory breaks, such as lunch, dinner, etc.

Node 4: Efficacy Rate or Job efficiency

$$Job\ Efficiecy = JE = \frac{Efficiency\,time}{Operating\,time} \quad (5)$$

During the cycles of operations, expectations due to bad provisions are inevitable. This is the case when a shovel has many trucks assigned to it more than its saturation. The shovel will not delay operation, but if the trucks yes.

Node 5: Maintenance Efficiency

$$Maintenance\ Efficiency = ME = \frac{Maintenance\,Time}{Downtime} \quad (6)$$

For a value of the absolute rate of efficiency, you must multiply the different rates:

Node 6: Absolute Efficiency Rate for mining machinery

$$AER = A * U * WE * JE \quad (7)$$

Sources of Information for the Calculations

In practice, we have several sources for the collection of information on the performance of operations and maintenance: the counter in the cabin of the operator, the worksheet of the operator, the dispatch records, the automatic recordings from suppliers such as VIMS from Caterpillar, etc.

Weibull.com [3] offers a number of sources depending on the type of desired availability, speaking of readiness that the measurement of the actual availability of medium for a period of time including all sources of downtime encountered as stops administered, the logistics stops, etc. (eqn. 1).

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Terms	Definition
total time	The total available hours and hours of stops. This is equal to the programmed times for operations.
Uptime	This is the time during which the machine is able to perform its specified function. It's all working hours and standby hours.
Work time	Hours during which an operator or a team is assigned to the equipment in working condition. It is expressed in hours and not in terms of hours read from the counters. Working hours include all delay in operating process.
Pause time	This working time interval during which the equipment could cycles but it is not cycling.
effective time	The part of the operating time that the machine is in production mode. To shovel, this would include time spent in the excavation, lifting and swinging, spill, and equity return and lowering.
Operating Delay time	This would include time delays such as ● shortest travel time ● daily maintenance, fuel, lubrication ● waiting time in the operating cycle ● time lost due to weather
Standby time	Time during which an operational machine is not used because of the weather, the work schedule, long travel, etc.
long mote time	Time during which the machine is operational but scheduled to travel long distances
Non-Schedule Time	Portion of the total number of hours that the operational machine is programmed to operate.
Downtime	Time during which a machine cannot perform its specified function. It includes the maintenance hours, the hours of supply delays and administrative hours.
Maintenance time	Time to preventive and corrective maintenance
Supply delay hours	Time that the maintenance work is not possible due to lack of immediate availability of spare parts and equipment necessary for the performance of maintenance
administrative time	All judgments less maintenance time and delivery delays. Administrative time is the time to see a breakdown, to give directions to maintenance, etc.
Overtime maintenance time	Additional service hours are maintenance performed during the hours the machine was not programmed to operate. For a scheduled work day on a machine, it would describe the maintenance performed on another team.
Daily maintenance time	Time required to perform daily maintenance. It is included in the working hours. According to the strict definition of the field of reliability engineering, daily maintenance hours should be included in the maintenance hours. Here, however, it is included in the working hours, taking into account common practices in the mining industry.
Mean time between failures (MTBF)	Average value of the operating time between successive failures of a product, device, component or part.
Mean time to repair (MTTR)	Average time to repair a failure. It does not include the hours of lead time or administrative hours, because it assumes that the repair is done in an ideal support environment.

Table 1: Terms and definations.

