The Maintenance and Production: Integration Approach

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Abstract

In the contemporary competitive industrial climate, companies must account for integrated maintenance policies to remain in business. The objective of this study is the integration of the policy of maintenance and the production control with an aim of thus improving its dependability its total productivity. Our goal through this communication is to improve the performances of a system of production, which rest on several criteria whose principal ones are the Cost, the Availability, Reliability, Maintainability and the Productivity.

The factors that influence each criterion are the basic attributes. The means of actions are the various policies of maintenance available. In order to facilitate the analysis and the choice of the "best " policy to be integrated. Our work falls under a total prospect that consists to conceive and carry out a system of assistance to the choice of the policy of maintenance in a system with continuous lawsuit. The Cement factory of Ain Touta was used as case study in this paper

1. Introduction: Monitoring and Maintenance

The search of the increase in the performances of the production systems become complex results in transferring on the function maintenance the responsibility to guarantee the availability of such systems. Therefore, if maintenance is taken into account as of the phase of design and readjust in criterion and production run according to the performances considered fixed by the production, it can cause productivity. The role of the function of monitoring consists in following the course of the operation of an industrial system with an aim of detecting, of locating and of establishing a diagnosis of the failures and degradations that can affect its performances and its dependability. For following the operation of the industrial process well, a policy of maintenance is applied. By holding account of the policies of maintenance integrated into the level of the industrial process, the indicators of performances and the

dependability are evaluated and make it possible to select the best policy to satisfy the objectives laid down on each machine.
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2. Maintenance Policies

A policy of maintenance consists in defining technico-economic objectives relating to the assumption of responsibility of the hardware of a company, by the service maintenance (Bigret R., Frelon J.L. 1994). The latter with for mission, the implementation of the means adapted to these objectives, it is the management of maintenance. Several types of maintenance were defined in the literature and can be classified in 3 main categories (Zwingelstein G. 1995).

- Corrective Maintenance (MC),
- Preventive Maintenance (MP) and
- Mixed Maintenance (MM).

A classification of the types of maintenance can be done according to several criteria like the definition of the time of Intervention, the definition of the budget Maintenance, the improvement of the output and the availability. This classification makes it possible to make the choice of the method of maintenance answering the problems arising from the unit like the new requirements (political context, environment, market, needs for the company). This work aims primarily the integration of the policy of maintenance and the production control with an aim of thus improving its reliability its total productivity. Our approach first of all consists in modeling our system. The stochastic Petri nets seem to us best adapted to this study. Indeed, they allow a modular and functional modeling system considered. The integration of various policies of maintenance for the improvement of the parameters of the reliability on the one hand and to guarantee the durability of the system on the other hand constitutes the second point of this paper.

3. Industrial Application

3.1 Production system presentation

The production system (PS) consists of three distinct parts to knowing, the preparation of the raw material, its transformation and its forwarding (Fig. 1). We carried out a structural cutting on PS in order to be able to model it with the type of maintenance that is associated with it.

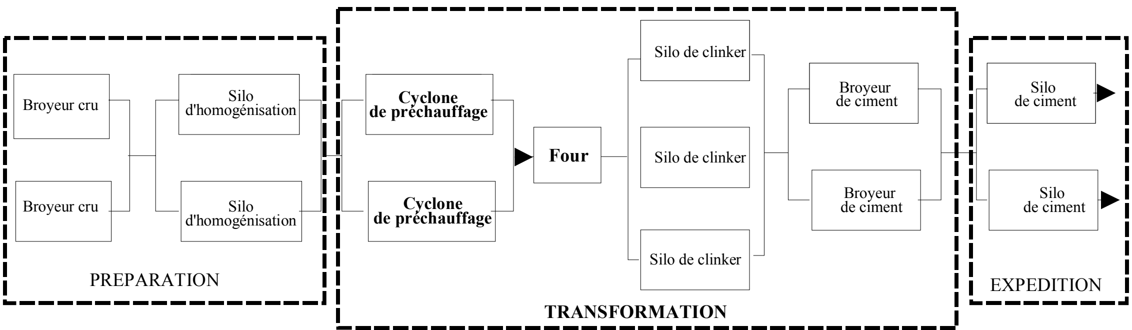

Figure. 1: Production system presentation

3.2 Maintenance Modeling by RdPS²

The tool of modeling used, RdPS² (Synchronized Stochastic Petri nets), makes it possible to carry out a modular and functional modeling system considered (Daniel O. 1995). RdPS² describes each functionality of the system; the various signals are synchronized between them by the means of emissions receptions of data. The synchronization signals of are emitted by the places when they contain at least a mark and are received by the transitions. The marking of places PS1 and PS2 defines the state of draining of the machines S1 and S2. An absence of mark of the places means that the machines S1 and S2 fill. (Fig 2).

