OPEN ACCESS
International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-3, February 2019

Contribution to the Monitoring of an Automated Production System by Hybrid Interpreted Petri Nets

Rochdi Kerkeni, Anis Mhalla, Kais Bouzrara

Abstract: ***This article proposes the establishment of monitoring and diagnosis tools in order to implement an automated system. The purpose of monitoring task is to preserve the production equipments quality and personnel safety. The study proposed in this paper consists in developing algorithms, based on Hybrid Signal Interpreted Petri Nets (HSIPN) for monitoring the quality of bobbins obtained by a winding machine. This monitoring approach is integrated into maintenance decision process.***

Index Terms**:** ***Monitoring, Interpreted Petri Nets, Wires Quality, Plc, Coils Shape***

I. INTRODUCTION

To ensure the safety of automated system, many monitoring activities should be done every year. However, delayed monitoring activities would cause low service quality and require large sums of money. The aim of this paper is the study and the design of a monitoring module based on Hybrid Signal Interpreted Petri Nets for textile machinery. In this context, we propose new algorithms for monitoring the wires quality and the coil geometrical form obtained by a winding machine. The development of operating and monitoring algorithms and their implementation on a PLC represent the main contribution of this paper. Hybrid Petri Nets are an excellent choice for supervision manufacturing system. This tools enjoys wide applications in fields such as modeling and control [1-3], monitoring [4] and decision making [5], [6]. With the rapid increase of type and size of manufacturing systems, we may encounter a minority of work related to supervision of manufacturing system, as coil winding machine, using Hybrid Signal Interpreted Petri Nets. Therefore, in this paper we present a new approach, based on HSIPN, allowing the monitoring the wires quality and the coils geometrical shape will be presented. This paper is organized as follows. The second section begins by the definition of Hybrid Signal Interpreted Petri Nets as monitoring tool. The third section is dedicated to the presentation of the coil winding unit and its quality defected. The latter is used as a case study. Finally two algorithms, allowing monitoring the wires quality and the coil geometrical form produced by the winding machine, will be presented in the last section. Each one of these works has covered some aspects of supervision, however few works, nowadays, concern about how to use a combination of them to give a systematic procedure for diagnostic of manufacturing system, as coil winding machine, using Hybrid Signal Interpreted Petri Nets. Therefore, an original approach, based on HSIPN, allowing the monitoring the wires quality and the coils geometrical shape will be presented.

Manuscript published on 28 February 2019.
***** Correspondence Author (s)
Rochdi Kerkeni*, Research Unit LARATSI Automatic Signal and Image Processing National Engineering School of Monastir, Monastir, Tunisia.
Anis Mhalla, Research Unit LA.R.A Automatique National Engineering School of Tunis (ENIT), Tunis, Tunisia.
Kais Bouzrara, Research Unit LARATSI Automatic Signal and Image Processing National Engineering School of Monastir, Tunisia.

II. THE WINDING MACHINE

A. Presentation

Winding machines are used heavily in textile manufacturing. Its mission is to produce bobbins that will be exploited for the construction of fishing nets, figure 1.

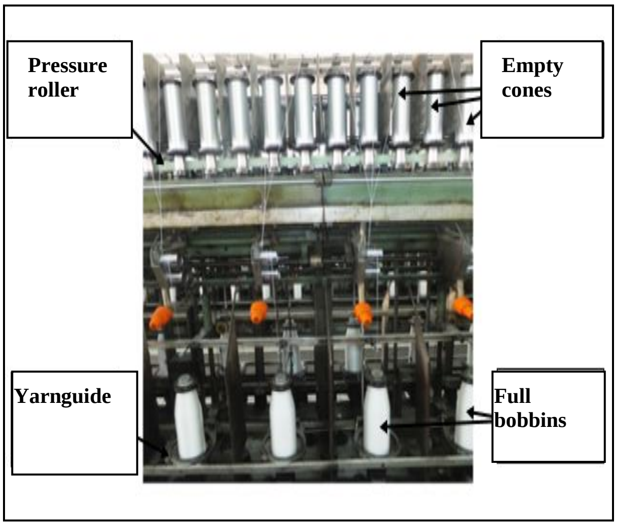

Fig. 1. Winding Machine

B. Bobbins defects

The main purpose of this paper is to monitor the wires quality and the coil geometrical form. Figure 2 shows the difference between conforming or non conforming bobbins conical shapes.

