Basic principles of industrial automation engineering essay

Industrial automation nowadays is very important especially due to globalization and competition that industries need to deal with. The main aim when applying this system is to increase the production rate without increasing the expenses. For example a certain task that usually needs 3 workers to be done, by introducing automation the same task can now be done by a single robot and maybe one worker just for supervision. Apart from that the quality of product and also the production rate (products per hour) can be improved. The three types of industrial automation are programmable, flexible and fixed automation.

Figure 1: Variety vs. Quantity for the 3 types of automation[1]

Figure 1 shows the difference between the three types of automation. Immediately one can notice that programmable automation allows variation while sacrificing quantity and fixed automation allows large quantities to be produced sacrificing variation. Fixed automation stands in the middle of both.

1. 1) Programmable Automation

Programmable automation allows reprogramming of the machines to satisfy different sequence of operations. Different products require different process to be done for the manufacturing processes. When a company deals with customised products like for example HVAC units the machines need to be programmed to fit the customer's needs. If the customer requires that the HVAC unit needs to be installed in a certain part of the building then the HVAC's dimensions need to be customised therefore the machines have to be reprogrammed to satisfy the customer's needs. Apart from that, if the

HVAC unit is going to be installed in a very cold climate region than the heat exchanger needs to be different than the one's installed in Malta.

A company using programmable automation needs to spend a high amount of money to buy the equipment and also needs personnel to program these machines. The personnel need to be trained and also be skilled enough to program the machines in the least time possible. The production rates are lower than the other two types of industrial automation and production is done in batches. As discussed above programmable automation can deal with customised products which means changes in the products are possible. [2]

1. 2) Flexible Automation

In flexible automation which is normally used in the automotive industry allows little variation when compared to programmable automation. The advantage is that the production rates are higher.

In an automotive industry the same model of a specific car can vary in colour, engine, wheels, interior etc. Therefore this is why the automation needs to be flexible. The same equipment and same programs are used but requires some changeover from one job to another. Automotive companies need to invest quite a lot of money on the machinery but the amount is less than programmable automation. The production is continuous and only little time is lost during changeover. The production rates are lower than fixed automation but as discussed allow some variation unlike fixed automation. [3]

1. 3) Fixed automation

A company that produces paper can be considered as fixed automation. In fixed automation the product produced is fixed and only a small tolerance for variation is allowed hence the term fixed.

This type of automation usually results in high production rates and large quantities of the product produced. Therefore the money spent on machinery is small when compared to the money earned by the amount of products produced. The major disadvantage as mentioned above is the lack of variation which sometimes can limit the company in producing other products because the equipment design and programs cannot be easily changed.[4]

2) What is the difference between precision and accuracy regarding measurement?

Nowadays on the market many type of sensors exist and also one may choose from a wide variety of brands. One important factor is that the sensor being bought is precise and accurate.

If a temperature sensor reads 23oC and the real true value is 25oC then there is an error of 2oC. Therefore this means that the sensor is not accurate which can be crucial on certain type of installations.

On the other hand if the temperature sensor reads 23oC and when measured for another couple of times the temperature always varies, than the senor is not precise.

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ANd9GcQU4V1_9G8xceZHmGDAMzBuTuUj2qERMmm5vkZKNxpjlm5KwF_khd

970joX

Figure 2: Precision vs Accuracy[5]

Figure 2 shows a diagram which can demonstrate what has been said above. Starting from the right the target shows an example of having a sensor which is neither accurate nor precise. The black dots represent the readings which are far away from the target (not accurate) and they are also far away from each other (not precise). The left target shows a representation of a sensor which is not accurate but precise which is why the readings are far away from the target but close to each other due to precision. The middle target represents an ideal sensor being both accurate and precise. The black dots are in the centre and also next to each other.

3) Strain Gauges

a) Explain the principle of strain measurement using strain gauges.

Strain gauges are used in sensors to measure force and related parameters such as torque, acceleration, pressure and vibration.

A strain gauge has its own electrical resistance which is varied when the device is subjected to strain. Therefore the more strain the more electrical resistance varied which then gives the reading of the current forces on the work piece. The bonded metallic strain gauge is most commonly used. This consists of thin metallic foil fixed in a grid pattern which is bonded to a thin backing (carrier) and then attached to the work piece. When the work piece

is subjected to strain then it is transferred to the strain gauge which varies its electrical resistance and can give the reading necessary.

b) Give the schematic for most common measurement set-up for this type of measurement.

Figure 3 shows the schematic of the most commonly used strain gauge (quarter bridge circuit). For the strain to be measured which includes very small values, an accurate measurement is needed to measure the small changes in resistance. This set up is called a Wheatstone bridge. It consists of four resistive arms with an excitation voltage " Vex" which is applied across the bridge. When there is a change in resistance in any of the arms shown below, an unbalance is created in the bridge and will result in a nonzero output voltage.[6]

Figure 3: Schematic set-up of a strain gauge[7]

c) Explain how sensitivity of such set-up can be increased, and what is a possible solution to compensate for environmental temperature variations.

The sensitivity of the set up shown in figure 3 can be further enhanced by using a half bridge circuit and also a full bridge circuit.

