Introduction of Information Technology in the process Industry

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Abstract:In Industries, automatic control method (Wired control systems) is usedfor valves in processes. Current industrial scenario includes Smart sensors and transmitters. Further, development in the process control field can be achieved by introducing wireless systems. One of the current strategies being adopted in the modern Industries is the introduction of wireless transmitters and receivers and Information and communication technology (ICT).Development in the process industry is the key to competitive advantage in the business world that is growing increasingly competitive and is strongly connected with economic growth. This research work explores the capacity of ICTs to equip process industry to perk up the industrial world.Investments made in ICT enabled process control systemsprovide a high amount of returns.This paperproposes a model titled 'information control technology based remote control valve (ICTBRCV)'. The current research examines the literature in the field, It is clear that the ICT based remoteprocess control valve model is not reported in the past.The conceptual features of the ICTBRCV model are presented, followed by an illustration of its implementation in a hypothetical industry. Implementation of this model will pave way to substantial economic development in process industries by remarkably reducing the amount of connecting cables, quantity of laborersand amount of instruments.The model can be implemented in a process industry, for a military application where situation demand, for a remote control in off shore refinery or a nuclear power plant.

Keywords: Information and communication technology, Development,Wireless Control System, Control valve, Microcontroller.

1. INTRODUCTION:

Recent trends in industry are to use some protocols to access data from a remotely located process wirelessly. Many a research has been done in internet based control systems. Wireless and Internet communications technologies are used for monitoring and controlling such systems (Thompson, 2004).The design methodologies for the local computer-based control system are not appropriate for Internet-based control system, as they do not consider the Internet environment issues such as Web-based delay, Web-based safety, Web-based interface, and uncertain users. The major challenge endured by Internet based process control systems is dealing with Internet time delay, hacking and data loss. Several studies conducted all around the globe pertaining to this problem resulted in the following inference: Two compensators located in the feedback and feed forward channels in the architecture can efficiently deal with Internet time delay and data loss. However, the time delay and data loss in the feed forward channel seem to cause more serious influence on the control performance and is more difficult to be compensated (Yang, et al, 2005).

One of the strategies that have been subject to wide implementation of remote control methods for valves in the process industry is information control technology. Information and communication technology (ICT) introduces the role of telecommunications (telephone lines and wireless signals) in modern information technology. ICT consists of all technical means used to handle information and aid communication, including computer and network hardware as well as necessary software. In recent years, the ICT has proved a powerful technology for distributed collaborative work. The emerging ICT technologies have the potential to apply the advantages of this way of working to the high-level control of process plants. The advantages include: (1) allowing remote monitoring and adjustment of plants, (2) allowing collaboration between skilled plant managers situated in geographically diverse locations, (3) allowing the business to relocate the physical location of plant management staff easily in response to business needs. However, very little research work has been done to date aimed at developing systematic design methods using this technology or for the design of ICT based process control systems.

ICTs and new media have advanced dramatically over the last decade. It is a well-proven technology in the modern competitive industrial world. The effectiveness of an information system is a product of the interaction between organizational goals and practices and the design of technology to meet them. Many dimensions of expected benefits exist in the ICT technology adoption (Hollenstein, 2004). In education,(Hinostroza, et al, 2011). Recent trends in education are to implement a variety of educationalprogrammes using ICT(Bidarian, et al, 2011). In providing education to the right people at the right time, challenges endured by the most underprivileged regions of the world are financial problems, scarcity of education material, and unavailability of capable teachers owing to their unwillingness to serve in isolated rural areas. The use of Information and communication technology for education is a feasible solution for all the previously mentioned issues. (Saïd Assar et al,).