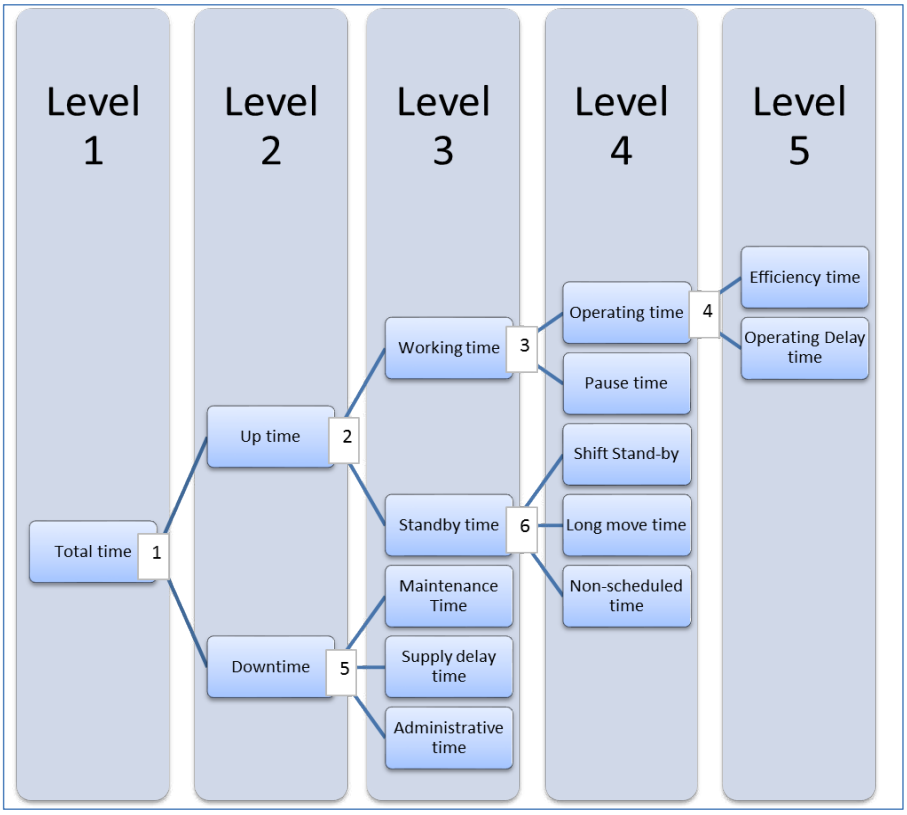

Figure 1: Distribution of the total time.

While many IT tools make easy the processing of information, that is the case with Caterpillar VIMS, worksheets proves of paramount importance and are the most reliable sources at an extremely low cost.

Here is a description of the first two sources of information:

The counter in the operator's cab

It is an essential tool in the working time management of mining machinery. It is not yet too reliable since it does not give details on the various stages in the operations. It just gives the time difference between starting at the beginning of the workstation, and stopping in the end workstation. The various delays in the work place, the fault does not require stopping the engine, the long-time travel, etc. cannot be recorded in the time counter of the machine [4,5].

Therefore, the time counter is intended only time motor running, not the working hours of the machine. We recommend using records from the time counter of mining machines for performance management of mining equipment. Sometimes users, contractors and especially knowing that the payment of invoices is done on the basis of hours taken counters use their equipment without stops the engine of their machines. What gives wrong values as pricing reference.

The operator's worksheet

Because the timer mining machines are not reliable for management, mining equipment operators must be teams of a worksheet that details the various movements of the machines. Job start to the stop of the machine at the end station, all movements must be recorded. The supervisor should check the current position and end position of records on work sheets operators. The recordings are of the type (Appendix 1).

For treatment worksheet, technical secretary or the statistician does the following:

1. Registration general data in the header (Table 2)
2. Saving downtime (Table 3)
3. Determinations of different rates (Tables 4 and 5).

Limitations and Suggestions

As defined in this article, different rate or effectiveness are obtained by the communication between the operator, supervisor, and dispatch. It is the duty of the manager to train operators on different writing different times in the workflow. The supervisor must monitor and ensure that the records written by the operators or the dispatch are correct.

For this, we recommend that mining operators to use automatic processing tools for information such as Caterpillar VIMS.

We are working on a model of automatic processing of mining machinery management will be automatic and universal, can be used on all machines in some brands either.

Conclusion

Mining machinery management is done through the determination of different rates or efficiency. Five levels are available for the manager and provide places for improvement on which it needs to

Date	Prefix	N	Starting time	Ending time	Starting Index	Ending Index	Starting Kilometer	Ending Kilometer	Fuel	Index Fuel	Time Fuel
25/08/2018	WB	1	7:00	19:00	1020	1022	324	350	225	1017	10:22

Table 2: Registration general data.

Date	From	To	Duration	Details	Catergorie	Code
25/08/2018	7:00	7:30	0:30	Safety meeting	Standby time	11120
25/08/2019	7:30	7:45	0:15	Preuse inpection	Standby time	11120
25/08/2020	12:00	13:00	1:00	Lunch	Pause Time	11120
25/08/2021	14:05	14:25	0:20	Parking break fault	Maintenance Time	11120
25/08/2022	16:00	17:00	1:00	Blasting	Standby time	11120

Table 3: Records downtime.

Date	**25/08/2018**	
Prefix	WB	
N	1	
Rubric	**Code**	**Valeur**
Total time	10000	12:00
Available time	11000	11:40
Downtime	12000	0:20
Working time	11100	10:40
Standby	11200	1:00
Maintenance	12100	0:20
Supply delay time	12200	0:00
Administrative time	12300	0:00
Operating time	11110	8:55
Pause time	11120	1:45
Shift change time	11210	0:00
Long move time	11220	0:00
Non-schedulled time	11230	0:00
Efficiency time	11111	8:55
Delay in operating time	11112	0:00

Table 4: Determination of time.

Rubric	Value
Availability	97.22%
Utilization	91.43%
Operating	83.59%
Efficiency	100.00%
General Efficiency Rate	74.31%

Table 5: Determination different rates.

address to improve profitability, production, and productivity of its mining machinery. An ideal system has an absolute return of 100%. Any deviation from this value shows a deflection which, when it is surrounded, gives rise to the system improvement efforts.

The easiest management system includes a worksheet on which operators write different deviations from the cycles of operation. This information is processed and come out the different rates that are the availability rate, use, operation, and efficiency, which give increased the absolute rate of return.

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