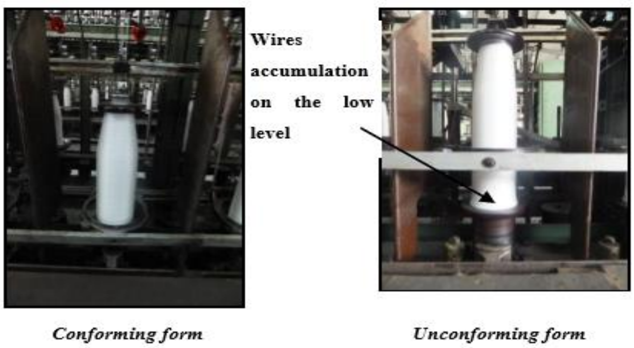

Fig 2. Conforming or non conforming conical shapes

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Given these defects, it is imperative to implement a monitoring policy to improve the products quality. In this context, our contribution consists in developing and implementing algorithms, based on HSIPN, for monitoring the wires quality and the coils geometrical shape.

The main objective of the monitoring approach is to ameliorate the productivity, availability and reliability of the coil winding machine.

III. MONITORING ALGORITHMS

A. Abbreviations

Table 1, shows the lists of the abbreviations used in the monitoring algorithms.

Table 1: Abbreviations

ALG: Algorithm M: Engine (Motor) V: Motor speed	V2: M2 motor speed V3: M3 motor speed M3H: M3 clockwise rotation sens H
Vm: Motor average speed	M3B: M3 counterclockwise rotation sens B
Rv: Speed ratio	Direction RM3: M3 rotation sense controller
m: measure ms: millisecond	ALv: Inverter alarm ALWT: Wires Twist alarm
rpm: rotation per minute	ALCF: unconform geometrical Coil Form
i: counter	C0: speed condition 140.6≤V3≤155.4
AUR: Emergency stop button	C1: Descent speed condition -155.4≤V3≤-140.6
BSH: top limit stop BSB: Bottom limit stop V1: M1 motor speed	BM: Power button BA: Stop button Vy: end of monitoring task
Vx: beginning of monitoring task	

B. Algorithm for monitoring the winding machine

1) Monitoring of wires quality

a) Algorithm structure

Figure 3 shows the algorithm for monitoring the wires twisting quality.

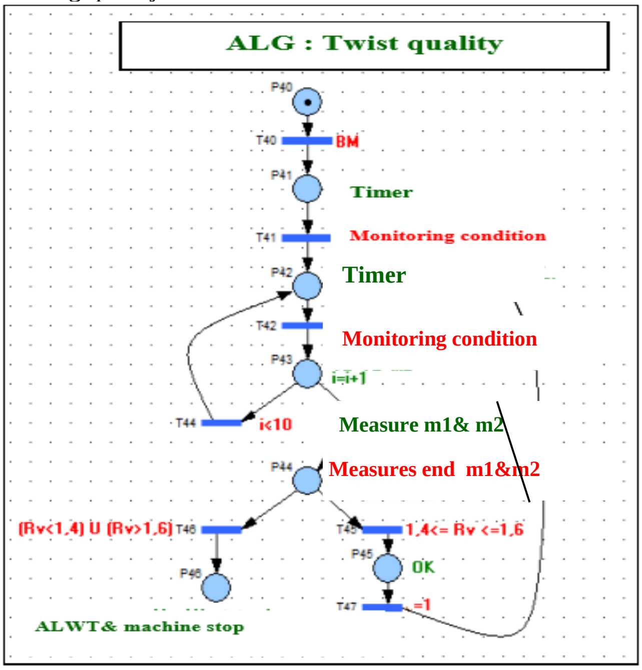

Fig 3. Algorithm for Monitoring the Twisting Quality of Wires

b) Algorithm description

Pressing the start button causes the startup of the two motors M1 and M2. V1 (resp. V2) represented the motor speed associated to M1 (resp. M2). The objective is to measure the average motor speeds "Vm" (obtained after ten successive pulses: transition T43), figure 3.

A good quality of wires torsion is expressed by a speed ratio "Rv" (Rv = Vm1 / Vm2). The speed ratio variation intervals are set by the manufacturer of the winding machine. In the studied case, if f the speed ratio "Rv" belongs to the range [1.4, ..., 1.6]: $1.6 \geq Rv \geq 1.4$

In this case the wires quality is qualified as good (P45), figure 3. On the other hand (the speed ratio exceeds these limits (Rv <1.4 or Rv> 1.6), an immediate stop of the machine is claimed and an alarm is generated informing the operator of the poor wires quality (P46).

