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Predictive Operation & Defensive Action (PrODA) for Intelligent Process Automation (IPA)

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Abstract - Industrial Process Automation (IPA) is being progressively integrated into numerous processes to enhance productivity, reliability, quality and cost optimization in all aspects. Currently, IPA is focusing on real time process control only even though system is upgraded with highspeed controllers, improved resolution time stamping, historian & other next Gen technology. With technological advancement, IPA can be developed to next generation so that prediction of process abnormality, control failure time to Alarm & Trip, Root Cause, Suggestion for Defensive Action etc. can be explored. Researchers, Designers Technocrats will get new insights Predictive Operation & Defensive Action (PrODA) for IPA.

***Key Words*:** Intelligent Process Automation (IPA), Predictive Operation & Defensive Action (PrODA), Process Control, Automation

1.INTRODUCTION

IPA is a broad and diverse discipline that integrates processes, equipment, electronics, software, and information systems to achieve key objectives such as productivity, quality, cost efficiency, and flexibility [1]. From inception to the industry 4.0 [2], growth in the field of IPA has been observed – Light switch automation, Relay based control, Solid State Electronic Controllers, PLC-DCS. During 1st Generation Automation, Hydraulic control signals mostly used. In 2nd Generation, Pneumatic systems have been developed. In 3rd Generation, voltage control based on Electrical system has been used and in 4th Generation, 4-20 mA analog signals and digital control systems have been explored by process industries. Now time to explore next step towards PrODA to take IPA towards Intelligent Automation (IA).

2. Objective

To explore new insight in the field of IPA. Prediction of future Process Value – Predictive Operation (PrO) and Defensive Action (DA) to correct Predictive Deviation so that process reliability can be enhanced which will impact on productivity, quality, cost, control accuracy, manual intervention & much more.

3. Technical discussion

At present, control system has advanced components. Neural Networks, Dual – Tripple redundancy, High Scan rate (1-10 milliseconds), High resolution time stamping (1 millisecond) [3]. Industries are exploring use of Industrial Internet of Things (IIOT) in process automation & control [4]. In conventional DCS, adequate historical data is available which can be used to train the model with latest technology like Artificial Intelligence (AI) and Machine Learning (ML).

In conventional IPA, Control Action is being designed with error (e) from Process Value (PV) and Set Point (SP) as per defined logic. IPA acts for present error / deviation and control the process with current condition / state of process.

As IT infra is being developed, capacity to handle BIG data, high speed processor, high scan rate & high-resolution time stamping of control system, next generation automation can be explored. Mathematical Model can be developed with Design Value (DV) for different process condition. Process Value (PV) to be compared with Design Value (DV) and difference (error – e) to be used to derive Rate of Change (RoC) and Direction of Change (DoC). RoC and DoC indicate instantaneous deviation of PV with compared to theoretical / technically desired DV. Mathematical Model based on latest technological tool, Artificial Intelligence (AI), Machine Learning (ML) can be developed to predict future PV – **Predictive Operation (PrO).** In this process (PrO), multiple aspects to be considered to develop model. Like:

- Identification of all dependent variables to PV & their time series behaviour
- Impact of Current Control Action to RoC & DoC
- Time prediction to reach PV at Alarm Value & Trip Value – **Predictive Operation**

In next step, AI & ML modelling to be done to identify Root Cause / Impacting Factor for PV deviation. Suggestion for **Defensive Action (DA).** DA can be correction in Operation of suggestion for equipment maintenance.

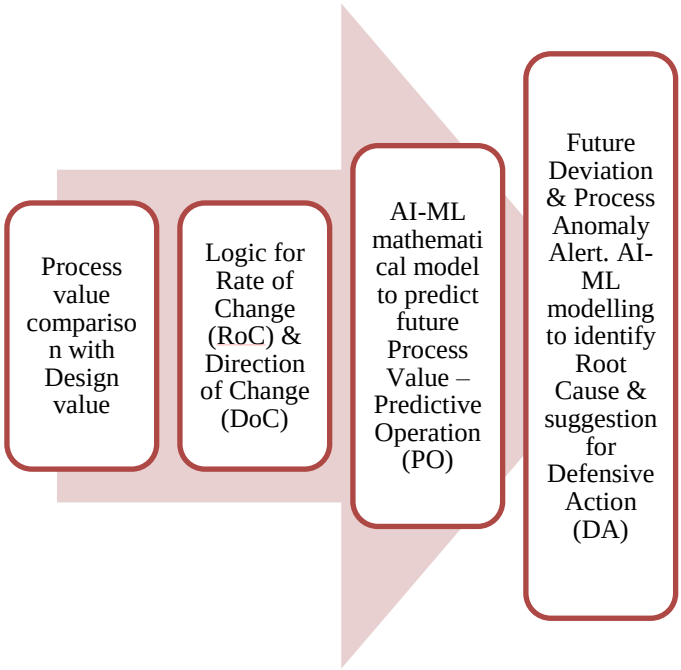

Fig – 1: Predictive Operation – Defensive Action (ProDA) for Intelligent Process Automation (IPA)

Process example: In process plant, one pneumatic Control Valve (CV) is controlling tank water level to 5-meter SP at 100% plant load and 4-meter SP at 70% plant load. Tank has two outlets with Motorized Operated On-Off Valve which operates as per operational requirement.

Case – 1: Conventional Industrial Process Automation

PV is level measured by SMART Ultrasonic Level Transmitter which read real time tank level. SP is 4 as plant is at 70 % load. Whenever outlet MOV will open, Level will reduce, PV<4 m, Control Valve will open to control SP @ 4 m. When level will reach at 4 m, PV-SP=0, Control Valve will be reduced to zero till level is 4 m and so on.

Risk of overflow of tank or empty in case of automation failure. Possible failure due to technical issue in (1) CV (2) MOV-1 (3) MOV-2 (4) LT (5) DCS

Case – 2: Predictive Operation – Defensive Action (PrODA)

In ProDA model, based on load Design Value (DV) will be compared with PV and conventional control is in place. Simultaneously, based on modelling, RoC and DoC will be continuously calculated. Time Series AI-ML modelling will predict future PV with consideration of all dependent variables like CV opening (% Feedback), MOV-1 & MOV-2 status, PV, RoC & DoC, LT healthiness, DCS healthiness etc. If RoC is 1 m/hr & DoC is + **continuously**, Alert will be triggered "Control Failure -Water will overflow after 2 hr". If RoC is 1 m/hr & DoC is (-) **continuously**, Alert will be triggered "Control Failure – Tank will empty in 4 hr".

AI-ML modelling can be designed to suggest Root Cause of Control Failure. Model will check different possibility like CV stuck up / passing, MOV-1, MOV-2 stuck up / passing, LT issue, DCS issue etc so appropriate Defensive Action (DA) can be performed timely to avoid control failure. DA may be operational or maintenance.

4. CONCLUSIONS

Conventional Industrial Process Automation is designed to control process in real time current condition. In case of technical issue or failure of any equipment, process interruption is being faced. To avoid process interruption, Predictive Operation – Defensive Action (PrODA) model can be developed with the help of advance hardware & software, AI-ML & other advance tools.

ProDA will be explored for (1) Prediction of process variable abnormality in future (2) Probable time of failure, Time to reach at Alarm limit (T_a) and Trip limit (T_t) (3) Root cause of predictive deviation. (4) Suggestion for Defensive Action.

This new insight in Intelligent Process Automation (IPA) will help to enhance process reliability, quality, control accuracy, cost optimization and customer satisfaction.

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BIOGRAPHIES

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