Owing to variations among business environments in developing and emerging economies, approaches to the usage of IT, success factors and models for IT applications to differ among businesses.(NarcyzRoztocki et al, 2011). The use of information and communication technologies (ICTs) accelerates development by facilitating access to new markets, increasing competitiveness, and access to knowledge and skill if applied to attend to local conditions and to confront individual challenges (Sajda Qureshi,2011).A sea change can be brought about by ICT in the organizational structure. ICT is also a potent catalyst when it comes to methodologies of learning, researching, developing, producing, marketing, distributing and servicing digital and traditional goods and services. The role played by ICT in augmenting the quality of life is noteworthy

Information and Communication Technology (ICT) is inevitable for the economic upliftment of developing countries. The policies framed and implemented by an organization in connection with ICT go a long way in determining its position in the global economy.Studies however indicate thatdespite the aforesaid fact, majority of the developing countries are yet to apply ICT in their socio-economic and political life. Many a research has been performed on the economic development and related benefits arising out of ICT.A fact agreed upon by everyone is that a very high degree of positive correlation exists between ICT and economic development. An interdependent relationship between economic activity and ICT infrastructure investment at state and country levelswas discovered by a landmark research by Adoni (2008).The inter-relationship between ICT and various influential global development establishments in their dissertations have highlighted economic development.(pr.korpela, et al Mikko, Montealegre, Ramiro and Poulymenakou,2002).The design and implementation of ICT take place within the determinative conditions of a specific social and organizational context (Suchman 1987;Ciborra and Lanzak1994,Avgerou 2002a). Researches began as early as 1980s in order to render ICT potentenough to claim that it epitomizes a sector and a technology with enough capability to generate operational change in the world economy.(Freeman & Perez, 1988). ICT has extensive influence on various prominent characteristics of the macroeconomy such as capital investments and economic growth(Brynjolfson&Kahin, 2000).Reduced transaction costs and more efficient marketsare noteworthy benefits of ICT(Malone, Yates & Benjamin,1987; Lee & Clark, 1997).A careful scrutiny of various studies at the macroeconomic level incorporating various European and other OECD nations brings to light the fact that ICT has had notable influence over macroeconomic variables in those nations too, thoughin many countries on a lesser scale (Mairesse, Cette&Kocoglu, 2000; Daveri, 2002; Jalava&Pohjola, 2002; Coleccia& Schreyer, 2002).

Average IT contribution to economic growth for 5 years since 2001 is as high as 39.6 per cent using ICT-related services is also constantly on the rise:the number of subscribers to Internet banking services reached 26.7 million in 2005;Internet trade accounted for 66 per cent of the total trading as of 2003;internet auction, e-business and e-commerce are another development to human and economy due to the introduction of ICT.

The general standard of living of people in many nations of the world needs to be enhanced by providing them access to the latest infrastructural developments. In such nations, IT is a tool that can enhance efficiency and productivity, in turn accelerating development.The workforce and management in most of the organizationsare keen on continuing with the incumbent practices. Besides, the initial cost of implementing ICT systems is high. These issues highlight the significance of making entrepreneurs and their staff aware of the paybacks of ICT so that the same can be successfully implemented.(S. Krishna et al). The advancement of most of the developing nations is hindered in the global economy, which is characterized, by sophisticated technology and wide availability of information. (Chrisanthi Avgerou,1998). ICT has equally high potential value across various sectors both in public and private enterprises and at several levels in software businesses in urban areas (Gee off Walsham et al,2006).ICT is capable of initiating development in poor nations by creating a sea change in uncompetitive industries and non-operational public administration, and by opening up a plethora of opportunities for information intensive social services such as health and education (sandeepsahay, 2002).

For most processes, there is a variety of requirements for information. Senior managers need information to help with their new ideas. Middle management needs more detailed information to help them monitor and control process activities. Employees with operational roles need information to help them carry out their duties. As a result, industries tend to have several "information systems" operating at the same time. Hence, in this paper a model named ICTBRCV is proposed. Two phases of activities were carried out before designing the ICTBRCV model. First, authors reviewed literature and found that no activities had so far been reported on titled information control technology based remote wireless process control valve. During the second phase, a survey was carried out among five process industries. The survey results also indicated that no effort to introduce wireless remote control of process valves had been reported in practice. On completion of these two phases of activities, the information control technology based remote control valve model was designed. The details of this work are presented in this paper. A hypothetical case is also described to provide the reader for a clear understanding of the procedure of ICTBRCV in a real-time situation.