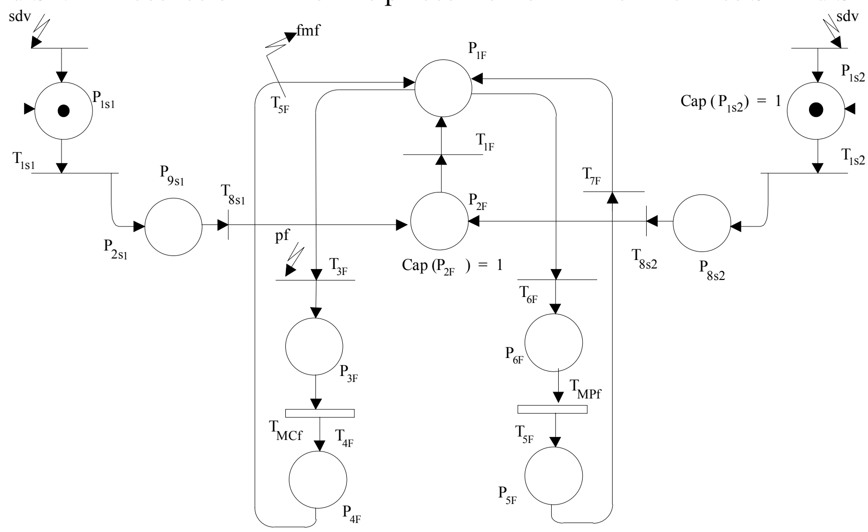

Figure 2: Modeling by RdPS² of MC and MP

The continuity of the existence of marking in PS1 or PS2 is ensured by the signal sdv (signal of draining). The power supply of the machine F by S1 or S2 is ensured thanks to the capacity limited to 1 of place P_{3F}. In production run, the policies of maintenance are in parts related to the state of the system where only the MP and MC are mentioned. The MM can be used on all the levels. Also, in our method, with each machine the model with maintenance is associated.

In order to be able to model each maintenance, it is necessary to study their time of intervention. A policy of Maintenance can be Corrective (MC), Preventive (MP) or Mixed (MM). The type of maintenance and the average time of preparation of maintenance thus characterize it. The MC awaits a signal of breakdown machine (PF) before preparing the system of maintenance, announcing that it is ready. With the end of maintenance, a signal (fmf) is emitted indicating that machine is ready. The MP reacts following an occurrence of date of intervention by preparing the system of maintenance. The launching and the end of maintenance follow the same procedure as that described for the MC.

3.3 Modeling of the adopted RdPS² system

On our system of production, we carried out a structural cutting and RdPS2 models each machine. Contrary to a manufacturing system, our system is continuous and is consisted a working whole of machines uninterrupted. With each machine a policy of corrective maintenance, preventive or mixed is associated according to cases. Before launching a policy of maintenance, a set-up time is necessary. It varies according to the breakdown and corresponds to an average time of preparation (Daniel O. 1995).

Each machine is modeled with the type of maintenance, which is associated to him by $RdPS^2$ (Fig. 3).Within the framework of our system, the preventive turn-around time, including the preparation, for the machines S1 and S2, is equal to the time of filling (Sassine C., Simeu-Abazi Z. 1997).

