System Modeling the Lacunas of ICT Enabled Control Valve

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Abstract - ICT enablement is a well proven strategy to improve the competency of any system while operating in multifavour locations and instruments. From the dawn of industry suitable control valve of variable designs and functions are used to optimize the process control systems. It has been observed that the lacunas of ICT based control valve exhibit many inter relationships. ISM (Interpretive Structural Modeling) is a supreme tool to study the inter relationships. Hence in this paper ISM is deployed. At the outset inter relationships have been established among the elements of lacunas of ICT based control valve. Subsequently initial reach ability matix, final reach ability matix and diagraph were prepared and diagraph is converted to ISM.

Keywords: Control valve, Diagraph, ICT, ISM, Lacunas, Reach ability matrix, Wireless communication

INTRODUCTION

Off late, industries use some protocols to access data from a remotely located process wirelessly. Pertaining to this, many researches are done in internet based control systems. Wireless and Internet communications technologies are used for observing and controlling such systems (Thompson, 2004). The design methodologies for the local computer-based control system are not suitable for Internet-based control system, as they do not take into account the Internet environment issues such as Web-based delay, Web-based safety, Web-based interface, and uncertain users. The major challenge confronted by Internet based process control systems is dealing with Internet time delay, hacking and data loss. Several studies have been conducted all over the globe regarding this and the inference arrived at is that two compensators located in the feedback and feed forward paths in the architecture can efficiently deal with the Internet time delay and data loss, but the time delay and data loss in the feed forward channel prove to be more inhibitory influence on the control performance and is more difficult to be compensated for (Yang, et al, 2005). One of the advanced technologies that can be used for remote controlling of valves in the process industry is information control technology. Information and communication technology (ICT) emphasizes the role of telecommunications (telephone lines and wireless signals) in modern information technology. ICT consists of computer and network hardware as well as necessary software. In other words, ICT comprises IT as well as telephony, broadcast media, and all types of audio and video processing and transmission. In recent years, the ICT has proved a potent technology for distributed collaborative work. The promising 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) It enables remote monitoring and adjustment of plants (2) Facilitation of collaboration between skilled plant managers situated in geographically diverse locations, (3) Allowing the business to change the physical location of plant management staff easily in response to business needs. Nevertheless, very little research work has been done to date targeted at developing systematic design methods using this technology or for the design of ICT based process control systems.

ICT is a well established technology in the modern competitive industrial world. Many dimensions of anticipated benefits exist in the ICT technology adoption (Hollenstein, 2004).

For most processes, there are a variety of necessities for information. Senior managers require information to help with their new ideas. Middle management needs more detailed information to help them keep an eye on and control process activities. Workforce with operational roles needs information to help them carry out their duties. Consequently, industries tend to have several "information systems" in service at the same time. The aim of this paper is to analyze the possibility of implementing ICT based control valves in industry. Main objectives of this paper is to analyze the inter relationships between the weak points of ICT based control valves using Interpretive Structural Modeling (ISM) (Pramod and.Banwet D.K 2010).

2. ISM Methodology

ISM is an ideal one to assess the interrelationships among the elements and their degree of associations. Management research is nourished with a plethora of multifarious application of ISM (Thakkar et al, 2008). The ISM methodology is interpretive as it is churned from the synergic opinion of the group of experts. It is structural too, since on the basis of relationship, an overall structure is extracted from the complex set of variables (Mandal and Deshmukh, 1994; Warfield, 1974; Thakkar et al., 2005, 2007 and Faisal, et al, 2006). To work out the aims and objectives of this paper discussions are done with about 15 experts from industry possessing through knowledge and rich experience in the field and their suggestions about implementing ICT based control valves have been collected. The weak points of ICT based control valves from their opinions were inter related using ISM where ISM is a strong tool to determine the inter connections. For this initial reach ability matrix, final reach ability matrix and diagraph were made and diagraph is converted to ISM.

