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Sensor Driven Energy Factor Relativities under Roll over Sequential Manufacturing

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ABSTRACT

Sequential manufacturing deals with production automation capabilities that rely on pre-programmed logical sequence of events within a limited constraint of time and resources. The importance of this strategy is not only limited to process conditions that requires revolving production schemes, but processes demanding intermittent operations to yield final or near consummate results. This study investigated the energy relativity consequence of this type of manufacturing, by implementing a simulation scheme using a capacitive level sensor device to control the inflow of filtered water on a municipal water treatment system. This approach evidently demonstrates the application of this control strategy under roll over production system. Consequently, the key issue of interest in the simulation applied in this study is the energy transduction ability of the capacitive level sensor and how this serves as primary and secondary feeder signals to integrated FRs logical controllers in order to achieve pre-determined responses and actions. The result of the simulation exercise is further probed and analyzed by generating a process truth and excitation table which was used to develop some resultant Boolean equations, indicating the suitability of thisenergyscheme to this specialized manufacturing strategy.

Key words: transducers, real-time, capacitive sensors, resistive element, simulation analysis, logic controllers

INTRODUCTION

Over the years, various types of sensors have been used to define operational limits on the performance of equipment and machines. Thus, in the determination of signal strength or value, and in the evaluation of structural or dimensional quality or characteristics, such as position, force, torque, pressure, temperature level, etc.; the use of sensors has largely dependent on the nature of application and intended results. Such issues as stopping the movement of machine tools,in order to restrict the function of a machine member, automatic shut-off capability of temperature and pressure gauges, control of excessive speed by implementation of governors on engines, etc. Hence, sensor technology is crucial to modern manufacturing capabilities and to a large extent has become the technical basis of enhanced machines applications. It is therefore an integral issue in data acquisition, interpretation and control strategy, where sensors are embedded into machine structures and substructures for data collections interpretation and transmission to logic controllers for decision path analysis and instructional codes. It is important to note that this performance ascribed to sensors are made possible on account of the various energy factor relativity for which the sensors are agents in the energy conversion process.

Consequent on the foregoing energy factor relativity on the basis of sensor technology, operates by converting one quantity or quality of energy to another. Devices with such capabilities are thus referred to as *transducers*. Hence, due to this transducing function, analog sensors produce a signal in the form of voltage with the proportionality of the measured quality, and relays same in the form of metered level or height indicator. Additionally, digital sensors after transducing the input signals, display results in numerical values or digital outputs, which are further transferred to logic circuits for further processing before system decision [1]. Many sensors exist in various industrial applications, and of particular interest in this paper, are the level measurement sensors which are used to monitor and regulate defined levels of liquids in containers and orifices. Thus, sensors are also used to monitor and regulate defined levels of free flowing fluids or fluidized substances, within a confined space. This study finds that there is a growing need for level sensors as emerging technologies replace older conventional applications. In this vein, level sensors that are designed to support the application of IoTand other remote digital frameworks must be accurate, fast and significantly dependable.

In view of the foregoing, there are so many industrial and domestic applications of level sensors; as they are deployed in vehicle design requiring measure of oil, fuel power steaming fluids, industrial oil, waste water storage tanks. In these applications basic or lower level is determined and upper level is also fixed. These identified points are crucial in the design and installation of level sensors. Consequently, on the basis of the simulation strategy of this investigation, sensors have capability to output the specific quantity or level of liquid in a container relative to the stated minimum and maximum calibration. Further, based on signal transfer by network of communication links, sensors can be used to maintain a continuous measurement and determination of volumes of fluidized substances [2]. It should be noted that the transducer referred to in ref [2] is limited in application, owing to the fact that in situations where continuous or real-time level determination is required it fails to give accurate readings due to accumulated errors on account of resistor hysteresis resulting from the varying levels of the fluids in the confined space. A possible solution to this identified energy related anomaly has been designed and proposed [3].

