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Autoclave Automation Using PLC & SCADA

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ABSTRACT-
Automation generally refers to the science and technology of process control and includesthe control of chemical and petrochemical plants, Oil refineries, iron and steel plant, Power plants,cement mills, Paper pulp and paper mills water and waste water treatment plants and many like allthis. The basic objective of automation is identifying the information flow and manipulates thematerial and energy flow as given process in a desired way. PLC & SCADA plays an important roleinautomatingindustrial system.
This work shows how automation is carried & implemented with software interface, PLC &Micro-SCADA in C.G. Ltd. Nashik, Maharashtra, India for CVT autoclave. The whole process is of121 hrs consisting of number of cycles, which is automated using PLC & SCADA for all processparameters.

KeyWords:-PLC,SCADA,Automation,CaseStudy-AutoclaveAutomation.

INTRODUCTION

PLC:-(PROGRAMMABLELOGICCONTROLLERS)
Automation of many different processes, such ascontrolling machines or factory assembly lines, is donethroughtheuseofsmallcomputerscalledas**Programmable Logic Controller (PLC).** This is actually acontroldevicethatconsistsofaprogrammablemicroprocessor, and is programmed using a specializedcomputer language.
Today, programmable logic controllers deliver awide range of functionality, including basic relay control,motion control, process control, and complex networking,as well as being used in Supervisory Control and DataAcquisitionSystemsandDistributedControlSystems.

1. PLCPROGRAMMING

Previously programmable logos controller wereprogrammedinladderlogic,whichissimilartoaschematicofrelaylogic.Modernprogrammablelogiccontroller is usually programmed in any one of severallanguages,rangingfromladderlogictoBasicorC.Typicallytheprogramiswritteninadevelopmentenvironment onapersonalcomputer,andthenisdownloadedontotheprogrammablelogiccontrollerdirectlythrougha cableconnection.
Recently, the International standard IEC 61131-3hasbecomepopularcurrentlydefines5programminglanguages for programmablecontrolsystems:
FBD (Function Block Diagram),LD(Ladder Diagram),
ST (Structured Text, Pascal type lang.)IL(InstructionList)
SFC(Sequentialfunctionchart)

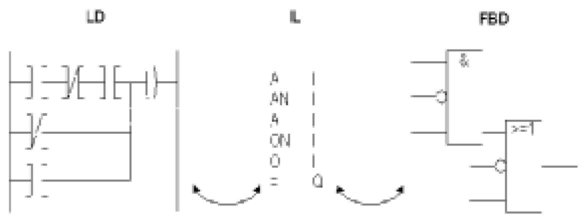


Fig No. 1PLCblockDiagram

PLCOperation&WorkingPrinciple
APLCworksbycontinuallyscanningaprogram. The scan cycle consists of three important steps.There are typically more than three but we focus on theimportantparts.

- Check Input Status: First the PLC takes a look at eachinput to determine if it is on or off. In other words, isthesensorconnectedtothefirstinputon?Howabout the second input? And so on it checks all theconnectedinputs.Itrecordsthisdataintoitsmemoryto beuseddduringthenextstep.
- ExecuteProgram:NextthePLCexecutesyourprogram, oneinstructionata time.
- Update output Status:Finally the PLC updates thestatus of the outputs based on which inputs were onduring the first step and the results of executing yourprogramduringthesecond step.

PLCSelection
SomeoftheKeyfactors fortheselectionofPLC

- NumberofI/Orequired
- Expandability
- Cost
- Serviceability/Support
- Flexibility

OrderingSpecifications
Power Supply: AC/DC, 220V AC/24 V DC.Configuration:TotalInputandOutputDetails- Digitaland Analog.