2.1. Lacunas of ICT based control valves

At the outset, by discussing with ten experts from industry having good knowledge in ICT and control valve, lacunas of ICT based control valves have been identified. These were further confirmed with three experts from Academia. Lacunas of ICT based control valves are1) Will take more time to make the common man understand 2) Accurate algorithm is needed. The programmer must take high degree of risk 3) Operating staff need training, 4) Initial investment is high. Competition from conventional methods of control 5) If control valve has error, then system failure occurs 6) Continuous control action is disturbed by noise, cross over distortion, mutual interference etc occurring in the transmission media 7) Industry gets more dependent on ICT

2.2. Formation of the Structural self interaction matrix (SSIM)

SSIM shows the direction of contextual relationships among the elements. The enablers are shown in column one and these enablers are arranged in reverse order in other columns. ISM commences with the preparation of a SSIM, which shows the direction of contextual relationships among the elements of strong points. In order to capture and represent the assessments in the table, four symbols were used V- enabler i leads to enabler j, A- enabler j leads to enabler i, X- enablers i and j leads to each other, O-enablers i and j are unrelated. SSIM thus developed is shown in Table 1

Table1. SSIM of the lacunas of ICT base control valve

Enablers.(i)	7 (j)	6.(j)	5 (j)	4(j)	3. (j) .	2 (j) ..	1(j)
1.	O	A	O	X	O	A	1
2	X	O	O	O	X	1	
3	A	O	O	O	1		
4	V	A	O	1			
5	V	O	1				
6	X	1					
7	1						

2.3. Initial reachability matrix (IRM)

In this step SSIM of above table has been converted into a matrix of binary elements named as IRM. For this following rules are used 1)If the (i,j) entry in the SSIM is V then substitute in the (i,j) entry in the reach ability matrix as 1 and (j,i) entry as 0.(2) If the (i,j) entry in the SSIM is A then substitute in the (i,j) entry in the reach ability matrix as 0 and (j,i) entry as 1.(3) If the (i,j) entry in the SSIM is X then substitute in the (i,j) entry in the reach ability matrix as 1 and (j,i) entry as 1.(4) If the (i,j) entry in the SSIM is O then substitute in the (i,j) entry in the reach ability matrix as 0 and (j,i) entry as 0. IRM thus developed is shown in Table 2.

Table 2 – IRM of ICT based control valve

Enablers	1`	2	3	4	5	6	7
1	1	0	0	1	0	0	0
2	1	1	1	0	0	0	1
3	0	1	1	0	0	0	0
4	1	0	0	1	0	0	1
5	0	0	0	0	1	0	1
6	1	0	0	1	0	1	1
7	0	1	0	0	0	1	1

2.4. Final reachability matrix (FRM)

Final reachability matrix accounts the transitivity to establish the relationship between various enablers. If a variable A leads to another variable B and if the variable B leads to a third variable C, as per the rule of transitivity A leads to C. It is shown in the table below. FRM thus developed is shown in

Table 3

Table 3 FRM of the lacunas of ICT based control valve

Enablers	1	2	3	4	5	6	7	Driving Power
1	1	0	0	1	0	0	1	3
2	1	1	1	0	0	1	1	5
3	1	1	1	0	0	0	1	4
4	1	0	0	1	0	0	1	3
5	0	0	0	0	1	0	1	2
6	1	0	0	1	0	1	1	4
7	1	1	1	1	0	1	1	6
dependence	6	3	3	4	1	3	7	

2.5. Level partitions.

From the final reach ability matrix, the reachability set and antecedent set of each enablers are located. Reach ability set and antecedent sets consist of a set of the elements itself and other elements. The variables, which are common in reach ability set and antecedent set, are allocated in the intersection set. This leads to locate the top level elements. The top level elements are removed from the set for the formation of the next table .Then the process is repeated till all levels of each element are found. These levels are utilized for the formation of diagraph. Levels are shown in Tables 4-6

Table 4 Iteration I

Enablers	Reach ability set	Antecedent set	Intersection set	Level
1	1,4,7	1,2,3,4,6,7	1,4,7	I
2	1,2,3,6,7	2,3,7	2,3,7	
3	1,2,3,7	2,3,7	2,3,7	
4	1,4,7	1,4,6,7	1,4,7	I
5	5,7	5	5	
6	1,4,6,7	1,6,7	1,6,7	
7	1,2,3,4,6,7	1,2,3,4,6,7	1,2,3,4,6,7	I