2) Monitoring of the bobbins geometric shape

The monitoring of the coil geometrical form is structured on the variation of the yarn guide motor speed "M3", figure 4.

- ***Phase1: Command change***

In order to avoid wires accumulation defaults, the time for brooch changing is estimated at 500 ms. Exceeding this time (transition T52) implies a default of bobbin geometric shape, figure 4. In this case an alarm is triggered claiming an immediate stop of the winding machine (place "P56"), figure 4.

- ***Phase2: Monitoring of motor speed V3***

This phase is structured on the monitoring of the motor speed "V3" associated to yarn guide engine"M3". In our study, the motor speed "V3" is estimated at 148 rpm. In order to avoid wires accumulation, the "V3" must be respected with a margin of error of ± 7.4 rpm. in this case condition C0 must be respected: C0: $140.6 \leq V3 \leq 155.4$

The non respect of this condition induces the machine stop.

C. Implementation of Monitoring Algorithms

This section focuses on the implementation of monitoring algorithms, developed in the previous section, on Programmable Logic Controller PLC S7-1200.

1) Wires twisting quality

The main causes of wires default are:

• Exceeded motors speeds V1 or V2: The causes are mainly mechanical such as the increase of the friction coefficient, failures of brooch bearings or drive belt.

• Sensor fault

Figure 5, shows the variation of the two motor speeds V1 and V2. The rotational speed V1 (resp. V2) associated to the brooch 1 (resp. brooch 2) is estimated to 6000 rpm (resp. 4000 rpm), figure 5. In this case the winding operation procee[illegible] ally. [illegible]d quality of wires torsion is expressed by a speed r[illegible] [illegible]v" belonging to the intervals [1.4, ..., 1.6]. In this case the wires quality is qualified as good, figure 6.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

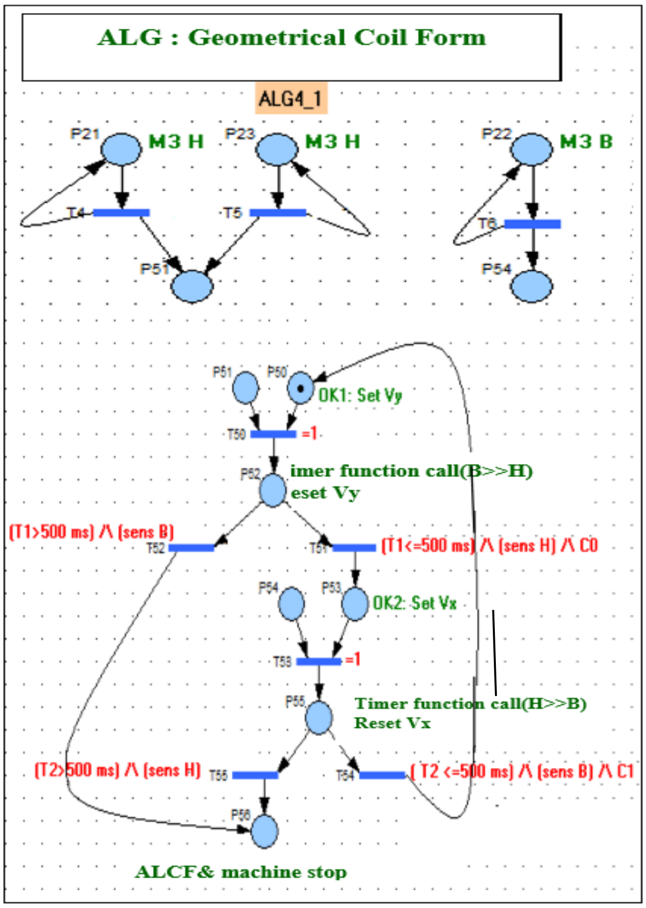

Fig 4. Algorithm for monitoring the coil geometric shape

A falling speed of the upper brooch, figure 7, causes a variation on the speed ratio, Figure 8. If the speed ratio coincides with the lower limit (Rv = 1.4), an alarm will be triggered.

The purpose of the implementation of these monitoring algorithms on a PLC is to explain in details what is happening on the system and to help operators identifying failures in order to preserve product quality and avoid a damage of the process.