2. ICT BASED REMOTE CONTROL:

ICT systemis defined as the combination of computers, operating systems, networks, communication equipment and applications (Ref.ISO/IEC 27005). ICT is highly beneficial for monitoring process variables in the process industry, controlling motors and actuators,

remotely programmable devices, smart sensors, flow computers, and condition monitoring. Foremost thing to consider in the execution of ICT based systems is the safeguarding measures that should be taken. A prerequisite to implement effective and efficient information security controls and measures is to have a clear understanding of the needs of each process control system and importance of the system in the process industry. Having a clear-cut idea of the process one can implement an appropriate information security control for the same. Nowadays vital infrastructures and systems are introduced not only to traditional safety of ICT, but also to new kinds of security threats (Fovino,et al, 2011).

Physical cables can provide a path for conveying data between two points in ICT. When wires and cables aren't preferable, wireless system is an alternative. Wireless capabilities add new expediency and cost savings to process measurement and control. Many more merits such as, faster, easier, and less expensive installation; good data acquisition facility exists. Most wireless equipment interfaces easily to standard computer equipment, whether through embedded Ethernet or USB.

Although the jargon may vary from case to case, wireless arrangements always include two components a transmitter and a receiver. The transmitter, which directly attached to a sensor of some type, captures the raw data. After capturing the data, the transmitter transmits the data wirelessly to a receiver, on the other hand, receiver transfers that data to another component, which can be Ethernet (for sharing across a network or through the internet), to a local display/controller, or to an industrial controller. Units also have external alarm capability, notifying operators when necessary. There are two forms of wireless link in common use: radio links and infrared. It is very important that a communication link has the capacity to convey the messages as quickly as they are arriving from the transmitter. Data is conveyed by sending a series of pulses from one end of a communication link to another. The ability of a communication link to convey data depends upon a quantity known as its 'bandwidth'. Every communication link has a maximum data rate it can support, which is the link's bandwidth.

Realizing that ICT implementation in the processes could benefit industry, the authors sought to locate any associated reported work.In this venture, recommendations of the consultation Group formed by Information Society and Media of European Commission, an industrial project andthe article 'Defense Forces Armed with ICT'andDaksh, an electrically powered and remotely controlled robot filed under: (FeaturedMagazine, March 2012), were identified.Following are the Recommendations of the Consultation Group formed by Information Society and Media of European Commission, Brussels in January 2009: A way to increase productivity in industrial processes is by applying advanced schedulingalgorithms with the help of ICT. At production system level, ICT-driven enhanced production scheduling allows for a scheduling of energy rigorous tasks when the lowermost economic and ecological effects are expected. The plant design can be ugmented towards maximization of performance and capacity. Here ICT enables a flexible access to economy process models and permits knowledge support for the same.

The following are excerpts from an industrial project (AnirbanMajumdar , et al,2011) :

In the recent past, the contribution of ICT to the manufacturing sector has been gaining increasing significance. Sensors, automation controllers and embedded systems have established themselves as parts of industrial applications.Things arranged by industries these days is much beyond their own 'Intranet of Things' focused on local, isolated and closed-loop scenarios.Consummate and secure interaction with real world objects and systems on a global scale, across a variety of application domains and promoters has become a trend these days.Information and communication technology (ICT) goes a long way in the betterment of end-to-end manufacturing processes. It is getting increasingly intertwined with factories of the futureby delivering efficiency gains through mechanization and integration of a variety of processes throughout the value chain. The most productive nations of the world have extremely high investments in hardware, software and services as well. The fact that the contribution of ICT to productivity improves with the increase in investment in ICT is well established. The projected annual growth in the process industry market is 6.9 %.(between 2007-2020).

The article 'Defense Forces Armed with ICT',describesaremote-controlledhummingbird plane (drone)-it looks like a humming bird-, developed by the California based Aero Vironment Inc. in addition, is equipped with video and audio equipment that can record sights and sounds. Such devices can be used for spying purposes and for attacking remotely located targets. Another, the later article, Daksh, an electrically powered and remotely controlled robot used for locating, handling and destroying hazardous objects safely which is a creation of Defense Research and Development Organization (DRDO). The primary function of this battery powered remotely controlled robot on wheels is to recover improvised explosive devices (IEDs). Daksh can climb staircases, negotiate steep slopes, navigate narrow corridors and tow vehicles. However, this feature did not include ICT based remote control valve. Thus, the review of literature revealed absence of any ICT based control valve in the reported papers.

