1	1	0	1	1	0	1	1	1	1	1	1	9
2	1	1	1	1	1	1	1	1	1	1	1	11
3	0	0	1	1	0	1	1	1	0	1	1	7
4	0	0	1	1	0	0	1	1	0	0	0	4
5	1	1	1	1	1	1	1	1	1	1	1	11
6	1	1	1	1	1	1	1	1	1	1	1	11
7	0	0	1	1	0	1	1	1	0	0	1	6
8	1	0	1	1	0	1	1	1	0	1	1	8
9	1	0	1	1	0	1	1	1	1	1	1	9
10	1	0	1	1	0	1	1	1	1	1	1	9
11	1	0	1	0	0	1	1	1	0	1	1	7
Dependence	**8**	**3**	**11**	**10**	**3**	**10**	**11**	**11**	**6**	**9**	**10**	

2.5 Level partition

From the final reachability matrix, the reachability and antecedents of each element of enablers are developed. Reachability set consists of a group of enablers itself and other enablers, which it may help to realize, whereas, the antecedent set consists of a group of enablers itself and other enablers, which may help achieving it. The enablers which are common in reachability sets and antecedent leads are assigned at the intersection set. The elements for which reachability and intersection sets are the same occupy the topmost level group (level I group). These top level elements are removed from the set for the formation of the next table. This process is repeated till all levels of each element are found. These levels are exploited for the formation of diagraph and the ISM model. These subsequent iterations are shown in tables 4 to 6.

Table 4. Iteration I

Enablers	Reach ability set	Antecedent set	Intersection set	Level
1	1,3,4,6,7,8,9,10,11	1,2,5,6,8,9,10,11	1,6,8,9,10,11	
2	1,2,3,4,5,6,7,8,9,10,11	2,5,6	2,5,6	
3	3,4,6,7,8,10,11	1,2,3,4,5,6,7,8,9,10,11	3,4,6,7,8,10,11	I
4	3,4,7,8	1,2,3,4,5,6,7,8,9,10	3,4,7,8	I
5	1,2,3,4,5,6,7,8,9,10,11	2,5,6	2,5,6	
6	1,2,3,4,5,6,7,8,9,10,11	1,2,3,5,6,7,8,9,10	1,2,3,5,6,7,8,9,10	
7	3,4,6,7,8,11	1,2,3,4,5,6,7,8,9,10,11	3,4,6,7,8,11	I
8	1,3,4,6,7,8,10,11	1,2,3,4,5,6,7,8,9,10,11	1,3,4,6,7,8,10,11	I
9	1,3,4,6,7,8,9,10,11	1,2,5,6,9,10	1,6,9,10	
10	1,3,4,,6,7,8,9,10,11	1,2,3,5,6,7,8,9,10,11	1,3,4,6,7,8,10,11	
11	1,3,6,7,8,10,11	1,2,3,5,6,7,8,9,10,11	1,3,6,7,8,10,11	I

Table 5.Iteration II

Enablers	Reach ability set	Antecedent set	Intersection set	Level
1	1,6,9,10	1,2,5,6,9,10	1,6,9,10	II
2	1,2,5,6,9,10	2,5,6	2,5,6	
5	1,2,5,6,9,10	2,5,6	2,5,6	
6	1,2,5,6,9,10	1,2,5,6,9,10	1,2,5,6,9,10	II
9	1,6,9,10	1,2,5,6,9,10	1,6,9,10	II
10	1,6,9,10	1,2,5,6,9,10	1,6,9,10	II

Table 6. Iteration III

Enablers	Reach ability set	Antecedent set	Intersection set	Level
2	2,5	2,5	2,5	III
5	2,5	2,5	2,5	III

2.6 Diagraph of ICT enabled wireless control system

Diagraph is the synonym for directed graph, which illustrates the relationship between the elements of enablers as per the numbers assigned to them. Relationship between elements j and i,can be represented by an arrow which points from i to j. Diagraph of the enablers is shown in Figure 1.

