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AUTOMATION OF CONTROL AND SAFETY SYSTEMS FOR CRUDE OIL EXTRACTION BY HYDRAULIC FRACTURE

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Abstract: The control and safety in oil depots or refineries plays a vital role in providing safety for working personnel and retains the accuracy in the control and maintenance of machines and minimizes the injuries of the work personnel due to hazardous risks occurred due to human errors or natural calamities etc,. However we can find the rapid development in the field of automation in few industries traditional methods are still followed to measure the operating temperature and pressure which causes life risks to the personnel at the site. In October 2009, the Jaipur oil depot broke out with fire at Indian oil Corporation (IOC). This incident occurred when petrol was being transferred from IOC to a pipeline which caused the explosion till 3 km from the accident site this caused a death of 12 and injuries over 200 [1]. To overcome this above mentioned issues, automation of control and safety systems known as Integrated Control and Safety Systems (ICSS) are being adapted in the industries to control and maintain the safety of the huge refineries or plants. This system is the integration of both Distributed Control System (DCS) and Safety Integrated System (SIS). DCS controls and apprehend the signals coming from the field to the Field Controller Station (FCS) which is connected to the Human Interface System (HIS) placed in the control room along with DCS, SIS, and FCS connected through a communication protocol called VNETIP. SIS monitors and maintains the hazardous activities which take place at the site through an indicating beep alarm or a hazard window on the HIS. HIS is been loaded with the P & ID graphics which mocks similar to that of the signals coming from the field, making the controlling personnel easy to locate the issues which occurs at the site. This design mainly focuses on the provision of the control and safety required for maintaining and monitoring the desired temperature and pressure for the hydrocarbon basin development of the oil hill reservoirs which requires a hydraulic fracture simulation for more effective commercial production thus; ICSS plays an important role in this process

Index Terms - Integrated Control and Safety Systems (ICSS), VNETIP, DCS, SIS, HIS, P&ID, FCS, Hydraulic Fracture Simulation

I. INTRODUCTION

The risk is an intolerable combination of the frequency of occurrence of problems which causes harm and also the grimness of that harm, gaining freedom from the risk is called as safety. In July 1988 Piper Alpha platform North Sea Scotland, the one of the most productive oil platform with 24 oil wells, 2 gas wells. Engulfed in fire due to the condensate oil pump tripped at the oil rig topside modules collapsed into the sea, 167 men died and many were injured. The world's biggest offshore disaster affected 10% of UK oil production and led to the financial losses of an estimated £ 2 billion [2]. To ensure the conductivity or ability of hydrocarbons to flow in the formation of the small pore size in the rock, hydraulic fracturing plays an important role and used in tight rock reservoir with minimal permeability. The goal of hydraulic fracturing in tight and rigid shale formations is to ensure a wellpad to produce the resource or to enhance the growth at which a wellpad is able to produce the resource. Hydraulic fracturing requires the wellpads which has low permeability and low pressure; this fracturing could be possible on the data based on the 3D seismic which is acquired and interpreted and acquisition of data during drilling of the wells. 3D seismic technology is the process which provides the detailed pieces of information about the geophysical fault distribution and subsurface structures, to build high resolution geological models of an area of interest in oil exploration. Hydraulic fracturing is a common technique used to simulate the production of oil, fractures or cracks that extend from the wellpad hole into the rock formations. This is accomplished by infusing a mixture of water high viscosity fluid additives, under extremely high pressure. The water pressure would then increase the strength of the rock, causing fractures to enlarge. After the fractures take place, an "propping agent" known as proppant is injected into the fractures to keep them from closing. This allows the hydrocarbon to move more efficiently from the rock to the well. A single well may require up to 15,000 m3 of water which may vary depending on the fracturing requirements [3] Here, the maintenance of the high pressure and low pressure during certain stages requires a better system as the excavation is too deep sending the personnel causes high risk and also finding out the minute leakage wouldn't be possible in that deep excavation, therefore, safety and controlling of the system is an independent task and leads to a predetermined safe state in case that process runs out of control. In such cases the proposed system, the automation of control & safety systems for crude oil extraction by hydraulic fracture. ICSSs are used to capture and control the signals which is been sent from the field and provide the signals to the field which is connected to the Human Machine Interface (HMI) placed in the control room via communication protocols called VNETIP. The SIS monitors hazardous risks. Thus helps in the required low and high pressure and temperature of the deep excavated wellpads of the hydrocarbon basin.