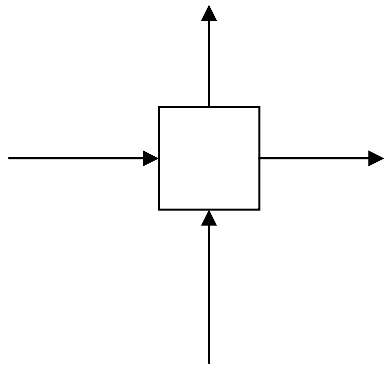
UserInterface
PLC's may need to interact with people for thepurposeofconfiguration,alarmreportingoreverydaycontrol. A Human- Machine interface (HMI) is employedfor this purpose. A simple system may use buttons andlights to interact with the user. Text displays are availableaswell asgraphical touchscreens.Mostmodern PLCscan communicate over a network to some other system,suchasa computer running SCADAsystem.

2. S.C.A.D.A
3.1S.C.A.D.A-(SUPERVISORYCONTROLANDDATAACQUISITION)canmeanmanythingstomany

etc.Asincomingdatachangesthescreenisupdated.Figure shows the examples of inputs from the MTU andfield devices.

RemoteTerminalUnit
Remote terminal units gather information fromtheir remote site from various input devices, like valves,pumps, alarms, sensors, meters, etc. Essentially, data iseitheranalog(realnumbers),digital(on/off),orpulsedata(e.g., counting revolutions of meters). Many remoteterminalunitsholdtheinformationgatheredintheirmemory and wait for a request from the MTU to transmitthe data. Other more sophisticated remote terminal unitshave microcomputers and PLC that perform direct controlover a remote site without the direction of the MTU. TheRTU central processing unit receives a binary data streamin accordance with the communication protocol. Protocolscanbeopen,likeTransmissionControlProtocolandInternet Protocol (TCP/IP) or proprietary.Figure showsanexampleofoutputsoftheRTUtoMTUandfield

people. The acquisition of data, the processing of thosedataforusebytheoperator,andoperatorcontrolofremote devices are the fundamental building blocks uponwhich all modern utility control systems are based. Thesystemtoaccomplishthesefunctionsisknownas SCADA system. As the name indicates, it is not a fullcontrolsystem,butratherfocusesonthesupervisorylevel.Assuch, it is a purely software package that ispositioned on top of hardware to which it is interfaced, ingeneralviaProgrammableLogicControllers,orothercommercialhardwaremodules.
devices.



Inputs fromMTU

- DiscreteControlorder
- AnalogsettingInstructions
- SteppingMotorPulses
- Orderstoresponse

Inputsfromfielddevices

- FieldAnalogSignal
- AlaramswitchSignal

RTU

Outputtofield devices

- Contact1Closureor0-24Vcontrols
- Analogcontrol
- PulseTrainsteppingMotorControl
- SerialMessagetofieldEquipment

OutputtoMTU

- FieldAnalogSignal
- Alarms
- Equipmentstatus
- TotaledMetersignals

BasicSCADAElements

Therearefourmajorelementstoa SCADAsystem,masterterminalunit(MTU),communications,andremoteterminalunit(RTU).Theoperatorexercises

- Equipmentstatussignal
- PulseMeterSignal
- SerialMessagefromfield
- EquipmentMessage

control through information that is depicted on a videodisplay unit (VDU). Input to the system normally initiatesfrom the operator via the master terminal unit's keyboard.The MTU monitors information from remote sites anddisplaysinformationfortheoperator.Therelationshipbetween MTU and RTU is analogous to master and slave.SCADA systems are capable of communicating using awide variety of media such as fiber optics, dial-up, ordedicated voicegradetelephonelines, or radio.