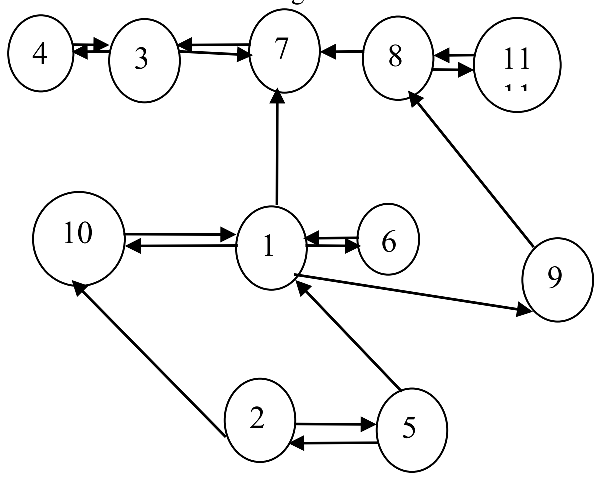

Figure 1 Diagraph of Enablers

2.7 Formation of ISMmodel of enablers of ICT enabled process control system

Diagraph simply represent the directions of relationships and does not give a wide – ranging picture of the context. It is further converted to ISM to get a complete depiction of the inter relationship among the elements of enablers. In the ISM elements of the enablers of the process control system are represented by the statements of elements itself instead of numbers. ISM of enablers of ICT enabled process control system is shown in Figure 2.

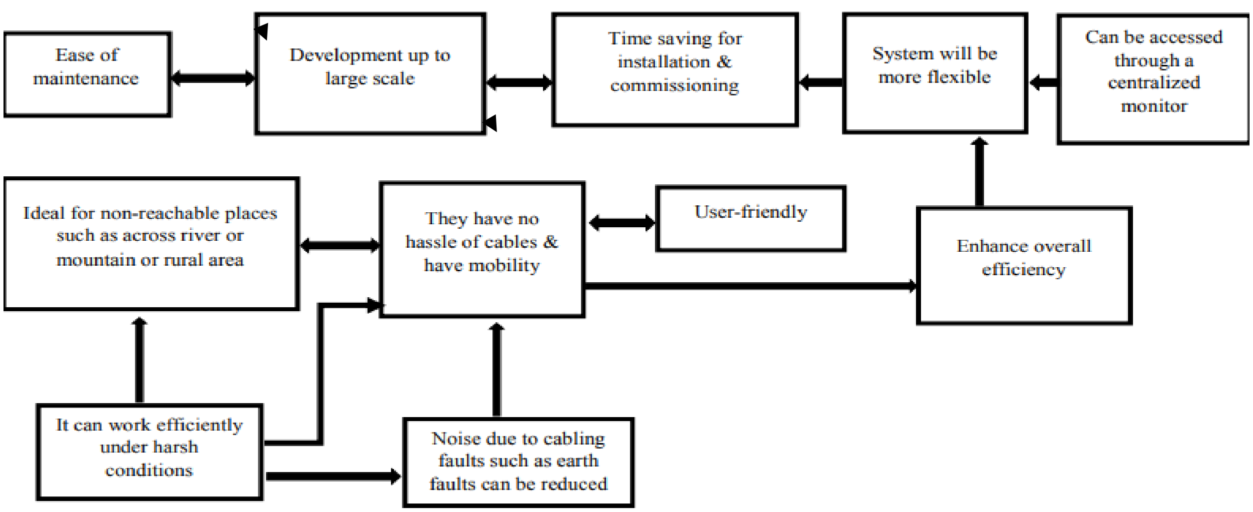

Figure 2.ISMofenablers

2.8 ISMMICMAC Analysis

Theintention of this exploration is to sort out the enablers according to their driving power and dependence (12). The driving power and dependence of each of these enablers are taken from Table 2. Based on that, initially a driver power-dependence diagram is developed as shown in Figure 3. Depending upon the driving power and dependence, enablers of ICT enabled wireless control system have been classified into four clusters. They are (i) autonomous (ii) dependent (iii) linkage and (iv)independent enablers [12].In Figure 3, driving power is marked in the vertical axis and dependence is marked in the horizontal axis. Enabler 1 is having driving power 9 and dependence 8. It is allocated in the appropriate position of (8, 9). Similarly, other enablers are also allocated.Autonomous group has low driving power and low dependence enablers and can be eliminated from the system. Dependent group has low driving power and high dependence enablers. Linkage group has high driving power and high dependence enablers. They are the most important enablers. Any action on this will affect the entire system. Independent group has high driving power and low dependence.