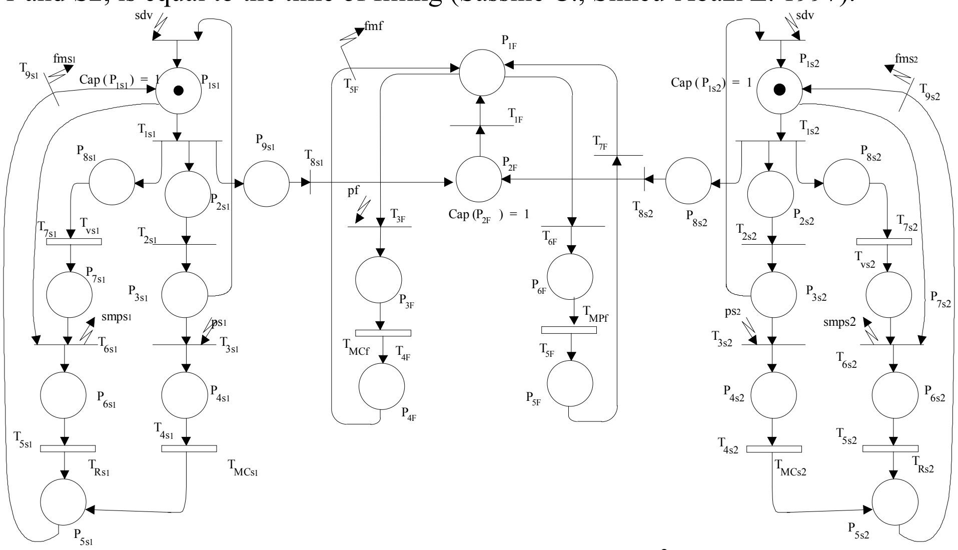

Figure.3. Modeling of the adopted $RdPS^2$ system**.**

T_{VS1}, T_{VS2} : Draining time of pre-heating cyclones S1 and S2
T_{RS1}, T_{RS2} : Filling time of pre-heating cyclones S1 and S2
T_{MCS1}, T_{MCS2} et T_{MCF} : Corrective maintenance time of S1, S2 and Furnace

4. Results

4.1 Model of $RdPS^2$ of the adopted system with MC for S1, MP for S2 and the furnace

Compared to the generic model without maintenance, various places were added. They are necessary for sends signals of synchronization. The models of the system consisted the two cyclones of pre-heating and the furnace including a curative corrective maintenance for S1 and a preventive maintenance systematic S2 and the Furnace are presented (Fig4).

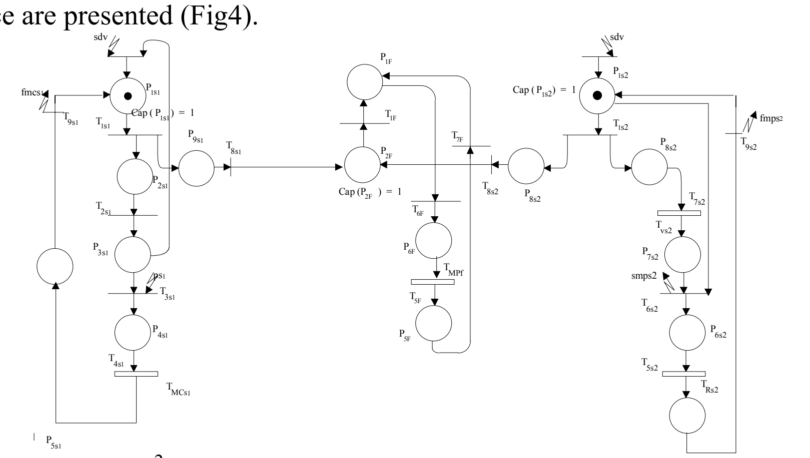

Figure 4.Model of $RdPS^2$ of the adopted system with MC for S1, MP for S2 and the furnace.

4.2 Maintenance Evaluation of the adopted system

In this paragraph, it is a question of evaluating the indicators in order to be able to find the best case to apply, and classify by set of priorities the various possible cases following certain criteria. Within this framework, we study the influence of integrating two maintenances MC and MP, to the three machines, the Cyclones of Pre-heating (S1 and S2) and the Furnace (F).We suppose that only one policy of maintenance per category is available (Dekker R. 1996). Therefore, for the selected system, we have four possibilities $4^3 = 64$ possible scenarios. The objective of the direction is to reach 8 MP for 2 MC. Thus for these two types of maintenances 27 scenarios were identified and only 16 cases are possible (Fig. 5) in accordance with the objectives of the direction .

Cas	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
CP_1	-	-	-	MP	MC	MP	MC	MP	-	MC	MP	-	-	MP	MC	MP
CP_2	-	MP	MC	-	-	MP	MP	MC	-	-	-	MC	MP	MP	MP	MC
F	-	MP	MP	MP	MP	-	-	-	MP	-	-	-	-	MP	MP	MP

Figure 5: Different possible cases.

Our goal is to reduce the failure rates of the Cyclones of Pre-heating and the furnace (F) and to decrease the unavailability times of these machines. While being based on the values of the probabilities of state, it clearly appears that the minimal failure rates for S1, S2 and F are obtained in the cases, 14, 15 and 16. As high stops for maintenance its for the cases 14. Thus, 15 and 16 thus constitute the best cases.