MasterTerminalUnit

At the heart of the system is the master terminalunit(MTU).Themasterterminalunitinitiatesallcommunications, gathers data, stores information, sendsinformationtoothersystems,andinterfaceswithoperators. The major difference between the MTU andRTUisthattheMTUinitiatesvirtuallyallcommunications by its programming and people. Almostall communication is initiated by theMTU. The MTUalso communicates with other peripheral devices in thefacilitylikemonitors,printersorotherinformationsystems.Theprimaryinterfacetotheoperatoristhemonitorthatportraysarepresentationofvalves,pumps,

Fig.No.2:-Inputs&OutputsforRTU

The data acquisition part of SCADA is gettingmorePC-Basedthanstand-alonehardware.Manyoftoday'sRTUiseitheraPersonalComputeroraProgrammableLogic Controller (PLC)

WhySCADASystem& Functions
Somebasicneedsarelistedbelow

- Save Time: The time taken to travel remote sites togather information or issue controls, to sift throughmanually entered data, write out a report or performany of the functions that a SCADA system does as amatterofcourseisconsiderable.Timesavingbenefitsgofarbeyondthemanhourssaved-timelinessofalarms,actions,controlhavehighmonetaryvalue aswell.
- Avoid Trouble: A SCADA system's primary purposeis to give advance warning of trouble. Hence actioncan be taken before it swallows thewholesystemand createsproblem.

- AchieveSystemwideProcesses:

SCADA systems afford the user an opportunity tomonitor and control processes that take place over awidegeographicalarea.e.g.,A sewagetreatmentplantorenergymanagementsystem.Theseapplicationscancauseconsiderablefinancialsavings in running cost and capital cost which canpayforthecost of SCADA in itself.

- SaveManpower:BeforeSCADAsystemswereimplemented; remote sites such as substations andpumping stations were either manned or inspectedfrequently.Theneedforthiswaseliminatedorgreatly reduced by the implementation of wide areaSCADA.This was the primary economic driver forSCADAsystemimplementationinthefirstgreatwave of comprehensive systems in the 1970's and1980's.

Fig.No.4:-GraphicalScreenOfProcess

SCADAFunctions

- **Access Control: -** Users are allocated to groups,which have defined read/write access privileges tothe process parameters in the system and often alsoto specificproduct functionality.
- **MMI:-**Theproductssupportmultiplescreens,whichcan contain combinations of synoptic diagrams andtext. They also support the concept of a "generic"graphical object with links to process variables.These objects can be "dragged and dropped" from alibraryand included intoasynopticdiagram.

MostoftheSCADAproductsthatwereevaluateddecomposetheprocessin"atomic"parameters(e.g.apowersupplycurrent,itsmaximumvalue,itson/offstatus, etc.) to which a Tag-name is associated. The Tag-namesusedtolinkgraphicalobjectstodevicescanbe editedasrequired.Theproductsincludealibraryofstandardgraphicalsymbols,manyofwhichwouldhowevernotbeapplicabletothetypeofapplicationsencounteredintheexperimentalphysicscommunity.

Standardwindowseditingfacilitiesareprovided:zooming, re-sizing, scrolling... On-line configuration andcustomization of the MMI is possible for users with theappropriateprivileges.Linkscanbecreatedbetweendisplaypagesto navigatefromoneviewto another.

- **Trending:-**

Theproductsallprovidetrendingfacilitiesandonecansummarizethecommoncapabilitiesasfollows:

- The parameters to be trended in a specific chartcanbepredefined or definedon-line
- Achartmaycontainmorethan8trendedparameters or pens and an unlimited number ofcharts can be displayed (restricted only by thereadability)
- Real-timeandhistoricaltrendingarepossible,althoughgenerallynotinthesamechart
- Historical trending is possible for any archivedparameter
- Zoomingandscrollingfunctionsareprovided
- Parameter values at the cursor position can bedisplayed

Thetrendingfeatureiseitherprovidedasaseparatemodule or as a graphical object (ActiveX), which can thenbeembeddedintoasynopticdisplay.XYandotherstatisticalanalysisplotsaregenerallynotprovided.

- **Alarm Handling :-**Alarm handling is based on limitand status checking and performed in the data servers.More complicated expressions (using arithmetic or logicalexpressions)canbedevelopedbycreatingderivedparametersonwhichstatusorlimitcheckingisthenperformed. Thealarmsarelogicallyhandledcentrally,i.e., the information only exists in one place and all usersseethesamestatus(e.g.,theacknowledgement),andmultiple alarm priority levels (in general many more than3 suchlevels)are supported.