ENERGY RELATIVITIES IN SEGMENTED RESISTANCE LEVEL SENSORS

This energy relativity investigation bothers on the design of a contactless resistive type transducer where air gap between the slide strip and the resistive element generate an energy gap filled with air. This air gap has a capacitive contingencyoperation for which changes in fluid level implies a displacement of the resistive element and on the potentiometer such changes are transmitted as electrical voltage. This is schematically depicted in Fig 1 below:

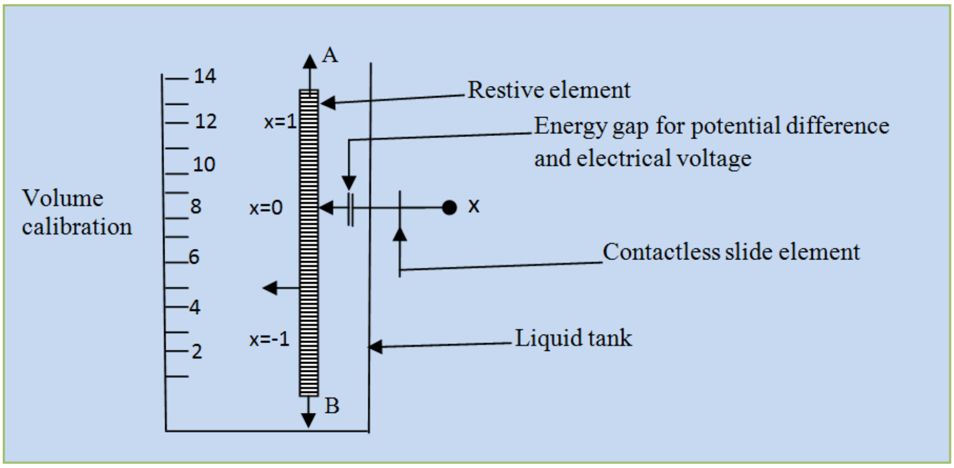

Fig. 1 Contactless resistive transducer sensor for level determination
Source: Thathachary *et al* (with modifications)

As could be seen in Fig 1, the air gap constitutes the energy relativity necessary for the proper operation of this segmented resistance level sensor. This gap with capacitive features enables the sensor to transducer (or convert) the displacement force and the air corridor into an electrical voltage which is further processed and relayed as a liquid volume level matching the specific electric voltage value relative to the displacedvolume by using microcontroller with significant precision and accuracy. This energy relative characteristics of this sensor it applicable in mining, ground water, geological and agricultural conditions measurement [4]. Although this study is aware of the drawbacks of inductive transducers, suffice to state that their energy connotation is affected by varying magnetic fields of coil for which they are prone to erroneous results; thus, a proper design which takes cognizance of the various energy properties of inductors could produce sensors with high capacity inductive transduction applicable in some special conditions [5].

In view of the foregoing, capacitive transducers are more reliable when the task requires homogenous fluidized level measurements. Their advantage over inductive transducers is that they have stable reading due to balance of energy signals arising from the air gap phenomena. The implication of this energy relativity factor is the fact that this type of sensor provides high resolution and can be deployed insituations where time relative sensors are required. Because of this precision element, they are also used to trigger some operational functions such as start and stop operations where they are relatedly linked to external timers and logic controllers [6].

Further, as observed by Gabor [6], the operational principle under which capacitive transducers function is associated with the charging and discharging phenomena of an average solid state capacitor. The energy relative implication of this, is that the generated electric voltage signal for external analysis and further processes appear as energy displacement current which is determined by the comparative difference between the upper fixed limit and the lower limit with respect to the position on the slide in Fig 1. Instructively, this displacement current enables the air gap to store energy in between the resistive element of Fig 1 and its contactless slide element. Thus, the magnitude of the displacement current determines the extent of energy storage generated by the electric field in the air gap which in turn is sent out by the senor as an electric voltage signal [7].

As shall be discussed later, this electric voltage signal is further processed for specific actions relative to system functionality. Under remote manufacturing sequence control, capacitive sensors have the capability to release this transduced energyinto a logic controller that can interpret and trigger a corresponding response. This imply that sensor technology of this type can be applied beyond fluid level determination to activate internal control functions,which would be definitive of the appropriate management of energy related transmissions under various manufacturing conditions. Thus, the accuracy of a sensor element is a direct consequence of the energy relativity which is its output but an input into the microcontroller. This view shall be illustrated in the simulation detailed in Fig 2 below.

Time Dependent Sensor Control of Manufacturing Processes

The study further draw attention to the process conditions for smooth operation of no contact sensors which operate by creating energy fields or beam of energy, for which it characteristically responds to any perturbation of that field [8]. Thus, time domain sensors with time dependent signals and switching capabilities have been found to render the following support to manufacturing activities; (i) arithmetic mean, average value and magnitude of materials [9], (ii) root mean square or effective value output [10], (iii) variance or standard deviation [11], and many other parameter definitions. In view of these beneficial applications of sensors, a time dependent capacitive level sensor having high linearity and low cost of production was fabricated into a circuit board [12].