3. A MODEL FOR ICT BASED REMOTE CONTROL VALVE:

Methodology used for the research: An automated physical model was formed which consisted of ICT, smart components and systems, sensor/actuator networks and control algorithms. Optimization of process control loop could be achieved by allowing data exchangebetween the automation system, the manufacturing execution system, and the enterprise resource planning system. The quantity of data that is accessible in and around an ICT automation system contains a lot of Information about the process or

plant. Advanced quality monitoring systemsthat investigate the data, extract information about the state of production, and monitor the well-being of the plant economizes the process industry.

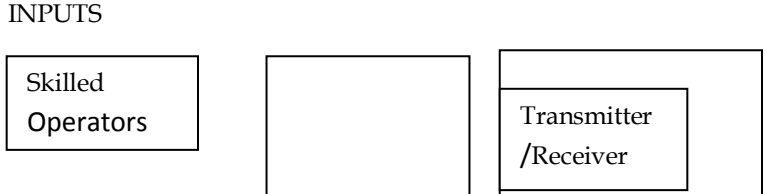
Control valves are mainly used in process industries to control process variables such as flow, pressure, temperature, and liquid level. For this, the output signal from sensor installed in the process is directed to a controller. Required value of the process variable can be set in the controller. Controller always compares the measured value and set value, and the variation is used to open the control valve fully or partially. The fully opening or closing of control valves is done by means of electrical, hydraulic or pneumatic control systems (Firoozshahi.et al., 2011);the control signals are 4-20mA signals for industry and 0-10V for "Smart" systems. Several works are reported in control valves. In one such work, the effect of friction in control valves is compared using different models (Garcia, 2008). Valve timing and valve lift control mechanism for engines are discussed in another work. In that, both the valve lift and valve timing were continuously controlled using electric motors (Nagaya, et al., 2006). Specification of control valve performance is very important in the process industries (Coughran, 1998) .The application of a valve-positioning controller for maximizing the process throughput to increase plant profitability was demonstrated in another work.(Jha and Kaistha, 2007).However, this reported works did not include ICT based remote control valve. Even though few ICT based remote control valve paper work was reported so far, some manufactures developed remote control valves for particular purposes. To greatly improve safety in the oil, gas and water industry and domestic environment, a valve controller is designed by Radin Radio Controls(designers of innovative safety products),whichcan be used to remotely open or close valves using a PC or mobile phone. The device using machine-to-machine (M2M) communications features with a switch, whichis powered by kinetic energy through the action of pressing the switch. Through this action a transmitter is activated, which sends a message to a receiver that sits on the solenoid valve controlling the flow of oil, gas or water, instructing it to open or close the valve.

The lack of implementation of ICT based remote control valve in the industries prompted the authors to propose a model named 'information control technology based remote control valve (ICTBRCV) in the present work. Plenty of small wireless control systems are available in industry. However, if we can control the process through ICT, it will be highly advantageous. Successful implementation of ICT based process control systems enables controlling a process in India from places as far as other continents. Adoption of such a technology can be a shot in the arm for modern industry.

Block diagram of ICT enabled control valve is shown in Figure 1. Checking with a Model is a promising approach for the verification of process control systems (Reinbacher, et al., 2011). Due to advancement in technologies, sensors are involved in almost industrial field (Aqeel-ur-Rehman, et al, 2011). Recent trends in industry are to use wireless sensors, which consists of a sensor node, a relay node, a network coordinator, and a wireless actuator (Somov, et al, 2011). Model essentially consists of a sensor, installed in the process for sensing the instantaneous values of process variable (PV). This value of process variable is send to a microcontroller placed in the local station through a process variable transmitter. A microcontroller (sometimes-abbreviatedμC) is a small computeron a single integratedcircuit containing a processor core, memory, and programmable input/output peripherals, which provides real time identification of the process (Prickett, et al, 2011). Microcontrollers make it economical to digitally control processes. Serial input/output such as serial ports are available in microcontrollers through which inputs and out puts can be transferred.

Process variable transmitter output is a 4-20 MA current signal, but μC accepts only digital voltage signals. A current to voltage converter is used to convert this signal into corresponding voltage form and an analogue to digital converter (ADC), integrated in the microcontroller, converts the signal into discrete form. An analogue to digital converter can access eight inputs and produce eight outputs through a single port. This signal is then processed and wirelessly transmitted to a computer placed in a far-off location. A transmitter receiver set is installed in the μC as well as in the remote computer for wireless transmission. Adaptive coded modulation schemes can be incorporatedin the wireless networked control system to improve the energy efficiency and data rate over the communication channel (Li yang, et al, 2011).

