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Hybrid Petri Net Approach for Batch Process (Glass Process)

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Abstract*: Simulation is the most important tool used for planning, optimization, and analysis and controller design of industrial batch process. Modelling and analysis for the design and operation of glass manufacturing system is a vital need for glass tempering process, which are large scale process systems discrete petri net do not constitute on adequate tool for modelling and analysis. In fact, use of discrete Petri net is confronted with state explosion and high cost of simulation. The existing model is very slow and cannot provide output on both analytical and graphical, whereas the proposed model hybrid petri net gives an accurate output with faster response both analytical and graphical results are obtained which are highly useful to understand process behaviour.

Keywords*: Hybrid petri nets, modelling, petri nets, simulation, glass process

I. INTRODUCTION

This paper is proposed as a new method of approach for studying the behavioural modelling of batch process. A Batch process in which a desired amount of input quantity is given to the system and according to the input an estimated output is obtained. Some examples of batch process are biscuit manufacturing, tablet manufacturing, bottle filling, etc.

Raw material we have chosen is a manufactured glass sheet. In which the glass is treated under tempering process. Modelling of this process is done by SIRPHYCO software. This software is very user-friendly and mainly used for industry oriented application purpose. In which it is mainly devoted for modelling and analysis of glass tempering process.

The new method is called as Petri nets. Petri net is a tool which makes possible to model and visualize the Plant process in pictorial representation.

II. PETRI NET

A Petri net (also known as a place/transition net or P/T net) is one of several mathematical modelling languages for the description of distributed systems. It is Based on strong mathematical foundation. A Petri net is a directed bipartite graph, in which the nodes represent transitions and places. It looks very similar to State Transition Diagrams. It is used over concurrent, asynchronous, distributed, parallel, nondeterministic and/or stochastic systems.

A. A Petri net is classified into three Petri nets namely

1) Discrete Petri Nets
2) Continuous Petri Nets
3) Hybrid Petri Nets

III. HYBRID PETRI NET

There are several methods, present in designing the behavioural modelling of the industrial process, few methods majorly used in industries are

A. UML activity diagram
B. BPMN method
C. EPC method

UML activity diagram is more complex when used with software languages and it is not user friendly. A hybrid Petri net is combination of both continuous and discrete Petri nets, in this method of approach we can design behavioural modelling for all

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kinds of industrial process, in which we can obtain accurate results.

A Hybrid Petri net has two types of nodes, namely places and transitions. A Place is represented by a circle and a transition by a bar. The number of places is finite and not zero. The number of transition is also finite and not zero. An arc is directed and connects either a place to a transition or a transition to a place. In other word Petri net is bipartite graph, i.e. places and transitions alternate on a path made up of consecutive arcs. It is compulsory for each arc to have a node at each of its ends.

Each place contains an integer of tokens or marks. The marking defines the state of Petri net, or more precisely the state of the system described by the Petri net. The evolution of the state thus corresponds to an evolution of the marking, an evolution which is caused by the firing of transition.

A Petri net is formally defined as

$$N=(P,T,pre,post,m) \quad \text{--- (1)}$$

IV. PROCESS MODELLING AND ANALYSIS

The Block diagram and flowchart of the petrinet approach for glass tempering process is given below.

