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Development Of An Automated Fault Detection System Using PLC And HMI

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Abstract: Machines keep factories running only when power and parts work without stopping. When something breaks suddenly, output drops, machines get hurt, people might too. Built here is a way to catch those failures early - using a PLC paired with an HMI for alerts. What shows up on screen comes straight from logic built into the controller. Each piece talks to the next so trouble does not go unseen.

Sensors keep watch on things like voltage, current, temperature, while also tracking how the motor behaves. When odd readings show up - overload, maybe a short circuit, too much heat, or missing phase - the brain of the setup reacts without delay. That brain, a programmable controller, checks everything as it happens, never falling behind. Once trouble strikes, protection kicks in fast: power cuts off before damage spreads. At the very same moment, warning signals light up to alert anyone nearby.

Right there on the screen, it shows what the system is doing at any moment. A quick glance reveals warnings, errors, or past events without digging through menus. Instead of guessing, workers see exactly where a problem started. Because everything links together, tasks take less time than before. Machines stay running longer when small glitches get caught early. Fewer breakdowns mean fewer risks near heavy equipment. Suddenly, making decisions becomes simpler with live updates front and center. No more flipping between tools just to check one value. When alerts pop up clearly, response feels natural, almost automatic. All of this adds up to smoother shifts and calmer workdays.

I. INTRODUCTION

Most factories today depend on automated systems to keep work moving smoothly while boosting output and protecting workers. Machines like motors, conveyor belts, and control units run nonstop during operations. When problems show up - overheating, power shifts, broken parts, sudden emergencies - they risk harming both machinery and workflow. Damage spreads fast if issues go unnoticed. Catching these glitches early means fewer breakdowns, less downtime, safer environments. A solid monitoring setup helps spot trouble before it grows. Reliability matters most when detecting faults at the first sign.

Back then, spotting issues meant doing everything by hand - slow work, full of mistakes. As factories grew smarter, machines took over the watching. Now, computers built tough handle decisions fast, working nonstop without failing. These devices talk to people through screens showing real-time data. Operators see what is happening using visual dashboards instead of guesswork. One part runs the logic silently, another lets humans check in when needed.

This setup builds a way to catch problems in machines by using a controller along with a screen interface. From buttons, detectors, and controls, signal data flows into the unit nonstop during operation. Logic rules baked into the system examine incoming info moment by moment. When something steps outside normal boundaries, alerts fire up without delay. The display panel lights up showing exactly what went wrong at that instant. Processing happens fast enough to spot trouble while it unfolds. Feedback paths

ensure warnings reach operators through visual cues onscreen. Rules inside decide whether readings are safe or risky each cycle. Signals shift state instantly once thresholds get crossed somewhere. Information pops onto the user view right after detection occurs behind scenes.

Watching how things run comes easy when the screen shows if machines are on, what errors pop up, or warnings flash by. Starting tasks, ending them, even restarting happens right there, which keeps work moving without extra steps getting in the way. When problems strike, fixes come faster since the brain of the machine talks directly to the display. Less waiting means fewer delays, everything holds together better over time.

II. SYSTEM DESCRIPTION:-

Faults in factories get spotted by a setup built around a PLC paired with an HMI. Built to watch problems as they happen, it links sensors, decision rules, actuators, plus screen feedback in one flow. Real time alerts come through when something goes off track. Inputs feed data into logic units which drive responses shown on display panels nearby. Monitoring happens without breaks thanks to steady communication across parts. This arrangement keeps operations visible and reactions quick. No delays pop up between sensing trouble and showing warnings. Each piece works together like steps in a sequence that never stops watching. Control stays active because signals move fast from device to device. Feedback loops close quickly so issues do not spread far.

Split into four parts, the setup begins with where data enters. Next comes the part that manages operations. Then there is what delivers results. Last handles tracking everything along the way.

1. Input Section

Starting off, the input part holds different gadgets that send signals into the PLC. Think of switches, sensors, or buttons - each one feeds data in its own way. Some react to heat, others notice movement or pressure changes. Each device links up so the system knows what's happening. Not every piece works the same, yet they all serve the task. Their role? Letting the controller respond based on real world conditions

Begin here. Press once to go. Halt anytime with a tap. Try again by starting fresh

Emergency stop switch

Selector switches

Variable control unit (dial/variatic)

Sensors (if used)

Right now, these inputs show how the industrial system is actually running. Take the adjustable knob - it creates odd states like too much voltage or too little. When things need to stop fast, the emergency button steps in, mimicking a real safety failure.