The receiver of remote computer receives the signal transmitted. Required value of process variable is set in the computer software. The computer always compares the instantaneous value with the required one and if there is any deviation between them a control action is send to the local station microcontroller through the transmitter. A prerequisite for transmitting the digital signal output of μC to control valve of physical variable is the incorporation of a digital to analogue converter in between μC and control valve. Number of digital to analogue converters (DAC) to be installed in the process is proportional to number of physical variables to be measured. Inputs of the model are amenities provided to the ICT based remote control system to get the optimum result and outputs will be the expected result of the proposed work.



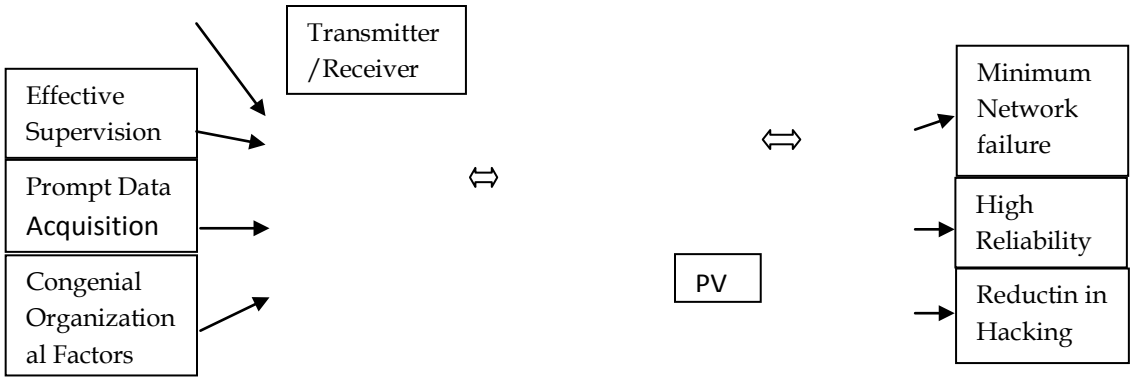


Figure 1

4. A HYPOTHETICAL CASE STUDY

An industry ABC is a major player in the oil field. It was decided to implement information and control technology based remote control(ICT BRC) in ABC. ABC has oil depots throughout India. The case area is a typical oil depot in a village. There are 3 sets of tanks – diesel, kerosene, and petrol. Oil is carried through the refinery and is stored in tanks and distributed to the local suppliers by tanks. While the oil reaches, it is collected through the tanker lorry delivery section. The tankers are filled at tanker lorry filling area.

Currently all the control valves are operated manually, which is risky and requires man power. Often, human errors may lead to malfunction of equipment and may critically affect the process parameters. The above-mentioned reasons led the industry to decide to switch over to ICTBRC from the contemporary control method. Instead of operating the valves manually, ICT based remote control operation is incorporated. A capacity level sensor is used to measure the level of fuel inside the fuel tank of tankers. Output signal from the level sensor is connected to a level transmitter and a voltage to current converter, to convert the voltage signal to current. Then this signal can be directly given to the micro controller. An analogue to digital converter is incorporated in the micro controller itself. All these instruments are available in each depot. Signal from the micro controller is transmitted to the remote computer placed in the control room of central station. Normally, fuel gauge indicator shows "fuel low" position prior to fuel filling. A hose is connected to the fuel storage tank in the depot to transfer the fuel to the tankers. The level sensor, placed inside the tanker identifies the fuel position. Subsequently, as per instructions from the remote computer, the fuel is transferred to the fuel tankers through the connected hoses. Required value of fuel to be filled in the tanker is usually a little less than full tank capacity. This required value is known as optimum value and this can be set in the controller placed in the control room. Therefore, when the fuel inside the tank reaches optimum value, this is sensed by the level sensor and is transmitted to the control room via micro controller. As soon as the signal reaches the controller in the remote computer, a control signal is sent by the remote computer to the micro controller to stop the fuel flow to the tanker. Even though an optimum value of fuel is set in the controller of remote computer, by using this method, operator in the control room can reset the required value to a lower one in the event of a scarcity of fuel.