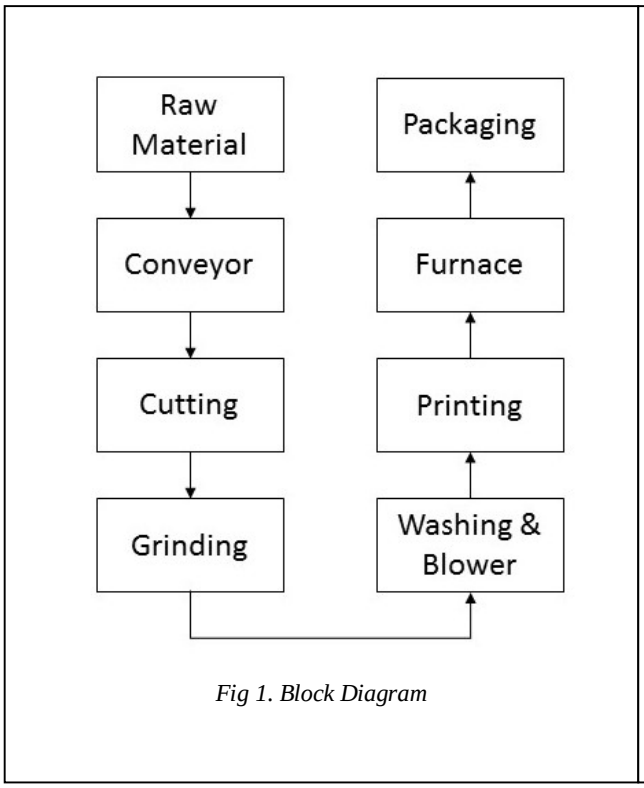

Fig 1. Block Diagram

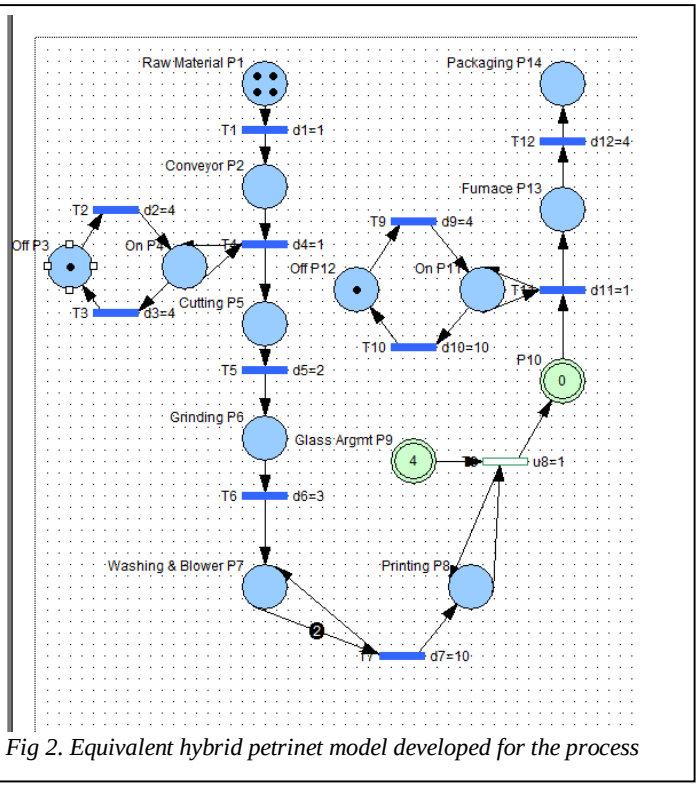

Fig 2. Equivalent hybrid petrinet model developed for the process

A. *Raw Material*

A Manufactured glass sheet is used as a raw material. Which is treated under the following process in order to made the glass as an Auto Glass with UV resistance, strong and brittle.

B. *Conveyor*

The Conveyor is a mechanical roller which is used to load the glass into the cutting section. It by operated manually also automatic and controlled by CNC Machine using PLC programming.

C. *Cutting*

After the glass are loaded cutting of glass takes place, glass cutter is a tool used to make a shallow score in one surface of a piece of glass that is to be broken in two pieces. The scoring makes a split in the surface of the glass which encourages the glass to break along the score.

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D. Grinding

After cutting grinding takes place, Grinding is a process of removal by abrasion. The process of grinding glass as a preparation for polishing it and to get a smooth edge.

E. Washing and Blower

After the glass cut into required shape it is subjected to washing section were glass is come under forced water spray to get more clear texture which is followed by blowing of air in order to absorb moisture on glass.

F. Printing

Printing is done for well treated glass in order to make it UV-resistance, fir the installation of spacer, this is take as border to drill the holes and defogger lines are printed in the glass in this section.

G. Furnace

After printing, the glass is fed in to the furnace at a slow, controlled rate by the batch processing system. The furnaces are natural gas- or fuel oil-fired, and operate at particular temperature. The temperature is limited only by the quality of the furnace's superstructure material and by the glass composition.

H. Packaging

Glass is inspected under quality testing, testing for scratch, bubble, cullet, white spot, breakage, powder mark, etc. Then it is packed using W-Thread and then dispatched to consumers.

Place no.	Explanation	Transition no.	Explanation
P1	Raw Materials	T1	Raw material State Transition
P2	Conveyor	T2	Valve 1 closing coefficient
P3, P4	Valve On/Off	T3	Valve 1 opening Coefficient
P5	Cutting	T4	Valve flow rate Coefficient
P6	Grinding	T5	Cutting state transition
P7	Washing and Blower	T6	Grinding state transition
P8	Printing	T7	Washing and blower state transition
P9, P10	Glass Arrangement	T8	Printing state transition
P11, P12	Furnace valve ON/OFF	T9	Valve 2 closing coefficient
P13	Furnace	T10	Valve 2 opening Coefficient
P14	Packaging	T11	Glass arrangement state transition
		T12	Furnace state transition

The algorithm is explained as follows: The flow starts from getting the Glass sheet to loading them into the conveyor. Glass move to next level when the valve gets on then glass is cut in appropriate shape and passes to grinding to mould its edges. Followed by

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washing, printing done on each glass on its Tin surface then comes under heating in furnace up to 750° Celsius. From furnace glass is at semisolid state which is cooled by quenching process. Then glass is inspected and get into packaging.