2. Control Section (PLC)

Inside the setup, the controller runs everything. Without pause, it pulls in data while working through steps written in ladder code.

The PLC compares input values with predefined limits

When everything runs inside the green zone, operation continues without interruption

Fault found by the PLC when limits get crossed

From there, outputs form to manage devices while alerts activate when needed. Quick reactions happen because the system runs steady no matter what comes up.

3. Output Section

The output section includes devices controlled by the PLC:

Relays and contactors

Indicator lamps (fault indication)

Buzzer (alarm system)

Motor/actuator (load) When a fault is detected:

Once motion ends, the engine halts on its own

A loud beep sounds when the trigger engages

Indicator lights turn ON to show fault condition

Keeping things safe happens while also protecting the system from extra harm.

4. Monitoring Section (HMI)

Operators watch how the system runs by using the Human Machine Interface. This screen lets them make changes while things are happening. Control happens right away through this link between person and machine.

Displays system status (ON/OFF)

When something goes wrong, it tells you - like too much load, power issues, or if the emergency stop kicks in

Allows operator interaction (Start/Stop/Reset)

Operators find system status clear because the HMI uses straightforward visuals that guide decisions without delay. Though simplicity stands out, every detail helps speed up responses when timing matters most.

5. System Operation

The overall operation of the system is as follows:

Power reaches the machine when someone flips the switch on the front screen

Inputs are given through switches and sensors

PLC processes the inputs using ladder logic

Under normal conditions → system runs smoothly

Under fault conditions → PLC detects abnormality

Output devices (buzzer, indicators) are activated

Fault details are displayed on HMI

Operator resets the system after resolving the fault

6. Fault Detection Capability

Broken parts show up clear. When gears wear down, it notices. Leaks get flagged fast. Overheating triggers alerts. Misaligned components stand out. Voltage spikes register instantly. Stuck valves pop into view. Unusual vibrations catch attention. Failing sensors come through loud. Pressure drops appear obvious

Overload condition

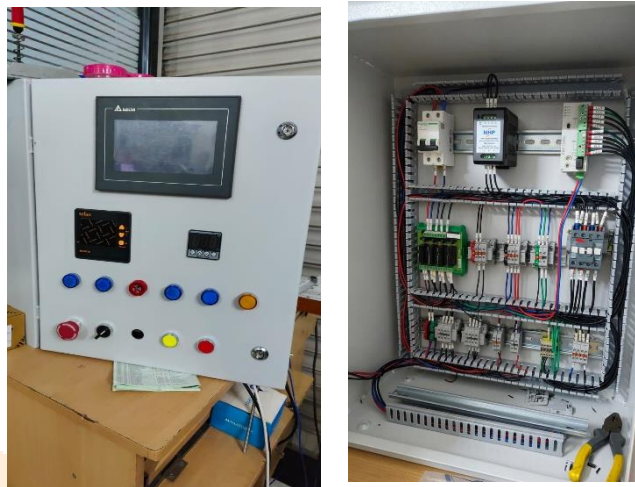
Under/over voltage

Emergency stop activation

Motor failure or abnormal operation

III. HARDWARE IMPLEMENTATION:-

From scratch, the physical build of an Industrial Fault Detection System uses a PLC paired with an HMI to mirror actual factory environments. Built around a control board, it brings together a programmable logic controller, human-machine screen, output device acting as load, alongside related wiring and power parts. Each piece links into the next, forming one working loop that spots issues



instantly while showing them live on display.

Fig. 1 Hardware implementation

1. Control Panel Setup

Inside the metal box, every part links up through wires and clips. This setup lets operators manage functions easily from one spot.

Manual operation gets handled through switches labeled Start, Stop, or Reset

Lights come on to reveal what the system is doing, also hinting at problems. Sometimes they glow steady, sometimes blink - each pattern tells a different story. A flicker might mean something's off, while full brightness shows normal operation. These small signals work quietly, always reporting behind the scenes

Should things go wrong, a stop button comes into play. This red switch halts operations fast when triggered. Safety takes priority with this built-in feature. Operation pauses only when someone uses it. The system respects that immediate cutoff need

Proper wiring and terminals are used for secure connections

A rough-looking setup gives it the feel of a factory switchboard, keeping things both tidy and secure. While built tough, its layout guides users without confusion. Not flashy at all, yet every piece fits where it should. Though simple in look, it handles tasks without risk. Because it follows clear patterns, mistakes happen less often.