This time dependent senor was designed to incorporate two comb electrodes which enabled some quantized outputs that made it an inter-digital capacitive sensor. The discharge time correlated to the water level which in turn is used for computation of its capacitance between the comb electrodes, using a microcontroller. Hence it has been demonstrated that this capacitive sensor can be used in determination of liquid flow in pipelines, since its energy relativity can be transduced from flow pressure to stored capacitive signals in between the two comb electrodes [13]. In view of the foregoing, this time dependent capacitive sensor can be utilized under process conditions of heterogeneous fluids with divergent properties but in the same containment. Consequently, studies have also indicated that capacitive sensors have been deployed in situations where liquid content of a tank had been measured during a time specific stir perturbation period [14].

DEMONSTRATION OF ENERGY RELATIVE SENSING UNDER TIME DEPENDENT SWITCHING CONTROL

The paper presents a simulated application of an integrated capacitive level sensor, discussed in [12] by the installation of LV3000/4000 series level measurement sensor into a municipal water pre-treatment system as a liquid level determinant with trigger and control input functions. It should be noted that this sensor is by design made to give reliable and real-time level measurement. This model is known to be appropriate for liquids, oils, flowing pastes with varying viscosity and some solid-liquid mixtures or aggregates. It can also be used on conductive and non-conductive substances. It has the ability to rectify and filter input voltage and can generate a radio frequency signal which can be transmitted real-time to the control terminal in the form of an electrical energy. This sensor can calculate changes in current, with an integrated electronic circuit which produces 4 to 20mA output power conveyed by two wires with its output signal proportional to the desired process or fluid level.

In this section, we shall demonstrate by simulation analysis the energy factor relativity of deploying this level sensor in the processing of river waterwith sedimentary waste particles in a water pre-treatment and pumping system, as the schematic show below.

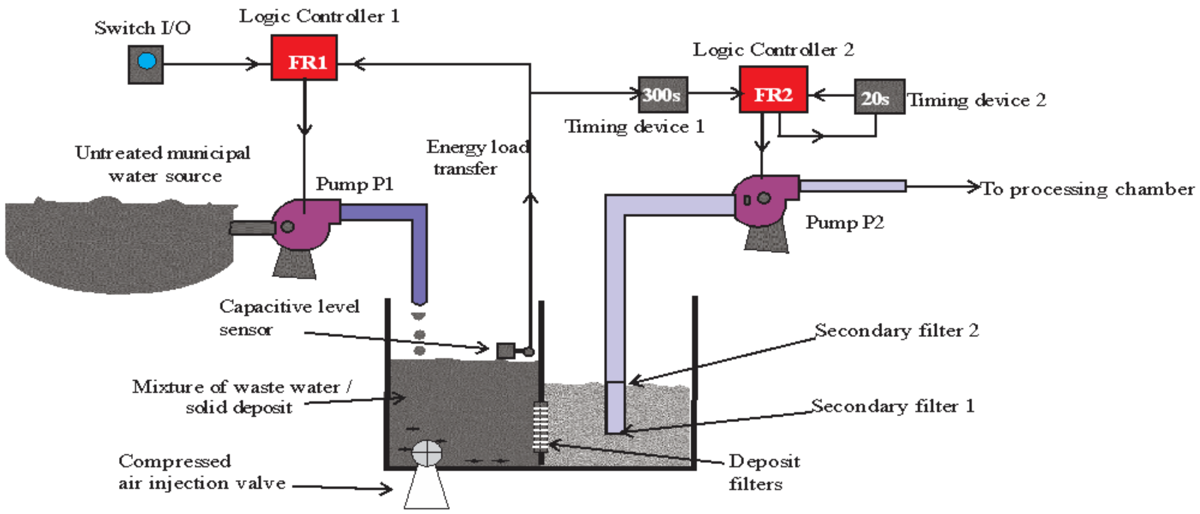

Fig. 2 Municipal water pretreatment facility indicating energy relativity flow from capacitive level sensor

Table -1 Process Simulation and Sequence Analysis for Water Treatment with Double Tank Single Omega-LV3000/4000 Series Level Measurement Sensor (Truth and Excitation Analysis)