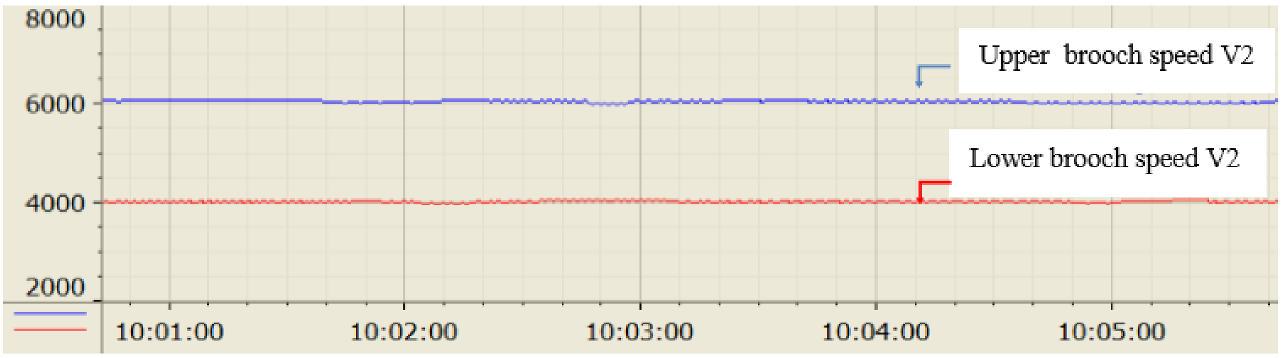

Fig 5. Motors speeds V1 and V2

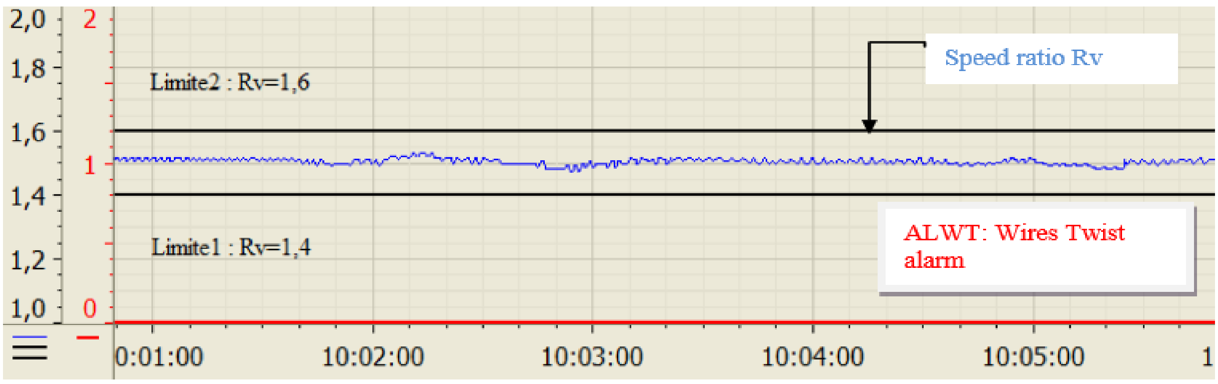

Fig 6. Normal Speed Ratio

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

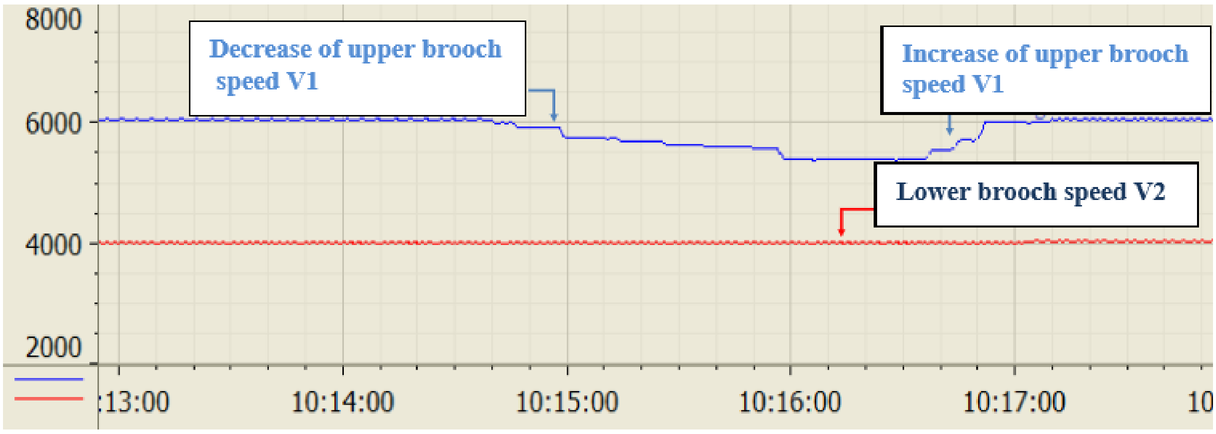

Fig 7. Falling speed of the upper brooch

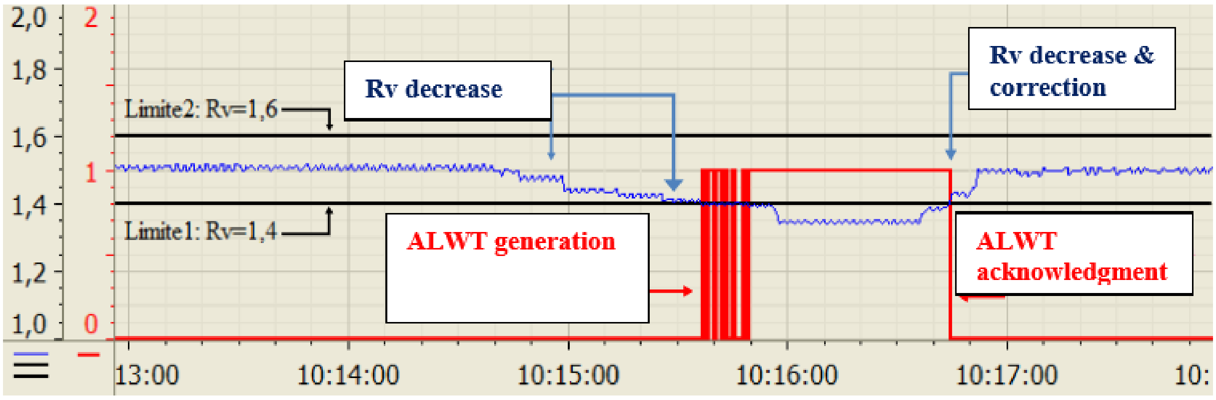

Fig 8. Alarm generation due to wires twisting fault

IV. CONCLUSION

This paper presented an approach to improve the product quality of a winding machine. Our contribution consists in developing a strategy for monitoring the wires quality and the coils geometrical shape.

The development of operating and monitoring algorithms and their implementation on a PLC represent the main contribution of this paper.

In perspective, it would be interesting to develop a specific reflection on the implementation of maintenance algorithms on the winding machine. Maintenance actions can be curative or preventative.

REFERENCES

1. Vatani, M., & Doustmohammadi, A. (2015). decomposition of first-order hybrid petri nets for hierarchical control of manufacturing systems. journal of Manufacturing Systems, 35, 206-214..
2. Li, H., Yang, H., Yang, B., Zhu, C., & Yin, S. (2018). Modelling And Simulation Of Energy Consumption Of Ceramic Production Chains With Mixed Flows Using Hybrid Petri Nets. International Journal Of Production Research, 56(8), 3007-3024.