Table 5 Iteration II

Enablers	Reach ability	Antecedent set	Intersection set	Level

	set			
2	2,3,6	2,3	2,3	
3	2,3	2,3	2,3	II
5	5	5	5	II
6	6	6	6	II

Table 6 Iteration III

Enablers	Reachability	Antecedent set	Intersection set	Level
2	2	2	2	III

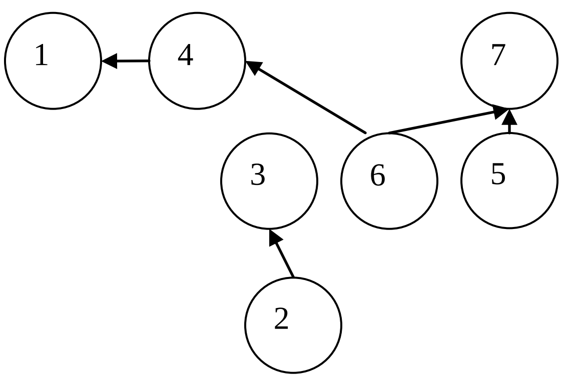


Figure 1 Diagraph of lacunas

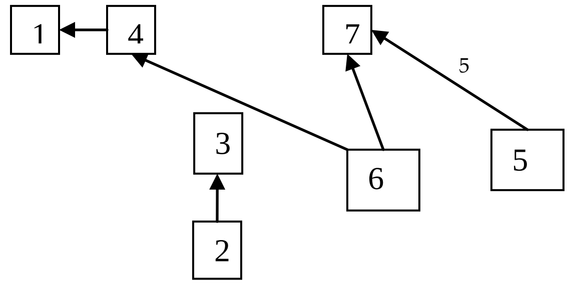
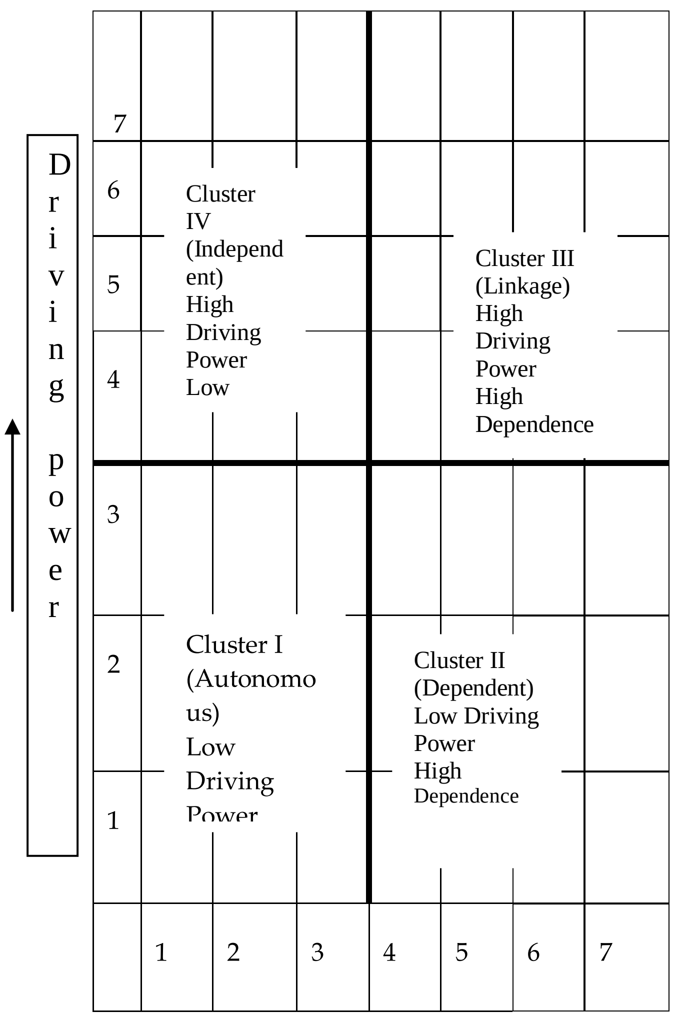


Figure 2 ISM of lacunas



Dependence

Figure 3. Driving power-dependence diagram for weakness of ICT enabled control valve

3.Results and Discussions

Continuous control action is disturbed by noise, cross over distortion, mutual interference etc occurring in the transmission media and if control valve has error, then system failure occurs are the main disadvantages. Initial investment of such a system is high. Another disadvantage is competition from conventional methods of control. Common man has a resistance to accept the new technology.

4. Conclusion and scope for future research

In order to study the behavior of a system it is an easier and commonly adopted practice to model it to a standard one. This gave rise to the formation of various models in engineering and management. Though these models generally have many limitations, the practical applicability and robustness of these models always supersedes. Thus models always fascinates the researchers with good outcomes. This paper illustrates the inter relationships between the weak points of ICT based control valves using Interpretive Structural Modeling (ISM).In the current study 7 weak points were identified and considered for analysis. The identification of these points and awareness of their driving power and dependence helps the experts in industry to focus on them and prioritize them as strategic issues. The analysis can further done for opportunities and threats of ICT based control valves which are under progress.

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