Sequence	Input Devices			Output Devices		Analysis	
	Switch			FR_1	FR_2		
	I/O	R_{input}	R_{outout}	(Pump 1)	(Pump 2)	Changing	Virtual
1. Tank empty (tank 1)	1	0	1	1	0	X	
2. Filling tank (tank 2)	1	0	0	1	0		
3. Tank full (tank 1)	1	1	0	1	1	X	
4. Emptying tank (tank 2)	1	0	0	1	1		

At the input Switch I/O operation, electric signal is transmitted into the energy signal logic controller 1 (FR_1). This input signal interferes with the resting pump1 with a suction consequence. Thus, the input energy also implants trigger ready response on the dual functioning capacitive sensor. Upon sensing of the rising water level by reason of water touch on the capacitive sensor, a relative energy is spontaneously transmitted to logic controller 2 with a dual timing circuit for 300 seconds and 20 seconds respectively.

It should be noted that timing device 1 has 300 seconds configuration cycle. While timing device 2 has an intermittent 20 seconds relay configuration. This recycling 20s switching device is also a digital counter modulated by logic controller 2 (FR_2). Hence, timing device 2 is a 15 times revolving scheme which is programed for 5 minutes water delivery of 15 cycles of 20s each.

In view of the foregoing, FR_2 activates pump 2 with input suction and output transfer capacity. Thus, the energy flow for timing of 20s is imposed on FR_1 which maintains a steady transfer of the multi-filtered water for further processing. It is important to note that the secondary filters 1 & 2 creates an energy balance overload on pump 2 for which, this overload is characteristically transferred to the logic controller 2 (FR_2). The impact of this double filtration energy is further compensated by level balance of the capacitive level sensor. In this regard, it should be noted that the energy output sequence from the capacitive level sensor maintains the balance of energy flow within the logic controller 2 and enables a simultaneous flow of unprocessed water into tank1 and output of multi-filtered water into tank 2.

Energy Relativity Applications of the Logic Controllers

As could be seen in Table 1 below, the truth and excitation analysis indicate an energy flow sequence in four stages with switching I/O, R_{input} and R_{output}. The binary function for start of the filtration process implies energy relativity input at stage 1, which commences with a switch sequence (1,0,1) at tank empty condition. Thus, relay FR1 activates pump 1 to operate until the capacitive sensor activate logic controller 2 and the binary sequence of tank-2 at a sequence of (1,0,0) and pump output (1,0). At the 3rd stage of the energy sequence, tank-1 full, is logically represented as (1,1,0) which activates pump-1 until water level contact is made with the capacitive sensor which activates pump-2 to empty tank-2 defined by the binary control logic (1,0,0), and at that point, pump 1 and 2 operate simultaneously within the 5 mins' cycle at the binary control logic (1,1,1) until the timer activates a stop component (I/O) of the logic controller 1 after the 5 mins trigger timing.

In view of the Table 1 parameters, let CLs=capacitive level sensor, TD1 = Timing Device 1 and TD2 = Timing Device 2. The Boolean relativity of table 1 becomes:

$$FR1 = (FR1 + Start).CLs$$
$$Pump\ 1 = FR1$$
$$FR2 = (FR2 + CLs).TD1\ [20sec]$$
$$TD2_{300sec} = FR2$$
$$Pump\ 2 = TD2[300sec]$$
$$TD1_{20sec} = TD2_{[300sec]}$$

The foregoing implies that the application of process energy by the logic controllers is on the basis of revolving 20 sec operation, within 300 sec constraint similar to 15 small circles of 20 units diameter linked head to tail in a larger circle of 300 units diameter.

As have been observed, the identified revolving energy factor is relatively a chain of uninterrupted flow signal from the capacitive level sensor (CLs) which also act as a primary switch to the logic controller 2 (FR2) and a secondary switch to pump 2; while FR 2 serves as the primary switch to pump 2. It is important to note that the energy relativity in the foregoing circumstances is therefore a function of the capacitive level sensor (CLs) as it serves as an energy feedback mechanism to logic controller 1 (FR1) which enables it maintain the flow of electrical signal to pump1.

Hence, the input energy from CLs to FR1 is equal to the input energy from CLs to FR2, however the energy is processed differently on account of the various functions of the two logic controllers.This phenomenal behavior of the CLs is on the basis of the memory coordination between it and the pair of FR1 and FR2 logic controllers.