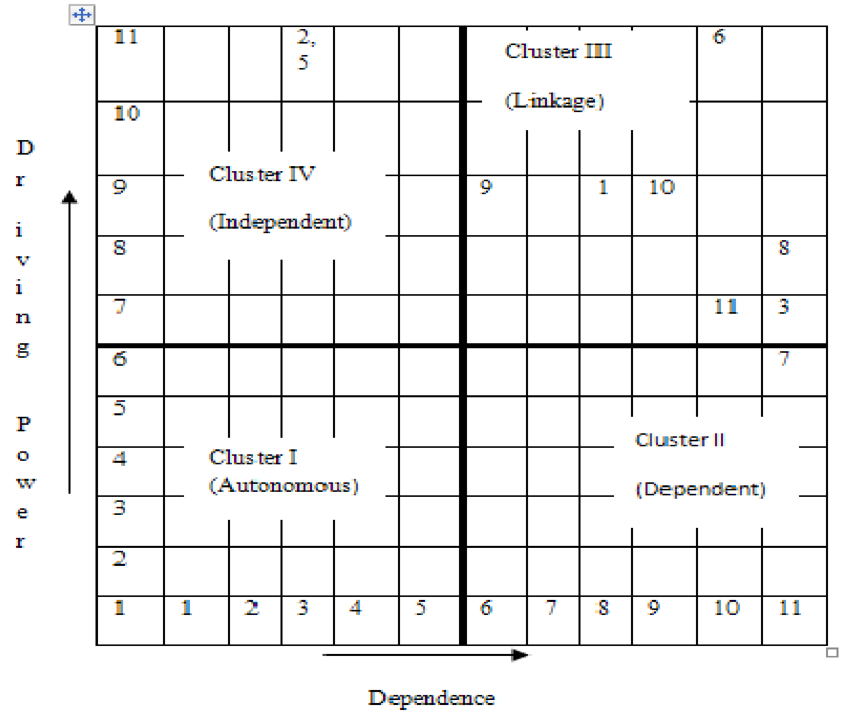

Figure 3.Driving Power Dependence Diagram

The row sum and the column sum of final reachability matrix are known as driving power and dependence power respectively and are represented as R1 &C1. Then final reachability matrix is multiplied to a power of 2. Here the row sum and column sum is taken as R2 & C2. The multiplication process is continued for powers 2,3,4,….etc till a stagnation is reached (the hierarchy of enablers are not changing). So the supremacy of transitivity can be minimized. In this analysis the stagnation has been achieved by raising the power of the matrix to 5. Each time row sum and column sum is calculated and tabulated. Row sums are represented by R1, R2, R3etc and column sum is represented by C1, C2, and C3.etc.Row sum and column sum of the power of matricesof enablers is shown in Table 7.

Table 7.(Row sum and column sum of the power of matrices)

Enablers	**R1**	**C1**	**R2**	**C2**	**R3**	**C3**	**R4**	**C4**	**R5**	**C5**
1	8	9	44	30	255	175	1461	1011	8363	5809
2	3	11	18	40	94	227	525	1296	2990	7418
3	11	7	48	66	279	394	1603	2281	9188	13101
4	10	4	57	33	335	187	1931	1069	11075	6122
5	3	11	14	66	76	394	431	2281	2465	13101
6	10	11	18	40	94	227	525	1296	2990	7418
7	11	6	59	12	350	58	2026	313	11640	1761

8	11	8	66	23	394	134	2281	773	13101	4436
9	6	9	56	23	328	121	1887	675	10820	3841
10	9	9	14	61	76	364	431	2106	2465	12090
11	10	7	57	82	445	642	3449	4976	13411	13156

A comparison is made between R1 R2, R2 R3 and so on until the rank of the driving power and dependence power remains the same, i.e. maximum to minimum value of the driving power remains the same for the sameenabler. Repeat the process for the dependence power.A matrix is said to be in stagnation when the driving power and the dependence power ranks remains the same for the same enablers even though matrix is multiplied to higher powers.Driving power and Dependence power ranks of enablers for stagnation matrix is shown in Table 8. When comparing R4 and R5, C4 andC5 the value remains the same.So the matrix is said to be in stagnation.For example enabler 1 is keeping 6th position in driving power for 4th power of Multiplication of the final reachability matrix and 5th power of multiplication of the final reachability matrix as shown in table8.For the same enabler the rank of dependence power is 3rd position for the 4th power of final reachability matrix. This position remains the same for further multiplication.(Table8). Stagnation of the final reachability matrix is obtained for a power of 4.. MATLAB function is used for matrix multiplication.

Table 8.Driving power and Dependence power ranks of enablers for stagnation matrix

Enablers	R4	R5	C4	C5
1	6	6	3	3
2	7	7	1	1
3	3	3	6	6
4	1	1	5	5
5	7	7	1	1
6	7	7	5	5
7	2	2	6	6
8	5	5	6	6
9	6	6	2	2
10	6	6	4	4
11	4	4	5	5

Based on this hierarchy, Matriced'ImpactCroises multiplicationAppliqueeaunclassment or Cross impact matrix-multiplication applied to classification (MICMAC) matrix has been made.(Figure 4). The MICMAC analysis helps to identify the key enablers, that is to say, those essential to the system's implementation. Comparison of the hierarchy of enablers in the various classifications is a rich source of information. It enables one not only to confirm the importance of certain variables but also to reveal that variables which, because of their indirect actions, play an important role (yet were not identifiable through direct classification) [16, 17].