4.3 Selection indicators and criteria for the selected system

Following an assessment of experiment, a list of basic attributes and indicators are deduced The principal basic attributes most significant are calculated starting from Pr(Mi), Pr(Pi) and Pr(Ai) which respectively constitute the probability of Functioning, Breakdown and Stop for maintenance of the Machine I. Therefore, the most significant attributes selected are

- Unfailure Time of Machine i,
  $T_{bf}(i)= Pr(Mi)*t_{requis}$ = **6832,8h**
- Stop Time for failure of Machine i,
  $T_{ad}(i)= Pr(Pi)*t_{requis}$ = **167,31h**
- Stop Time for Maintenance of Machine i, $T_{am}(i)= Pr(Ai)*t_{requis}$ = **652,62h**
- Effectif availability Time of Machine i,
  $T_{ed}(i)= T_{bf}(i)$ = **387966,38t**
- Product Quantity by Machine i,
  $Q_{pm}(i)= T_{bf}(i)*\theta i$ = **6832,8h**
- Number of specific Stop of Machine i,
  $N_{ap}(i)= T_{ad}(i)*\mu i$ = **13**

From this list of attributes, we determine the principal parameters characteristic of the reliability as the availability which represents the behavior of the system during its cycle of life, the reliability which indicates as for it the behavior of the system until the first failure, and which can be quantified through the time of Tbf(i) correct operation. Maintainability, related to Tam(i), represents the behavior of the system during the failure. Finally the productivity of the machine I which corresponds to Qpm(i) / trequis. In what concerns us, the principal objective is the improvement of the performances and the reliability. It must establish a compromise enter the criteria Reliability (R), Availability (A), Maintainability (M), Productivity (P) and Cost (C). Each one as of the these criteria contains certain numbers of indicators evaluated for all the machines of SdP. Our limited the number of indicators of each criterion to a maximum of 9 criteria in order to avoid obtaining successive values at the time of the comparison of elements per pairs. For that we have to choose a scale of values from 1 to 9. Each category is associated only one significant indicator composed of some basic attributes The objective is to minimize or maximize the significant indicator of each category (Fig. 6) (Richet D, Gabriel M., Malon D., Blaison F. 1996).

Parameter	Indicator	Criterion
R: Non Reliability	$R(i)=T_{ad}(i)/ N_{ap}(i)$	Minimise
A: Availability	$A(i)= T_{ed}(i)/ t_{requis}$	Maximise
M: Maintainability	$M(i)= T_{am}(i)/t_{requis}$	Minimise
P: Productivity	$P(i)=Q_{pm}(i)/ t_{requis}$	Maximise
C: Cost	$C(i)= T_{am}(i)/t_{requis}$	Minimise

Figure.6: Indicators of performance and selection criterion**.**

The calculation of the significant indicators for different policy from maintenance gives us the matrix of classification for each machine. Only the matrix of classification of the furnace is presented on Fig. 7 (Dekker R. 1996)

Cas	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
MS_1	-	-	-	MP	MC	MP	MC	MP	-	MC	MP	-	-	MP	MC	MP
MS_2	-	MP	MC	-	-	MP	MP	MC	-	-	-	MC	MP	MP	MP	MC
MF	-	MP	MP	MP	MP	-	-	-	MP	-	-	-	-	MP	MP	MP
R	8	2	3	2	3	6	4	4	3	7	5	7	5	1	2	2
D	1	6	5	6	5	2	4	4	5	1	3	1	3	7	6	6
M	1	4	5	4	5	1	1	1	4	1	1	1	1	2	5	5
P	1	5	4	5	4	3	4	4	6	2	4	2	4	8	7	7
C	1	5	4	5	4	3	4	4	6	2	4	2	4	8	7	7

Figure.7 : Classification matrix of the furnace

If one is interested in the criterion of reliability, one notices that the cases 14 seem better 2, 4, 15 and 16, which are in their turn better than cases 3, 5 and 9. As the prime objective is to improve the reliability of SdP selected, i.e. to minimize the breakdown criteria of the machines, then cases 14, 15 and 16 seem to be the best choices. Among the selected cases, cases 15 and 16 give a better maintainability as well as a very good rather economic productivity. From the matrices of the selected machines, we deduce the total matrix from classification. For our system, the total matrix is obtained by making the product term in the long term and by reordering the result. One finds our conclusions on the best policy of maintenance to be applied which indicates than a reliability is obtained when a MP is applied to S1 resp (S2), one MC applied to S1 resp (S2), and a MP applied to F.

5. Discussion

The choice of the policies of maintenance strongly depends on the objectives laid down by the direction of the production. These objectives in general play the role of one or several combined criteria. The analysis of the selection criteria thus needs a decision-making process allowing for choice of the type of maintenance to be applied and especially at which time and under which conditions.

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