3. Lu, X., Zhou, M., Ammari, A. C., & Ji, J. (2016). Hybrid Petri Nets For Modeling And Analysis Of Microgrid Systems. IEEE/CAA Journal Of Automatica Sinica, 3(4), 349-356
4. Hu, H., Liu, Y., & Zhou, M. (2015). Maximally Permissive Distributed Control Of Large Scale Automated Manufacturing Systems Modeled With Petri Nets. IEEE Transactions On Control Systems Technology, 23(5), 2026-2034
5. Vieting, P., De Lamare, R. C., Martin, L., Dartmann, G., & Schmeink, A. (2018, June). An Adaptive Learning Approach To Parameter Estimation For Hybrid Petri Nets In Systems Biology. In 2018 IEEE Statistical Signal Processing Workshop (SSP) (Pp. 543-547)
6. Dotoli, M., Epicoco, N., Falagario, M., & Cavone, G. (2016). A Timed Petri Nets Model For Performance Evaluation Of Intermodal Freight Transport Terminals. IEEE Transactions On Automation Science And Engineering, 13(2), 842-857.
7. Borges, M. U., & Lima, E. J. (2018). Conversion Methodologies From Signal Interpreted Petri Nets To Ladder Diagram And C Language In Arduino. International Journal Of Mechanical Engineering Education, 0306419018759921.
8. Vázquez, C. R., Gómez-Gutiérrez, D., Ramírez-Treviño, A., & Navarro, M. (2015). Eventual Generic Observability In Linear Hybrid Systems With Discrete Dynamic Modeled By Petri Nets. IFAC-Papersonline, 48(27), 47-53.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)