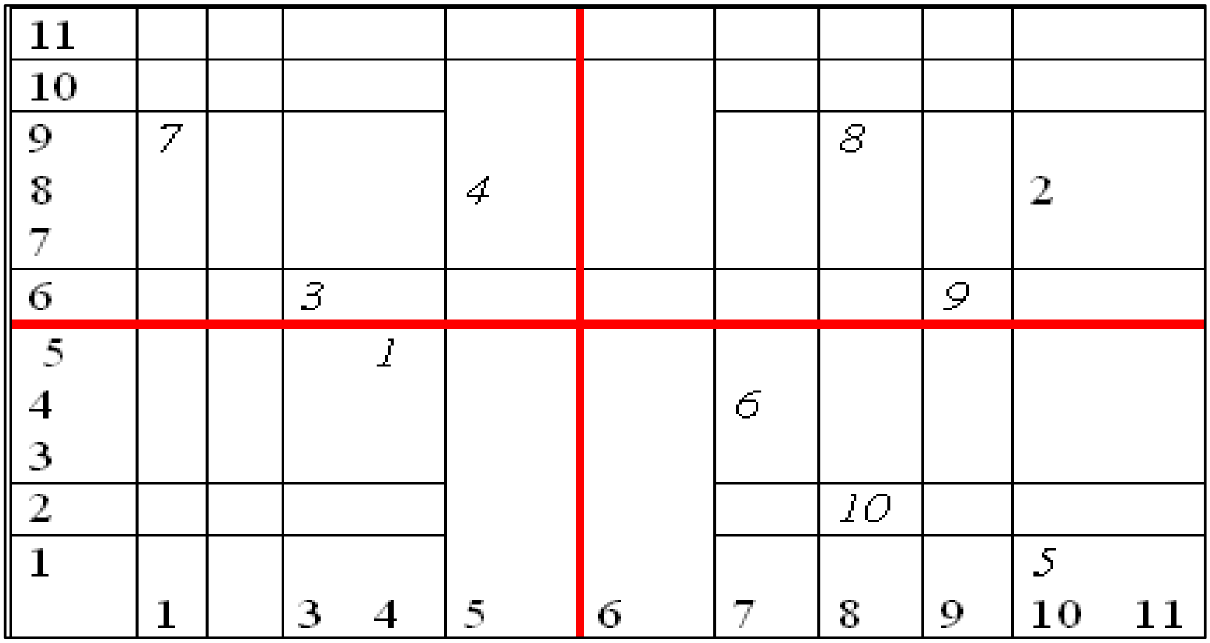

Figure 4. ISM MICMAC analysis

2.9Fuzzy ISM

It is an advanced ISM, which is based on the assumption that there exists variation in the interrelationships between the enablers in ISM [15]. In ISM binary numbers are used to assign values to the interrelationship between the enablers. No intermediate values can be assigned to the various correlations between the enablers. Analysis that is more precise can be made by assigning intermediate values [13]. This makes fuzzy logic a more natural approach to this kind of problems [18,19]. In this regard, by discussing with the experts the interrelationships among the enablers considering their fuzziness were finalized. They were requested to prioritize in the scale 0-1 (0= No relationship and 1=Good relationship). The average of the ripostes of 10 experts has been concluded in this regard. Using this method, the decision-makers fuzzy assignments with different rating viewpoints are considered in the aggregation procedure to ensure more accurate decision-making. The interrelationships established in this regard are shown in Table 9. This matrix has been multiplied several times to get the stagnation matrix. It is pictorially represented as fuzzy ISM in figure 5.Hierarchy of enablers based on driving power and dependence of variables while incorporating fuzziness is given in the table 10.Based on this a Fuzzy MICMAC matrix is developed as shown in the figure 6.