ICT based remote control plays a prominent role in reducing manpower used in the industry, which in turn enhances both the profit of the organization and reliability of operation. Moreover, accuracy of operation can be increased.

The same is implemented in nearby depots as well. Therefore, by using this method, a central control room can control the amount of fuel filled in the tankers in different depots.

The procedure was achieved through a no: of steps as mentioned hereunder:

Step 1: A manger was assigned to the ICT BRCV, who delivers a seminar to the experts in the top managerial level of the company ABC, who then agree to implement ICT BRCV in the industry.

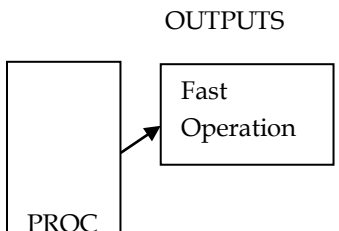
Rationale

Experts support and commitment are greatly indispensable for the successful implementation of ICT BRCV model. The main requisite of the above seminar is to persuade the top managerial level experts of the prospective value of implementing ICT BRCV and to achieve their obligation to and tenure of it.

Step 2:The ICT BRCV manger and top managerial experts of the company ABC endure brainstorming sessions on ICT BRCV implementation. At the final stage of these sessions, they decide to apply ICT BRCV at oil tanker lorry filling station.

Rationale

Top managerial experts are vigilant when embarking on any new program me. A convincing illustration of the merits of ICT BCRV by its manager to the top managerial experts will lure the latter to the models, which in turn will



lead to initiatives for the implementation of the model.
Step 3:An ICT BCRV team consisting of seven members is formed. The proposed membership is as follows:
Plant/installation manager
Information Security Responsible for the PCSS domain
Design Engineer
Technical Manager
Vendors and suppliers of PCSS/ICT systems and services
Operation Support Manager
Computer/Microprocessor operator.
Rationale
The knowledge of a single personality is consideredtoo narrow and self-seeking for acceptance in real-time environments (Pramod et al, 2006). To create more valuable decisions, a team endeavor is required (van der Wall and Lynn, 2002). The knowledge of several experts in the different departments of company ABC is inevitable for successful implementation of ICT BCRV
Step 4:A meeting of ICT BCRV team is planned by its manager to provide appropriate instructions to the members of the team.
Rationale
After the configuration of the ICT BCRV team, the experts in the top managerial level of the industry ABC shall support its successful functioning by providing the requisite resources. For this, they permitted ICT BCRV manager to conduct a meeting among them.
Step 5: ICT BCRV team conducts an awareness program me for both top managerial level experts and employees.
Rationale
Parts of the top managerial level experts and employees have a resistance to change to novel technique from the conventional method, because they are dubious with the merits of the new one. To convince them the features and merits of the innovative technique an awareness program me must be conducted.
Step 6: The ICT BRCV manger has continuous discussions with Information Security personnel, design engineers, technical manager, vendors and suppliers of PCSS/ICT systems and services and operation support manager and give instructions to them for the successful implementation of ICT BRCV system.
Rationale
Foremost thing to consider in the execution of ICT based systems is the safeguarding measures that should be taken for successful operation. A prerequisite to implement effective and efficient information security controls and measures is to have a clear understanding of the needs of each process control system and importance of the system in the process industry. Hence, discussion with Information Security personnel is inevitable. Design engineers design the new system as per the requirement of company ABC. Technical manager do the needful for successful implementation of ICT BRCV. Vendors and suppliers of PCSS/ICT systems supply the items according to the required specifications of the systems. Hence, discussion with all these experts is inevitable.
Step 7:The technical manager developed suitable software for the new technology.
Rationale
Controlling of the process can be done by means of the installed software in the ICT system. Hence, software development is a prerequisite for the successful implementation of ICT BRCV.
Step 8: A level sensor is located in the tanker lorry. It indicates the actual oil level in the tank. Oil level in the tank is the process variable (PV). Each local depot is installed with a micro controller for data acquisition and signal processing. The process variable is transmitted to the micro controller after converting it into a voltage signal. Processed data from the micro controller is serially transferred to the remote computer and vice-versa by wireless communication methods. This can be achieved by installing wireless transmitters and receivers in the local as well as remote stations.
Rationale
ICT based remote control plays a prominent role in reducing manpower used in the industry, which in turn enhances both the profit of the organization and reliability of operation. Moreover, accuracy of operation can be increased.
Step 9: The ICT BRCV team submits the results to the top managerial experts of company ABC.
Rationale
Top management commitment and support is essential for successful implementation of any methodology. Therefore, whatever the new methodology is implemented has to be properly convinced to the top management.