It isgenerally possible togroup alarmsand tohandletheseasanentity(typicallyfilteringongrouporacknowledgement of all alarms in a group). Furthermore,it is possible to suppress alarms either individually or as acomplete group. The filtering of alarms seen on the alarmpage or when viewing the alarm log is also possible atleast on priority, time and group. However, relationshipsbetweenalarmscannotgenerallybedefinedinastraightforwardmanner.E-mailscanbegeneratedorpredefinedactionsautomaticallyexecutedinresponsetoalarmconditions.

- **Logging/Archiving**:-Thetermsloggingandarchiving areoftenusedtodescribethesamefacility.However,loggingcanbethoughtofasmedium-termstorage of data on disk, whereas archiving is long-termstorage of data either on disk or on another permanentstoragemedium.Loggingistypicallyperformedonacyclic basis, i.e., once a certain file size, time period ornumberofpointsisreachedthedataisoverwritten.Logging of data can be performed at a set frequency, oronlyinitiatedifthevaluechangesorwhenaspecificpredefined event occurs.Logged data can be transferredto an archive once the log is full. The logged data is time-stamped and can be filtered when viewed by a user. Thelogging of user actions is in general performed togetherwith either a user ID or station ID. There is often also aVCR facilitytoplaybackarchiveddata.
- **Report Generation**: - One can produce reports usingSQL type queries to the archive, RTDB or logs. Althoughit is sometimes possible to embed EXCEL charts in thereport,a"cutandpaste"capabilityisingeneralnotprovided.Facilitiesexisttobeabletoautomaticallygenerate, print and archive reports.
- **Automation**: - Themajority of the products allowactionstobeautomaticallytriggeredbyevents.AscriptinglanguageprovidedbytheSCADAproductsallowsthese actionstobedefined.Ingeneral,onecanload a particular display, send an Email, and run a userdefined application or script and write to the RTDB. Theconceptofrecipesissupported,wherebyaparticularsystem configuration can be saved to a file and then re-loaded at a laterdate.

Sequencingisalsosupportedwhereby,asthename indicates, it is possible to execute a more complexsequence of actions on one or more devices. Sequencesmayalsoreacttoexternal events.

3. CONNECTIONS & PROTOCOLS

As mentioned earlier that PLC is used frequentlyin a SCADA system as the RTU. We need to throw somelightonthecommunicationbetweentheSCADAComputer and the PLC, There are several different typesofconnectionsbetweentheSCADAcomputersandPLCs.Forexample,RS232,RS422,RS485,andEthernet.Notethattheseareonlytheelectrical**connection** and do not specify the **protocol** or languageused on the connection. We can call this as the Hardwareprotocol.Each PLC manufacturer has their own protocolor language that the PLC speaks.For example, Allen-Bradley (Rockwell) PLCs talk DF1, Data Highway 485(DH485),DataHighway(DH),DataHighway+(DH+), RemoteI/O(RIO),Devicenet,Controlnet,andafewothers.Talk about an identity complex!Modicon PLCsspeak Modbus, Modbus Plus, and now Modbus TCP/IP(Modbus over Ethernet).Automation Direct PLCs speakDirected and K-sequence protocols while some of theirPLCs stillcommunicateusing theiroldprotocols.TheoldGEPLCprotocolwasCCMbuttheynowuseSNPand variants such as SNPX.Siemens PLCs work mainlywith the Profibus protocol which is considered more of anopen, rather thanproprietary,protocol.