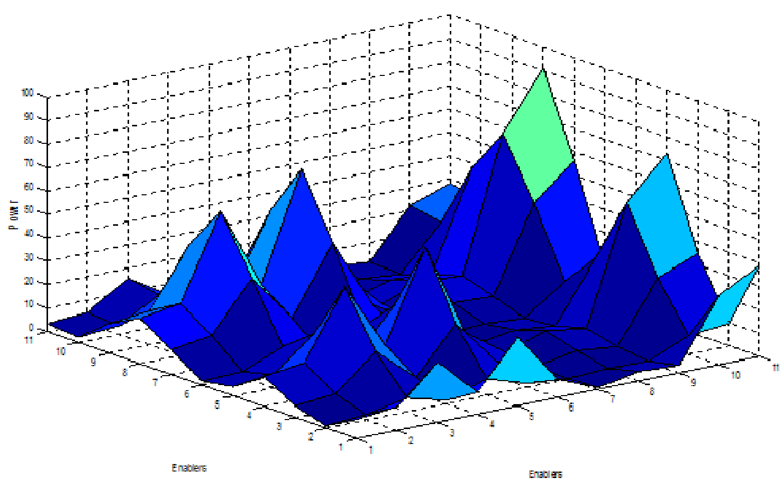

Figure 5. Fuzzy ISM

Table 9. Interrelationships between variables considering their fuzziness

Enablers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	1	.5	.6	.4	.1	.1	0	0	.1	0	.1
2	0	1	.2	0	.1	0	0	0	0	.1	.1
3	.1	.1	1	.1	.3	.1	0	.1	0	.7	.3
4	.5	.1	.3	1	1	.1	0	.1	.2	.3	1
5	0	0	.7	0	1	0	0	0	0	.1	1
6	0	0	.3	0	.2	1	0	0	0	.1	.2
7	0	.4	.2	.5	.3	.2	1	.1	.2	.3	.3
8	.4	.3	.4	.6	.4	.8	.4	1	.4	.1	.4
9	.6	.2	.3	.3	.6	.4	.1	0	1	.1	.6
10	0	0	.2	0	.5	0	0	0	0	1	.5
11	0	.1	0	.1	.3	.1	0	.1	0	.7	1

Table 10: Hierarchy of enablers based on driving power and dependence of variables while incorporating fuzziness

Enablers	Driving power	Dependence
1	5	4
2	8	10
3	6	3
4	10	3
5	1	10
6	5	6
7	9	1
8	1	5
9	6	9
10	2	3
11	4	8

11											
10			*4*								
9	*7*										
8										*2*	
7											
6			*3*						*9*		
5				*1*		*6*					
4								*11*			
3											
2			*10*								
1					*8*						*5*
	1	2	3	4	5	6	7	8	9	10	11

Figure 6. Fuzzy MICMAC Matrix

In the selected enablers1, 8 and 10 are coming under autonomous. Autonomous elements are very weak so it can even be eliminated from the system. The second cluster elements are 5, 6 and 11.They are having high dependent power and small driving power and are coming under dependent. The elements 2 and 9are coming under 3rd cluster (linkage). Elements in the linkage are key enablers. They are considered as very powerful enablers who can affect the system and should be handled carefully. Elements 3,4 and 7 are under 4th cluster- independent group. They have high driving power and low dependence power. They will also affect the system. In fuzzy MICMAC analysis a 'transition region' is also considered which is shown in blue color.

3. Results and Discussions

The proposed Fuzzy ISM model is an endeavor for identifying the key enablers that influence the implementation of ICT enabled wireless control system in process industries. An analysis of the driving power dependence diagram, ISM MICMAC and FUZZY MICMAC shows that FUZZY MICMAC is the precise method to identify the key enablers. After discussing with three industrial experts in the GM level and two experts from academia, an action plan has been formulated for enhancing the key enablers for the successive implementation of ICT enabled wireless control in industry.

Based on the fuzzy MICMAC, the following findings are reported:

1) The essential factors for the successful implementation of ICT enabled control system in process industries could be understood in advance.

2) Fuzzy MICMAC helps to identify the key enablers from the eleven enablers.

3) With the help of experts in industry and academia, by nourishing the identified enablers, ICT enabled wireless control system can be implemented in the industry.

4) Implementation of the ICT enabled wireless control system decreases the usage of several instruments in the process, thereby cutting down the costs and increases overall efficiency of the system.

As a future scope the research can be further extended by incorporating more enablers. Hypothesis testing and management modeling further catalyzes the relationships. Similar research is possible for inhibitors of ICT enabled process control system, which is under progress.

4. Conclusion

The fields of management are swarming with innumerable models and elicitations of experts. ISM is well proven to utilize the experts' knowledge and experience [14]. This research illustrates theinter - relationships between the enablers of ICT enabled wireless control system using ISM. Further, by the introduction of Fuzzy ISM more precise identification of the key enablers has been made. In this work, eleven enablers of ICT enabled wireless control system were identified and considered for analysis. The identification of the key enablers and awareness of their driving power and dependence from the Fuzzy MICMAC help the experts in industry to focus on them and prioritize them for successfully implementing ICT enabled wireless control systems. This study thus helps the industrialists to enhance the key enablers, which will be highly beneficial to the process industries.

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