The flow of each process is plotted below: In which printing plot illustrates that the glass starts printed after it crosses 21th firing which is washing. Glass are reduced from 4 to one corresponding to valve open and close movement.

Furnace also controlled by furnace on/off valve in which graph shows in 23rd firing glasses are coming under furnace one by one and then it gets released sequentially. This is followed by packaging by FIFO technique.

The main process to be analysed in this glass tempering process are Printing, Glass arrangement, Furnace and Packaging. The flow response of these processes are monitored for invariant analysis, evolution graph method and reachability graph method. The flow response is shown below.

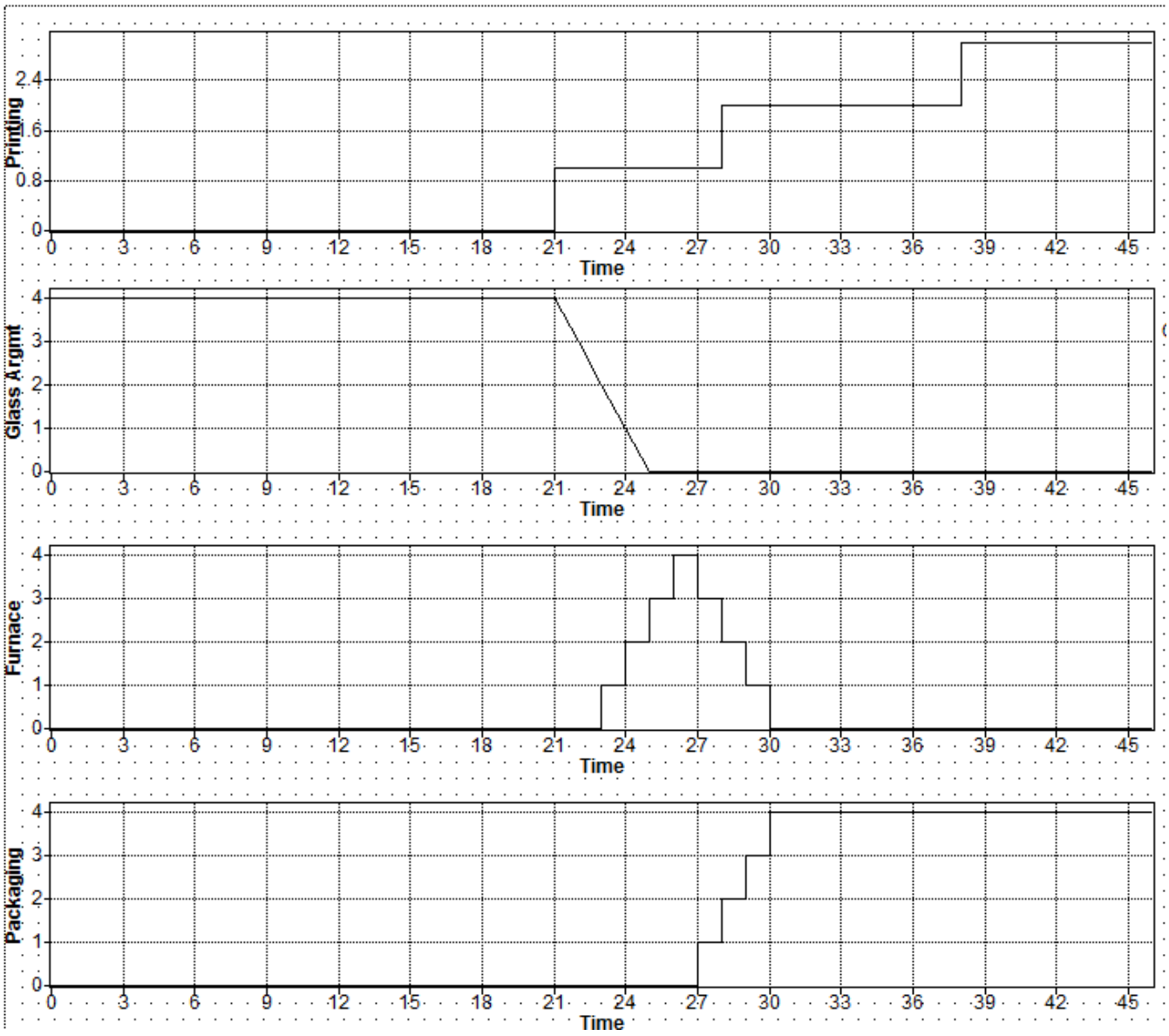

Fig 4. Glass process flow response

V. CONCLUSION

In this project a glass treating process is simulated with a new technique called hybrid Petri nets and the process is first designed using glass process and the same model is implemented in the SIRPHYCO software using Petri nets. This explains how the glass is treated to attend more quality and also explains us the behaviour of the system. Hybrid petri nets is very advanced over discrete and continuous method and also easier than existing method in its way or understanding, cost of implementation, handling, reduce risk of application, time consuming while studying its behaviour. This gives accurate result of the existing real industrial process.