II. PROPOSED SYSTEM

To maintain the desired low/high pressure or temperature for the hydraulic fracturing simulation or to just maintain the operating pressure or temperature throughout the plant a traditional pressure gauge or temperature meter is used to take the reading as few industries or refineries assume that traditional methods provides the accurate and précised values, however this above method may create the hassle by maintain and acquiring the presided reading from the site also causes dangerous life hazards. The purpose of the proposed system is to enable the control patrol to control the hardware equipment at the plant site and to monitor the behaviour of the process variable with respect to time. The plant architecture is been interfaced along with the ICSSs with the help of transmitters for the simulation of the hydraulic fracture of the hydrocarbon basin. The standard signal range will vary from 4-20mA analog transmissions are used to replace the foundation field bus, a bidirectional digital communication protocol for field transmission of data is been initiated. These signals sent through the calibrator for the analog signals and digital bits using the P & ID control logics. Thus varying the signals, the signal face plate called on the HMI reads the input transmitted from the FCS to the ICSSs along with the P & ID control mode controls the process plant with the desired operating range.

III. SYSTEM REQUIREMENT ANALYSIS

The basic goal requirement phase is to produce the hardware and software requirements specifications, which describes the complete external behavior of the proposed system. Requirement analysis is done in order to understand the problem and software system is to solve. The emphasis in the requirement analysis is on identifying what is needed from the system and how the system will achieve its goal.

3.1. Hardware Requirements

3.1.1. DCS System Hardware

An integrated process and production control system which provides the functional blocks for controlling, monitoring, manipulating calculating the logical functions and the sequences of the industrial plant that is used in a wide range of fields. The hardware includes the basic design of the Automation Design (AD) suite provides an engineering environment to configure and maintain the overall control system [5]. The SENG and the AD server can be installed in a single computer. Fig.1.1 shows the configuration of the DCS hardware.

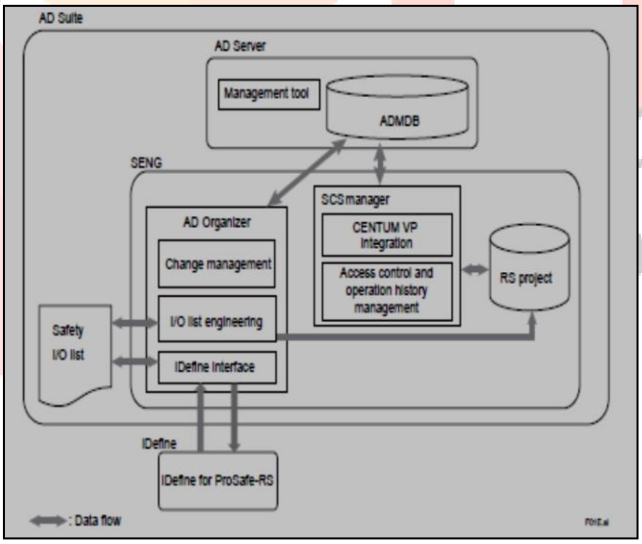

Fig.1.1: Configuration DCS system hardware [5]

3.1.2 Field Control Station (FCS)

FCS implements the control computational functions using each logical functional blocks and I/O functions using process and software I/O module signals. The Field control unit (FCU) is the core control part of an FCS; here we use AFV series, a duplexed FCU. FCS can communicate with the subsystems and field devices to exchange data through serial communication and Ethernet communications [5].