The most common "standard" protocols we seeare DF1, Modbus, and Profibus.DF1 and Modbus arepopular since they have been around longer than many ofthepeopleusing them.Profibus is popularbecause,inourhumbleopinion,combinesthebestofsimplicity(daisy chain, twisted pair), industrial ruggedness (RS485),speed(12MBaud),adaptability(youcanselectfrommanydifferentspeeds),scalability(fromsimpleCOMport uptocommunicationscontrollers),andfunction(mostautomation devicescan talk Profibus).Typicallyall PLC manufacturers will have a PLC module that willtalkthese protocols.

Now that Ethernet is becoming the "most hyped"capability in automation there are several protocols overEthernet.But remember -- just because an Allen-Bradleyand a Siemens PLCs are both put on the same Ethernetcable -- they cannot talk to each other because they do notusethe same protocol.

4.1SCADACONFIGURATION

ConfigurationinSCADAshouldbedonesequentiallyonly.Thisishaving followingsequence.

1. ProtocolConfiguration
2. PortConfiguration.
3. DeviceConfiguration
4. TagConfiguration
5. RoleConfiguration

4.2APPLICATIONOFSCADA

- ElectricUtility
- Water/WasteWaterUtilities
- Oil&GasTransmission&Distribution
- CommunicationNetworks
- IndustrialProcessControl
- Etc.

5. CASESYUDY–AUTOCLAVEAUTOMATIONCompany:-CromptonGreavesLtd. , Nashik
Address:-G.G.Ltd.Ambad,Nashik,Maharastra,India-422004,
Contact No.:- Mr. Shirode M.M. (+91-09422270801)Products:-C.B.s,RELAYS,CT'S,PT'S,CVT's
ProcessOfStudy&Design:-AutoclaveAutomstion

A case study of "AUTOCLAVE AUTOMATION"at Crompton Greaves, Nasik is considered. Demand forCapacitiveVoltageTransformer(CVT)hasrisenfrompastfewyears,becauseoffeaturessuchasmetering,protection & Carrier communication all being present inone single product, also it is reparable in case of failure.Considering the entire above thing CG wanted to increasetheir rate of CVT production by reduction of process time&manpowerwithenhancedquality.SinceAutoclaveprocess is one of the major processes in the CVT productcycle and also takes 5 & ½ days, the need for it's timeoptimization was faced, which was achievable through itsautomation.

SpecificationOfCVTAutoclaves

1. Size– 1400mmIDX2000mmusefulHeight
2. Purpose Processing of Capacitor Tags &ElectromagneticUnits
3. HeatingSystem–ThermicFluid
4. ProcessingCyclehasfollows
5. HydraulicLiftingCoverforAutoclave
6. QuantityReqd. =03 Nos
7. PC / PLC with SCADA System common for all03 Autoclaves & provision for another 03Autoclavesonthe samePC.
8. During FINE VACUUM Stage we must get 50microns Vacuum on Pirani Gauge in first 24Hoursforbothtype ofcycles.
9. Oil Heat exchanger with flow meter for temp.Controlled oil flow rate. (Max 200 Lts/hr) at 50deg. Cent.
10. Automatic vacuum control between 100 to 200micronsduringoilimpregnationstate
11. Control through PLC & monitoring throughSCADAsystem.
12. Activatedaluminaforvacuumbraking.

ProcessDescription

As mentioned in specification the process cycleconsistofalternatecyclesofAirHeating&RoughVacuumfollowedbyFineVacuum&impregnationcycles. Since capacitive voltage Transformer consists ofmix dielectric, there is the need of heating the product toremove moisture from the paper in the form of vapors.This is done in air heating cycle. The moisture in the formofvaporsissuckedfromtheautoclaveintheroughvacuum cycle. TheAir Heating & rough vacuum cycleare alternatively till a temp. Of 115 deg. Cles.& Vacuumof 15 mbar is achieved. The duration for the cycles ismentioned in the table. After this Fine Vacuum Heating iscarried out in which Vacuum of 50 microns is achieved,thentheFineVacuumCoolinginwhichthetemp.isbrought to 60 deg. Cels. & the Vacuum levels of 100microns are achieved. The end cycle is Oil Impregnation,which is carried out under vacuum of greater than 100microns.