2. PLC Panel Control Unit

Inside the setup, the PLC panel takes charge like a brain handling operations. Its role keeps everything running by making decisions on its own.

A PLC module is installed to execute ladder logic

A steady 24-volt current comes from an SMPS unit. This type of supply switches rapidly to maintain control. Voltage stays fixed even when demand shifts slightly. Regulation happens through quick internal adjustments. Twenty-four volts direct current is what it delivers reliably

A small breaker guards the electrical path. It stops damage before it spreads. Power flows safely because of its quick response. Trouble gets cut off fast when things go wrong

Relays and contactors are used for switching operations

Terminal blocks are used for proper wiring and connections

From moment to moment, the PLC watches incoming signals while managing outputs through preset rules. Though unseen, its work shapes how machines respond when conditions shift unexpectedly.

3. HMI Interface

Mounted up front, the Human Machine Interface sits right on the panel. Easy reach comes from its placement where hands go often.

Displays real-time system status

Alerts pop up when something goes wrong. Messages appear if a problem is detected. Warnings come through clearly as issues arise

From here, pressing Start begins the process. Hitting Stop ends it right away. Then again, Reset returns everything to how it was at first

Offers a user-friendly graphical interface

Connected via communication cables, the HMI links to the PLC, serving as both monitor and controller. While it receives data from the system, it also sends operational commands when needed. Not just displaying status, it allows adjustments in real time. Through this link, changes appear instantly on screen. Because of its role, operators interact with processes safely. Instead of being separate, components work together seamlessly.

4. Actuator and Load Area

A spinning unit sits inside the actuator part, doing the job of a motor. This setup copies what happens under real factory workloads.

The motor is controlled through relays connected to PLC

single motor might stand in for a whole assembly line's moving parts. Pumps get mirrored by digital twins that act just like the physical ones. Each piece of machinery finds its match through live data streams. Real-world actions echo inside virtual models constantly updating themselves

Faults like overload or failure are generated in this section

Here's how faults show up right away when tested outside a lab. Real-world settings reveal issues as they happen.

5. Variable Control Unit

Turning the adjustable dial changes how the system behaves under test. This knob lets you mimic various real-world scenarios by shifting settings slowly. Instead of fixed levels, it offers smooth shifts across a range. Each turn alters voltage just enough to reflect new conditions. Testing becomes flexible when inputs can rise or fall without jumps.

Used to vary voltage or speed input

Built-in triggers spark system errors like these: Over-voltage Under-voltage

Over-voltage

Under-voltage

Provides flexibility in testing system performance

6. Wiring and Interconnections

Wires link every part, fitted just right. Connections hold firm through careful setup. Each piece ties to another, built step by step. Setup follows clear paths, avoiding loose ends.

From sensors or switches, connections lead into the input ports of a PLC

From the PLC, signals go to relays instead of flowing straight to devices. Lights respond when triggered through intermediate switching points. Actuators receive commands after passing through control layers. Each output channel links a separate component on site

HMI is connected to PLC using communication protocol (RS232/RS485/Ethernet)

Cables stay neatly arranged because it keeps things safe, plus clear. A tidy setup prevents accidents while making everything easier to follow. When cords run straight, confusion drops away. Safety grows when clutter disappears. Order shows up where chaos might have been

7. Protection and Safety

The system includes multiple safety features:

MCB for overcurrent protection

Emergency stop switch for immediate shutdown

Proper grounding and insulation

Fuse safeguarding, when needed

When things get tough, safety stays locked in. Through every shift, protection holds firm. Even when stress builds, the controls keep working right.

8. Overall Hardware Operation

System power state active

The PLC receives input signals

Processes logic based on program

Controls outputs (motor, relays, indicators)

Detects faults in real time

Sends data to HMI for display

A working model of the system shows how machines can run tasks on their own while catching errors during operation. Equipment put together in real conditions handles both control jobs and spotting problems as they happen.

IV. Working Principle :-

When sensors spot changes, a programmable logic controller checks them without delay. Instead of waiting, it runs preset rules to decide what happens next. Visual feedback shows up instantly on a touchscreen panel nearby. If something goes wrong in production, the response follows within moments. Problems become visible right away thanks to live updates. Quick recognition means fixes start sooner than before.