3.2Software Requirements

3.2.1. Human Interface Station (HIS)

HIS provides the human machine interface of the CENTUM VP system for controlling, operating and monitoring the process of hydraulic fracturing simulation of the crude oil wellpad, and it is a computer with the operation and monitoring function software package installed [5].

3.2.2. Vnet/IP communication (Control Network)

It is a dual redundant control network consisting of Bus 1 and Bus 2 for connecting CENTUM VP components with each other for process automation via Ethernet communication. It provides the real time communication with high reliability for plant operations [5]. The following fig. 1.2 shows the example of Vnet/IP network communication.

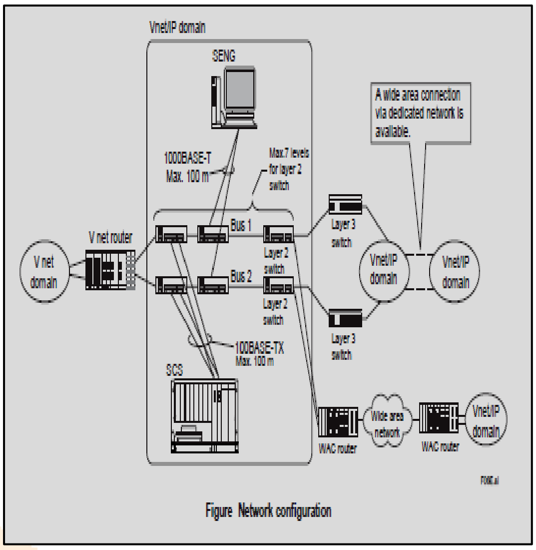

Fig.1.2: Vnet/IP Network Configuration [5]

3.2.3. Layer 2 Switches (L2SW)

L2SW is used for interfacing the communications between devices connected to the Vnet/IP network. The Vnet/IP system is connected by this switch referred to as Vnet/IP domain, with the communication speed of 1 Gbps [5].

3.2.4. Layer 3 Switches (L3SW)

L3SW is a 1 Gbps communication speed is required for the communications for the devices between the Vnet/IP domains. CNETUM VP engineering functions are required for multiple domain configuration.

IV. SYSTEM IMPLEMENTATION

Implementations are the realizations of the applications, or execution of a plan, idea, model, design, specifications, standards, algorithms or policy.

4.1. Designing of System Configuration

The fig. 1.3 shows the schematic representation of the system configuration, used to define the interconnection between the control systems, communication protocol, and network accessories. Each block has its own specific requirements for the components. The primary element which is considered while designing the system configuration is switch. The switches define the source and destination of signals which is connected via L2SW and provides the communication between the field signals and the controller station.

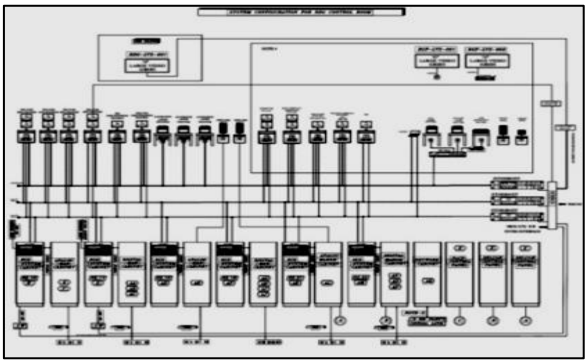

Fig. 1.3: Schematic representation of System Configuration

4.2. Designing of ICSS

An ICSS is designed based on the requirement as per site signals. The cabinets will be of different sizes and varies according to the number of signals coming from the site. The cabinets will be of different sizes and varies according t the number of signals coming from the field/site IO requirement. The fig.1.4 shows the schematic layout internal arrangement of the 1200 width marshalling cabinet. This design is generated using Auto CAD software. Thus the marshalling cabinet consists of Power supply unit, connector's network accessories, and surge protection etc, required for maintaining of the signal strength which will be the incoming signals to these cabinets.