DeviceUsedforProcess:-

1. ThermicFluidPump–usedinheatingsystem
2. AircirculationFan-OneONduringAirHeating
3. RootsVacuumPump –OneONduringFineVacuum
4. VacuumPump1(SingleStage)–OneONduringRoughVacuum
5. VacuumPump2(DoubleStage)–OneONduringFineVacuum
6. HydroPowerPack–forAutomaticDoorOpening/Closing
7. ThreeRTD's–Temp. Sensing
8. PiraniVacuumGauge–Vacuummeasurement
9. ElectricallyoperatedSolenoidValves
10. LightFlasher
11. LiquidLevelSensors
12. PLC &PC

DesignedLogicforsystem

Logic of only one cycle is mentioned & othersare on similar basis. Logic is prepared considering thedifferent interlocking that needs to be satisfied for theoutputtoget activate.

Beforestartofthecyclethedoorshouldbeclosed that is the NO s/w of the door limit need to beclosed.ThisactasoneofthedigitalI/Pto thePLC.

5.4.1 AH1:-

- OpenThermicFluidLineValves
- StartAircirculationFan
- VacuumValveshould beClosed
- StartTimeratthecyclestart(TheSetValueforthetimer is18Hrs.)

5.4.2 Switchingfrom**AH 1**to**RV1**conditions-

- JobTemp.105deg.Cels. &AH1Timecompleted
- ChillingPumpON

TABLENO.1 VACUMMDETAILS

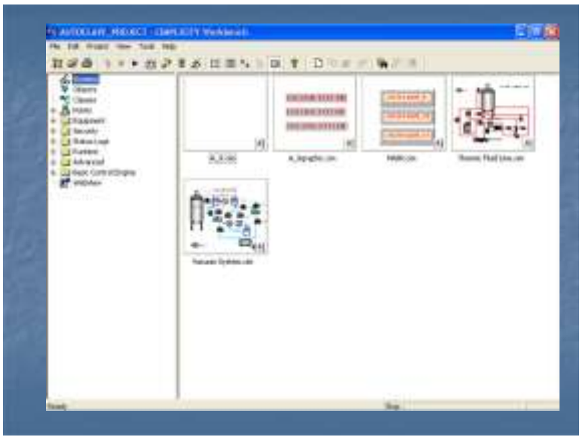
Stage	TempDeg.Celc	Vacuum	DurationHrs.for CapacitorCycle	DurationHrs forEMU Cycle
AH 1	105	-	18	08
RV1	105	35mbar	06	04
AH 2	110	-	04	-
RV2	115	25mbar	12	-
AH 3	115	-	-	-
RV3	115	15mbar	-	-
FVH	115	50 microns	60	12
FVC	60	100 microns	25	12
OI	60	100–200 microns	06	06

RV – Rough Vacuum FVC – Fine Vacuum CoolingOI – Oil ImpregnationFVH – Fine Vacuum HeatingAH– AirHeating

AutoclaveMonitoringScreensDesignSoftware:-
BasicDesignSoftware: -Complicity
FrontEndDesign:-VisualBasic,VC++.BackEnd Design:-Oracle, SQL
ReportGeneration:-Excel,Access.

ScreensWhichDesignedForMonitoringProcess:-
1. FrontMonitoringScreenSCADAWorkbenchview
2. AutoclaveControlScreen
3. FrontEndOfA-9AutoclaveMenu
4. A-9SubsystemScreen
5. A-9VacuumSystem
6. HeatingSystem