CONCLUSION

The study has drawn attention into the importance of sensors to the development of current industrial and manufacturing related practices. This makes sensing devices an integral part of modern automation design, since their relevance are direct consequences of higher manufacturing performance requirements. Further, as emerging technologies advance into higher efficiency work inputs and better design interface is desired between various digital and data technologies, the benefits derivable from such interplay to the development of modern manufacturing technology is enormous.

As have been observed in the study, evolving technologies such as IoT would rely on multi-capacity sensors to transmit real-time data from machine elements to remote terminals using 5G network capabilities. This imply that a proper understanding of the energy relativities inherent in sensor design and applications is required to realize more benefits in that regard.

The result of the energy transduction capability, exemplified in this study's simulation table and its incidental set of Boolean equations, draws attention to the likelihood that capacitive level sensors can be effectively deployed in manufacturing conditions where level measurement as basis of specialized roll over production strategy is applicable. This is due to its ability to send intermittent signals of interferences to its generated force fields to the logic controllers for pre-programed analysis and further instructions; as shown in the case of the simulation where operational timing of 20 seconds is a subset of the larger timing of 300 seconds.

Consequently, the revolving 15 cycles of 20 seconds each is indicative of the operational performance limits imposed on the process which also determines its efficiency in terms of production capacity. Consequently, the study finds that the ability to convert and transmit these signals in the form of electrical energy to the controllers is an energy relative function that requires proper assessment for better optimization.

REFERENCES

[1]. S. Kalpakjian, and S. R.Schmid, Manufacturing Engineering and Technology 5th Edition, Pearson Publishers, New Jersey, 2006, p. 1172

[2]. G. N. Popa, I. Popa, C. M. Diniş, and A. Iagăr, "Resistive stepped transducer used for water level measurement," in *Proceedings of the 1st WSEAS International Conference on Sensors and signals*, 2008, pp. 66–71

[3]. S. V. Thathachary, B. George, and V. J. Kumar, "A resistive potentiometric type transducer with contactless slide," in *Seventh International Conference on Sensing Technology (ICST)*, 2013, pp. 501–5.

[4]. X. Yao, Y. Zhang, L. Gao, W. Yin, J. Yang, and C. Wang, "Ground water level measurements using a segmented resistance sensor," in *IEEE Instrumentation and Measurement Technology Conference*, 2009, pp. 1357–60.

[5]. S.Marick, S. K. Bera, and S. C. Bera, "A float type liquid level measuring system using a modified inductive transducer," *Sens. Transducers*, Vol. 182, no. 11, pp. 111–8, 2014.

[6]. V. Gabor, "The Principles of Level Measurement," *Sensors*, Oct., 2000.

[7]. E. Hughes, Electrical Technology, 7th Ed. Longman, Essex, 1995, p.120

[8]. A. Somogyi, Industrial Automation Technologies in Manufacturing Engineering Handbook, McGraw-Hill, New York, 2004, p.11.6

[9]. Binsaeid S, Asfoura S, Chob S, Onarc A (2009) Machine Ensemble Approach for Simultaneous Detection of Transient and Gradual Anomalies in Milling Using Multisensor Fusion, Journal of Materials Processing Technology 209: p.4728–4738.

[10]. Y.Guo, Ammula S (2005) Real-time AE Monitoring for Surface Damage in Hard Machining. International Journal of Machine Tools and Manufacture 45:1622–1627.

[11]. N.Ghosh, A.Ravi, S.Patra, S.Mukhopadhyay, A.Mohanty, Chattopadhyay A (2007) Estimation of Tool Wear During CNC Milling Using NN-based Sensor Fusion. Mechanical Systems and Signal Processing 21:466–479.

[12]. K. Chetpattananondh, T. Tapoanoi, P. Phukpattaranont, and N. Jindapetch, "A self-calibration water level measurement using an interdigital capacitive sensor," *Sens.Actuators A. Phys.*, Vol. 209, pp. 175–82, 2014.

[13]. M. Demori, V. Ferrari, D. Strazza, and P. Poesio, "A capacitive sensor system for the analysis of two-phase flows of oil and conductive water," *Sens. Actuators A. Phys.*, Vol. 163, no. 1, pp. 172–9, 2010.

[14]. D. Zou, M. Yang, X. Zhan, R. He, and X. Li, "Assessment of air entrainment in stirred tanks using capacitive sensors," *Sens. Actuators A. Phys.*, Vol. 216, pp. 92–101, 2014.