5. RESULTS

The implementation of this innovative system proved itself the right and opportune decision by being the catalyst that paved way to the following notable improvements:
Hacking has reduced to a remarkable extent (80%).
In internet services, hacking of data is a major problem. However, in an ICT control system separate networks are used for a particular requirement of the process. Only a few personnel are aware of the password. Several software programs are available for the quick cracking of passwords that are dictionary words and common names. Individual user security can be improved by using a randomized, mixed character-number password instead of an English word or common name. Installation of encryption software in sensitive communication net works will also reduce hacking.
A 70% decline in maintenance failure.
Enhancement in reliability to 85%.
Accessing of reliable security systems in communication networks enhances the reliability of process control systems.
Increase in operation speed to 80%.
The entire process has been rendered easier to control and monitor to a significant extent.

In short, ICT enabled control valve, being a wireless control systemconsumes only a lesser space and not concerned about distance between control room and process. By presenting ICT based control valves, production can be increased and the system can prove highly beneficial to industries. Controlling an industrial process from

geographical diverse location is a great process industrial development using ICT

6. CONCLUSION AND SCOPE FOR FUTURE RESEARCH

This paper outlines a brief description on ICT BRCV with a hypothetical case study to substantiate the model. Conventional methods used for controlling a physical variable in a process control system consists of a computer in the control room and instantaneous value of the physical variable is transmitted to the computer from then process location. According to the desired value of the physical variable, the computer can take control action. However,this is a wired system and is distance dependent. By replacing this system with ICT based system, process can be controlled even from farther locations. Disadvantages of wired systems such as larger space consumption and the distance constraint can be overcome. Reliability and speed of response can be increased. With the introduction of a highly secure system, hacking can be reduced to a notable extent when compared to Internet based process control systems. By introducing ICT based control valves, production can be increased and the system can prove highly beneficial to industries. In the present work, only one physical variable is considered and is controlled by a local micro controller and remote computer with the help of sensor, physical variable transmitter, V – I convertor, ADC, DAC, wireless receivers and transmitters. As a future scope, several physical variables can be controlled by using the same system by incorporating the same no: of DACs as physical variables. By incorporating more powerful wireless systems, a process in India can be controlled from other continents.

The following paragraphs explain how academicians and practitioners will find this research useful:

Academics: Laboratories in universities and educational institutions have miniature process plants with a view to provide industrial exposure to students. These are wired process control systems. By incorporating ICT into the process control system, it can be rendered wireless. This enables students, teachers, and research scholars appreciate the advantages of ICT enabled control systems over wired control systems. Moreover, they find themselves capable of implementing several processes in their respective educational institutions with their knowledge of ICT enabled systems.

Practitioners: The use of wired control systems places many limits on the controllability of industrial processes, which can be overcome with the implementation of ICT enabled process control systems. ICT enables centralized controlling of processes characterized by geographically diversity. Multiple processes can be controlled from a single control room. Processes controlled using ICT are much more reliable. Substantial enhancement is attained when it comes to process speed, leading, in turn, to higher production capacity. In aggregate, Information and Communication Technology brings about remarkable industrial development.

The control systems explored by this research can lend a helping hand to the society as well. ICT can facilitate implementation of a system whereby, a certain no: of units of electricity/ water can be purchased using a prepaid system; i.e., using prepaid cards. The requirement of the Electricity or Water Board to make periodic recordings of meter readings in order to issue bills to customers is done away with. Besides, the risk of theft/loss of electricity is eliminated since only the designated number of units of electricity/water for which prepayment has been done may be used.

In a similar way in the automatic control system for control valves, the topic of discussion here, ICT can make dramatic change not only in reliability of technology but can add to the economic benefits.

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