Fig.No.7:-FrontEndOfA-9 AutoclaveMenu



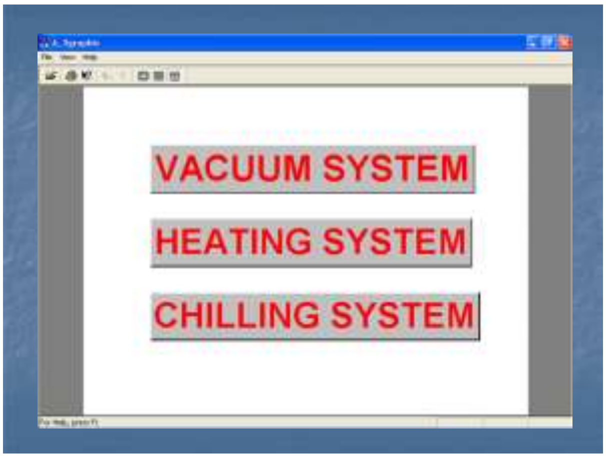


Fig.No.5:-FrontMonitoringScreenSCADAWorkbenchview

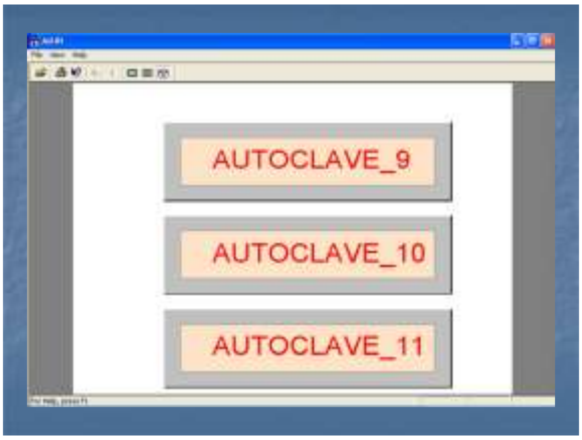


Fig.No.6:-AutoclaveControlScreen

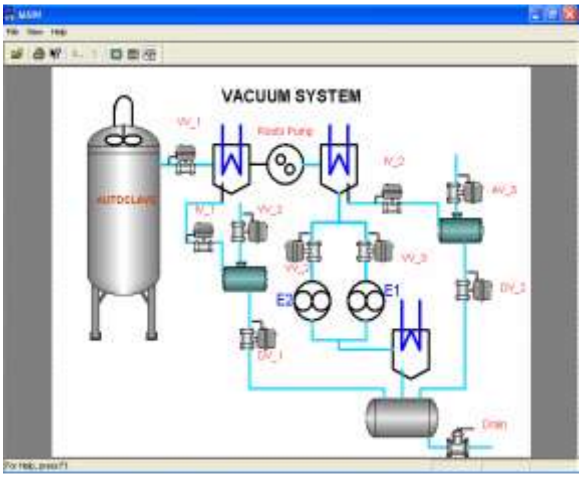


Fig.No.8:-A-9SubsystemScreen
Fig. No.9 :-A-9VacuumSystem
Fig.No10 :-Heating System

PLC&SCADARequirements

As per the Logic requirement 40 Digital signalsare required. There are total 5 Analog Signal I/P's. GEFanuc 64 Points micro PLC is used for this purpose. It hastotal 40 digital I/P's& 24 digital O/P's. Two expansionunitsareaddedtomainPLC,firstoneisaDigitalexpansionblock&secondoneisAnalogexpansionunit. CimplicitySCADAsoftwareisusedfordevelopingtheSCADAsystems.TheSCADAsystemwill be consisting of numerous graphical screens (LikeMain menu, Vacuum system, Heating system, Chillingsystem) through which the operator is visualize as well asinitiatesome activitiesofthecycle.

CONCLUSION

ThecasestudyofAutoclaveAutomationisdescribedbrieflybecauseofthespaceconstraint.TheSCADA system for the case is design as per the customerrequirement. Because of this automation both the productaswell as process timeis optimized.Thiswork showshow automation is carried & implemented with softwareinterface,PLC & Micro-SCADA in C.G.Ltd.Nashik,Maharashtra, India for CVT autoclave. The whole processis of 121 hrs.Consisting of number of cycles, which isautomatedusingPLC&SCADAforallprocessparameters.

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