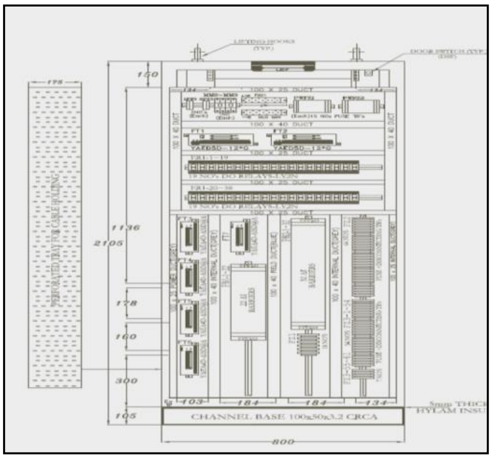

Fig. 1.4: Internal Arrangement of marshalling cabinet

4.3. Nest Loading & Front loading and IO allocation

Front loading is the arrangement of I/O modules in the nodes and Nest loading gives the complete details about the type of the signals, service description, range and the Field tags. Nest loading describes the complete segregation of the IO's coming from the field/site. The fig.1.5 shows the done in accordance with the "Functional Schematics", results in effective Nest Loading.

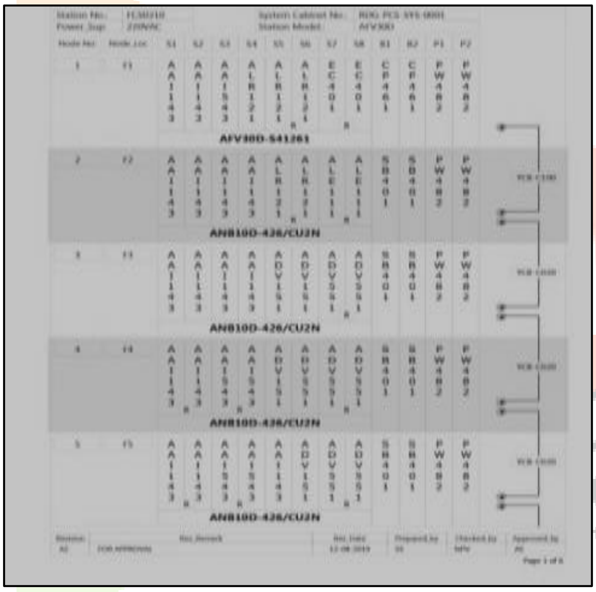

Fig. 1.5 (a): Front Loading and Nest loading

Station No:	FCS0551	Node_Model_No:	AFV30D-S41251	Node No.:	1	F1	Pre-fab Cable.: KS1
IO_Module Model:	AAI143-H53/K4A00	Terminal Board:	YAEA4D	Slot No.:	1		Board_Location: FT1

DCSTag	IO_Type	Range	JB_Number	JB_Term	Channel	Barrier_details	Relay_details	MR_Cabinet	Elco_Term	MR_Term
AWP01-TIT-2100	AI_FLD	0 - 125	AWP01-JB-PCS-A-0203	3	FCS0551N01S1			AWP03-PCS-MPA-001	1A	RZ5-3
				4					1B	RZ5-4
	2 WIRE	°C		#Error	Ch: 1	-0			1	
AWP01-TIT-2119	AI_FLD	0 - 125	AWP01-JB-PCS-A-0203	7	FCS0551N01S1			AWP03-PCS-MPA-001	2A	RZ5-7
				8					2B	RZ5-8
	2 WIRE	°C		#Error	Ch: 2	-0			2	
AWP01-PT-4011	AI_FLD	0 - 700	AWP01-JB-PCS-A-0203	9	FCS0551N01S1			AWP03-PCS-MPA-001	3A	RZ5-9
				10					3B	RZ5-10
	2 WIRE	Kpag		#Error	Ch: 3	-0			3	
AWP01-XS-2110P	AI_FLD	- - -	AWP01-JB-PCS-A-0204	9	FCS0551N01S1			AWP03-PCS-MPA-001	4A	RZ6-9
				10					4B	RZ6-10
	2 WIRE	-		#Error	Ch: 4	-0			4	
AWP01-XS-2120P	AI_FLD	- - -	AWP01-JB-PCS-A-0204	11	FCS0551N01S1			AWP03-PCS-MPA-001	5A	RZ6-11
				12					5B	RZ6-12
	2 WIRE	-		#Error	Ch: 5	-0			5	
AWP01-PT-2112	AI_FLD	0 - 800	AWP01-JB-PCS-A-0202	1	FCS0551N01S1			AWP03-PCS-MPA-001	6A	RZ4-1
				2					6B	RZ4-2
	2 WIRE	Kpag		#Error	Ch: 6	-0			6	
AWP01-PT-2113	AI_FLD	0 - 800	AWP01-JB-PCS-A-0202	3	FCS0551N01S1			AWP03-PCS-MPA-001	7A	RZ4-3
				4					7B	RZ4-4
	2 WIRE	Kpag		#Error	Ch: 7	-0			7	
AWP01-FIT-2110	AI_FLD	0 - 25	AWP01-JB-PCS-A-0202	5	FCS0551N01S1			AWP03-PCS-MPA-001	8A	RZ4-5
				6					8B	RZ4-6
	2 WIRE	Kpa		#Error	Ch: 8	-0			8	