Fig. Working of panel

1. System Initialization

System power state active

The MCB supplies power to the panel

Starting with household current, it becomes steady 24-volt power through the SMPS. This transformed output runs PLC systems along with associated controls. Instead of raw alternating flow, a regulated direct stream feeds these components. From wall socket to machine logic, voltage shifts happen inside this unit. Not left unchanged, incoming electricity adapts into usable form here

A signal fires up the PLC, then it slips into watch mode. Monitoring begins once the system powers on. It waits, quietly checking inputs. After startup, readiness follows. The cycle starts again each time power returns Ready signal shows on the display when the system is set

2. Input Signal Processing

A button press, a switch flip - these feed into the system. The dial twist travels straight to the controller. Each signal arrives through physical contact points. Manual adjustments shape what happens next. Input paths link directly to processing circuits. Changes in position register instantly inside the unit. Control begins at the touch of a surface

These inputs represent real-time operating conditions

The PLC continuously scans all input signals

For example:

Press the start button then the system powers on

Pressing the stop button turns off the system

Variable dial → Simulated voltage condition

3. PLC Logic Execution

The PLC processes inputs using ladder logic programming:

When things run smoothly, rules already exist. If problems pop up, there are set ways to handle them too

PLC compares real-time input values with set limits

Computers follow step-by-step rules like checking conditions, making choices, using time delays, tracking counts - each part connects through clear links instead of just adding steps together

When things go as usual:

PLC allows system operation

Motor/actuator runs normally

If abnormal condition occurs:

Fault shows up right away to the PLC

4. Fault Detection Mechanism

Faults show up when odd inputs come through, like these examples. Unexpected entries can trigger errors just that way. Strange data might lead straight into fault conditions instead. Weird values often bring about system faults too. Incorrect info has a habit of causing glitches suddenly

Overload condition

Under/over voltage

Emergency stop activation

Motor failure

If something goes wrong, the system reacts immediately

PLC stops the actuator/motor

Activates buzzer alarm

Fault light comes on when needed

Built-in safeguards stop harm while keeping things secure.

5. Output Control Action

The PLC sends signals to output devices:

Relays/Contactors → Control motor operation

Lights come on to reveal what the system is doing, also pointing out any problems that pop up. Sometimes they glow steady, sometimes they flash when something goes wrong

Buzzer → Provides audible alert

Outputs change state based on PLC decision.

6. HMI Monitoring and Display

The HMI Talks With The PLC And Shows Data

System status (Running/Stopped)

Fault messages (e.g., Overload Fault, Voltage Fault)

Alarm indications

Control options (Start/Stop/Reset)

Facing the HMI, clarity comes fast for the operator. System status shows itself without delay. A glance gives what's needed. Understanding follows naturally from display cues. Details appear just when they should. Information flows at a steady pace. The screen speaks plainly to those watching.

7. *Fault Handling and Reset*

Once it spots a problem, staying put in that error state is what happens next. Not moving on keeps everything locked until changes come through elsewhere

Operator must identify and correct the issue

Hold down the Reset button to wipe out the error

System returns to normal operation

8. *Continuous Monitoring*

The PLC continuously scans inputs in a loop:

Input leads to processing then output followed by display repeat

This ensures:

Real-time monitoring

Fast response to faults

Reliable system operation

V. *CONCLUSION*

Faults now show up fast thanks to a new setup built around a PLC. Instead of guessing, operators see alerts right away through clear visuals on an HMI screen. Logic inside the controller checks sensor inputs nonstop during operation. When something goes wrong, the response happens within moments. No complicated steps are needed to view what triggered the issue. Feedback appears instantly, helping reduce delays in fixing problems. Controls stay reliable because the design focuses on steady performance. Every part works together without extra layers slowing things down. Monitoring runs smoothly since the display keeps pace with live data. Users get updates continuously, not just at set intervals. Errors make themselves known before they grow into bigger troubles. Visual cues replace long diagnostic routines most systems require. Setup stayed practical by avoiding unnecessary complexity from the start. Interaction feels natural due to straightforward layout choices. Real-time detection stands out where older methods tend to lag behind.

Early warnings of issues like power spikes or sudden failures help stop machines breaking down. Instead of waiting for breakdowns, fixes happen before problems grow. This means less time spent repairing things. Machines keep running smoothly when glitches pop up unexpectedly. Safety gets a boost because risks are spotted ahead of time.

When something changes, the response comes right away thanks to how the parts work together. Smooth operation happens because inputs get handled without delay. A screen lets users see what is happening and adjust settings without confusion instead of guessing. Quick signal handling makes sure nothing gets stuck along the way.

Putting it all together, the results show PLC and HMI setups work well in spotting faults within today's factory environments. With additions like IoT connectivity, off-site tracking, or storing operational records, performance could grow even stronger over time.

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