When using a half bridge circuit (figure 4 left) the sensitivity can be doubled by having two gauges which are active. In this type of set up the output voltage is linear and the output value is double from the one shown in figure 3.

Figure 4: Half bridge (left) & Full bridge Wheatstone circuit[8]

By using a full bridge circuit as shown in figure 4 right hand side the sensitivity can be further enhanced by having all four arms active. Two gauges can be mounted in tension and the other two can be mounted in compression as shown in figure 5.[9]

http://www. sensorland. com/Images/SG-009. gif

Figure 5: Diagram showing a full bridge strain gauge circuit[10]

To compensate for environmental temperature variations a possible solution is to have a configuration where two strain gauges in the bridge are used. One gauge will be the active gauge and the other will be placed transversely to the applied strain which can be called a dummy gauge as shown in figure 6.

Figure 6: Using a dummy gauge to reduce temperature affects[11]

The temperature changes will be the same on both gauges which does not affect the ratio of their resistance and also does not change the voltage output therefore the temperature affects are small.[12]

4) What are intelligent (smart) sensors? Give general block schematics of usual elements that constitute such a device.

Intelligent (smart) sensors are an extension to the traditional sensors. The difference between a normal sensor and intelligent sensor is that a normal sensor detects and sends an unprocessed signal to a system which then identifies the reading whilst an intelligent sensor includes a processor to process the signal.

Figure 7: Block diagram of an intelligent sensor structure[13]

These are systems which usually consist of a series of analogue and digital blocks. Every block has its own function. By using these sensors data can be analysed and then corrected which means no human interface is needed. For example large buildings use smart sensors to control lighting, air conditioning temperatures, doors, switches etc.

Some of the functions that intelligent sensors do are self-diagnosis of faults, real-time data processing, communication interface and many more.[14]

5) Try to list all the tasks and requirements of a hydraulic fluids used in hydraulic installations.

Hydraulics is widely used around the world in simple applications like power steering of a car and also high tech applications like in aircrafts where safety measures are very important. By using a pump, other components (DCV's), actuators and a hydraulic fluid mechanical power can be achieved like lifting and pressing. The hydraulic oil which is sued needs to fit the requirement needed for the process to take place. For different applications different type of hydraulic fluids are used. In hard coal mining and forging presses low in flammability fluid must be used due to high risk for temperature therefore synthetic oils are used instead of standard oils.

Although different types of fluids are used they all need to perform the same tasks. These tasks are: pressure transfer, lubricating the moving parts, cooling, damping (cushioning) of pressure fluctuations in the system, protection against corrosion, reduce abrasion and signal transmission.[15]

For the hydraulic fluid to perform the tasks mentioned above the fluid needs to have the lowest possible density, good ageing stability, good viscosity-pressure/ temperature characteristics and many more, air release, non-frothing, resistance to cold, wear and corrosion protection and water separable.[16]

Nowadays water hydraulics is advancing but the principle tasks mentioned above still need to be done no matter the fluid used.

M3) Present and communicate appropriate findings.

6) Shaft power calculation

Flow rate = 35dm3/min

Pressure rise = 100 bar x 105Pa = 100MPa

Overall efficiency = 87%

To convert the flow rate from minutes to seconds:

Q = 5. 833m3/min

If we find the fluid power we can then find the shaft power:

Therefore now we can find the shaft power:

7) For the given schematics of dual pilot operated check valve locking circuit identify the numbered components and try to describe the circuit's operation.

7. 1) Components of circuit

Filter and check valve – (in case of filter blockage fluid passes through the check valve)

7. 5kW electric motor

Direction of motor and pump

Flow meter

Constant displacement hydraulic pump with one direction of flow (38 l/min)

Pressure gauge

4/3 way directional control valve, mid position closed, spring return (both sides) and operated via solenoid with one active coil.

Solenoid with one active coil

Pilot line

Pilot operated check valve

Double acting hydraulic cylinder with double ended piston rod

7. 2) Circuit operation description

When the electric motor (2) is started the hydraulic pump (5) starts to rotate. Hydraulic oil passes through the filter before entering the hydraulic pump. If the filter is blocked the oil will bypass the filter and pass through the check valve (in section 1). A flow meter (4) and pressure gauge (6) are installed to

check the flow and pressure of the hydraulic. With no activation of the solenoids the DCV (7) has its ports open to drain which will cause the pilot lines to rain therefore close the check valves.

When both solenoids A1 and B1 are off, the DCV (7) will be in the centered position. In this position both ports are open to the tank which allows the pilot pressure to drop and the pilot operated check valves to close. Therefore the hydraulic cylinder is locked.

When solenoid A1 is activated the valve will move to the right and the hydraulic cylinder (11) starts to extend. What happens is pressure is build up in the pilot line that leads to the piston end which opens the check valve (10). The other check valve opens by pump pressure like any other check valve and hydraulic starts to flow.

When solenoid B1 (8) is activated the valve will move to the left and the hydraulic cylinder (11) starts to retract. What happens is pressure is build up in the pilot line (9) which opens the other check valve this time. Check valve (10) opens by pump pressure like any other check valve and hydraulic starts to flow.

If the DCV (7) is in the center position, and it's ports are closed then the check valves will remain open which allow cylinder creep.