Fig. 1.5(b): IO Allocation

V. EXPERIMENTAL RESULTS

5.1. Factory Acceptance Test (FAT)

The Factory Acceptance Test (FAT) includes the redundancy checks such as hardware check, visual checks on designed cabinets, hardware components and functional tests in accordance with the programs. For Analog input 4-20mA shall be sent with the help of calibrator across the rack terminals. The calibrator is used in FAT is only for the testing purpose, in actual the signals will be connected from the field/site. The value of the input on the Face plate shall be noted in the range of 0-100% For Analog outputs tag value shall be forced from the face plate. The current is measured using a calibrator. For testing Digital Input/output loops, the signal will be simulated from the marshalling terminals & the status change is observed in face plate for inputs and for Output loops, the tag shall be forced from the faceplate and the voltage/Continuity across the marshalling terminals shall be checked by using the Multi-meter. Fig.1.6 shows the tests conducted during FAT

Fig. 1.6(a): Testing Analog input sent through calibrator

Fig. 1.6(b): The value obtained on the face plate

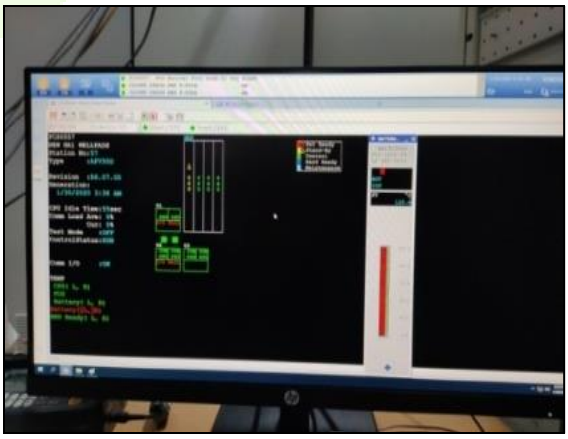

Fig. 1.6(c): PSU redundancy check

VI. CONCLUSION

Entire industrial plant can be made automatic without the intervention of the workforce however keeping its safety and maintenance into mind need of workforce will become a major necessity as few industries still follow the traditional methods to maintain the pressure and temperature required during the formation of the hydraulic fractures. Thus, in this paper we came across the procedure for providing the safety from the hazardous risks for the workforce panel and to the overall plant which occurs due to human errors or natural calamities there might be the chances of the life risk hazards. Hence, few MAC after a several field survey they introduced an integrated control and safety system which helps us to online monitor and control the overall plant. The signals are sent across the FCS from respective transmitters/ Junction box station/Limit switches/Valves and then those signals are indicated on the HIS with the help of the P & ID control functional blocks interfaced via VNET/IP communication protocol throughout the system architecture.

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