In future work, we will design hybrid controller to control the glass tempering process based on the modelling which is modelled by hybrid petrinet. The petrinet is a wide area where we can do more thing in the field of industry and other mathematical process and has many applications.

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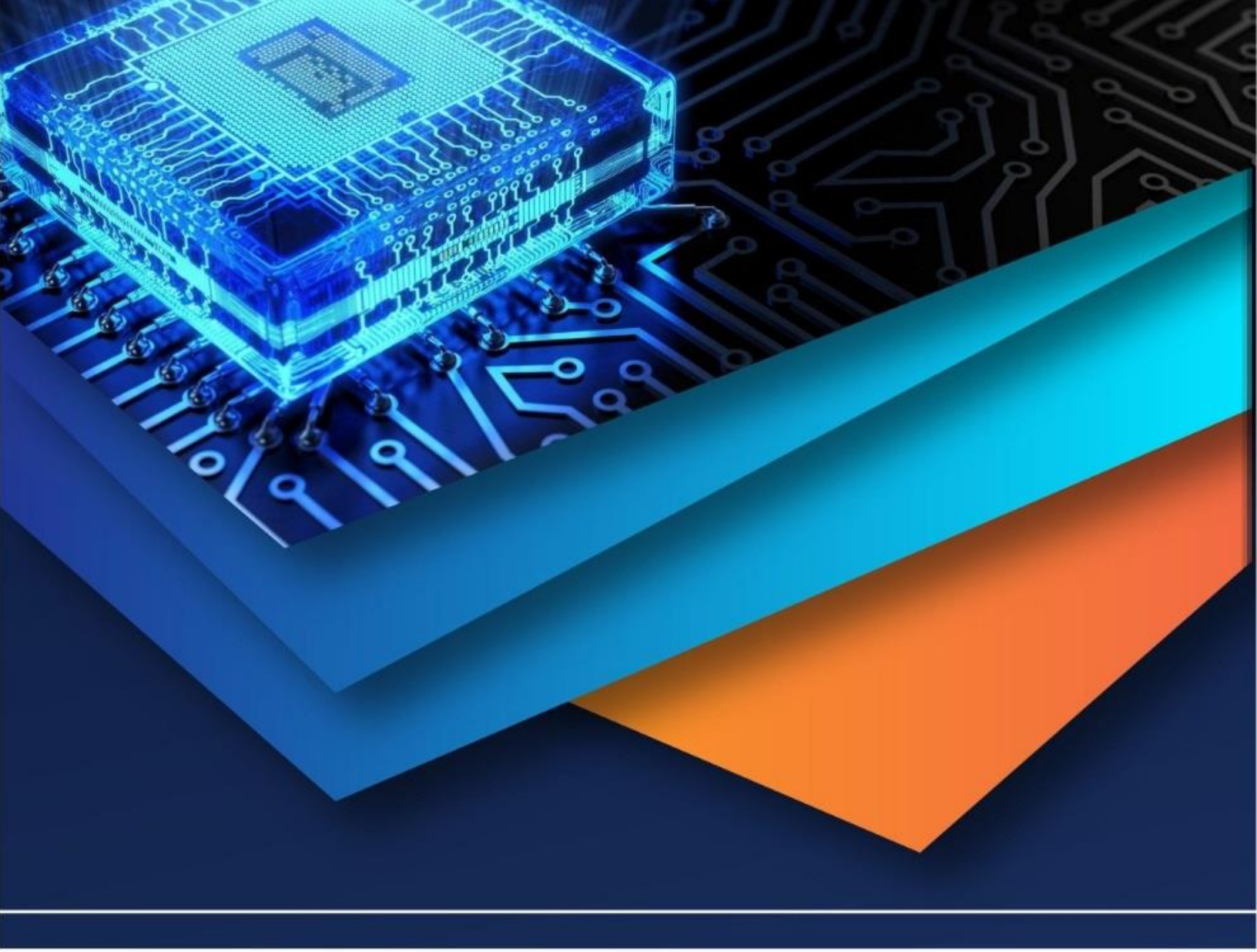

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