

OPTIMISATION OF LIME KILN USING ADVANCED PROCESS CONTROL

A PROJECT REPORT

Submitted by

ASHWIN.S

PURANI.M

in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

in

ELECTRONICS AND INSTRUMENTATION ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE.

(An Autonomous Institution, Affiliated to Anna University of Technology, Coimbatore)

ANNA UNIVERSITY OF TECHNOLOGY :COIMBATORE 641 047

APRIL 2011

ANNA UNIVERSITY OF TECHNOLOGY : COIMBATORE

BONAFIDE CERTIFICATE

Certified that this project report "OPTIMISATION OF LIME KILN USING
ADVANCED PROCESS CONTROL" is the bonafide work of

ASHWIN.S

0710106007

PURANI.M

0710106037

who carried out the project work under my supervision.



SIGNATURE



SIGNATURE

PROF.R.ANNAMALAI M.E.,

Mr. S.ARUNJAYAKAR M.Tech.,

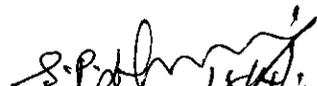
HEAD OF THE DEPARTMENT
Electronics & Instrumentation
Engineering,
Kumaraguru College Of Technology,
Coimbatore-641 006.

PROJECT GUIDE
Electronics & Instrumentation
Engineering,
Kumaraguru College Of Technology,
Coimbatore-641 006.

These candidates were examined by us in the project viva-voce examination held on
..18.04.2011...



18/04/2011
Internal Examiner



18/4/11
External examiner

ACKNOWLEDGEMENT

We express our sincere thanks to Principal **Dr.S.RAMACHANDRAN** ,who has been the back bone of all our needs.

We profusely thank **Prof.R.ANNAMALAI**, Head of the Department of Electronics and Instrumentation Engineering for his encouragement, to bring out this project work successfully.

We are highly grateful to our beloved guide **Mr.R.KANDHAVEL**, Deputy Manager, Department of Instrumentation, Tamilnadu Newsprint and Papers Limited (TNPL), who helped us with excellent guidance and valuable suggestions offered throughout the project.

We take immense pleasure to record our heartfelt gratitude to our esteemed project coordinator and project guide **Mr.S.ARUNJAYAKAR, M.Tech**, Lecturer, EIE Department, for their valuable guidance, timely help, constant encouragement and advice rendered throughout the project period for the successful completion of project.

We are also grateful to our faculty members of the Department of Electronics and Instrumentation Engineering, who have helped us in innumerable ways.

We also thank our parents without whom we could not have come so far and friends for their timely help that culminated as good in end



Tamil Nadu Newsprint and Papers Ltd.

Kagithapuram-639 136. Karur Dt., Tamilnadu.

CERTIFICATE

HR/31/23/3006B

April 9, 2011

Name : Mr. S. ASHWIN

Department : B.E. (EIE)

Name of the Institution : Kumaraguru College of Technology, Coimbatore

Project Title : Optimisation of Lime Kiln using Advanced Process Control

Project Duration : From 18.12.2010 To 02.02.2011


S. RAMAMOORTHY
ASST. GENERAL MANAGER - HRD



Tamil Nadu Newsprint and Papers Ltd.

Kagithapuram-639 136. Karur Dt., Tamilnadu.

CERTIFICATE

HR/31/23/3007B

April 9, 2011

Name : Ms. M. PURANI

Department : B.E. (EIE)

Name of the Institution : Kumaraguru College of Technology, Coimbatore

Project Title : Optimisation of Lime Kiln using Advanced Process Control

Project Duration : From 18.12.2010 To 02.02.2011


S. RAMAMOORTHY
ASST. GENERAL MANAGER - HRD

ABSTRACT

The project deals with optimization of lime kiln using Advanced Process Control. For efficient lime kiln operation, temperature control is an important criterion. Lime kiln has various parameters to be controlled like feed and firing end temperature, bio-gas flow, fuel oil flow, ID fan speed.

If the actions of one controller affect other loops in the system, then control-loop interaction is said to exist. If each controller has been individually tuned to provide maximum performance, then depending on the severity of the interactions system instability may occur when all the loops are closed. At present individual PID controls in DCS is not sufficient to handle these kind of Multivariable link parameter control. APC is designed based on multivariable control algorithm.

APC- controls the entire lime kiln to increase throughput, improves lime quality, reduce burned lime quality variability, controls excess oxygen, optimize fuel oil (cost effective) usage by utilising maximum bio-gas available and extends life time of lime kiln with less maintenance work. The APC solution optimizes the lime kiln operation by providing continuous monitoring of process.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE NO.
	ABSTRACT	VI
	LIST OF TABLES	IX
	LIST OF FIGURES	X
	COMPANY PROFILE	XII
1.	INTRODUCTION	1
	1.1 PROBLEM	2
	1.2 OBJECTIVE	2
	1.3 CHALLENGE	3
	1.4 SOLUTION	4
2.	PROJECT AREA	
2.1	SODA RECOVERY PLANT	5
	2.2 LIME MUD REBURNING KILN	6
	2.3 FUNCTIONS OF THE SYSTEM	8
	2.4 RAW MATERIALS FOR LIME KILN	12
	2.5 FUEL FOR LIME KILN	13
	2.6 EQUIPMENT DESCRIPTION	14
3.	ADVANCED PROCESS CONTROL	
	3.1 OBJECTIVE OF APC	20
4.	MUTIVARIABLE CONTROL	21
5.	BLOCK DIAGRAM	22
6.	CONTROLLING PARAMETERS	23
7.	LIME KILN OVERVIEW	24
8.	IMPLEMENTATION OF APC – LIME KILN	
	8.1 DISCHARGE END	25
	8.2 FEED END	27

9.	APC CONTROLLER MODULE	
	9.1 DISCHARGE END	29
	9.2 FEED END	31
10.	DISTRIBUTED CONTROL SYSTEM	32
	10.1 EXPERION PROCESS KNOWLEDGE SYSTEM	
	10.1.1 INTRODUCING EXPERION PKS	34
	10.1.2 EXPERION PKS BASICS	35
	10.1.3 BASIC CONTROL SYSTEM TOPOLOGY	37
	10.1.4 PROCESS CONTROLLER	40
	10.2 FIELD CABLES	
	10.2.1 CABLE TYPES	46
	10.2.2 I/O MODULE WIRING	46
	10.2.3 CONNECTING TERMINALS	53
	10.2.4 CONNECTING THRID PARTY – DEVICES	56
	10.3 COMMUNICATIONS CABLES	
	10.3.1 CABLE TYPES	57
	10.3.2 OVERVIEW	57
	10.3.3 COMMUNICATIONS CABLES	58
	10.3.4 FIBER OPTIC CABLES	58
	10.3.5 CONNECTING TO ETHERNET SWITCHES	59
11.	CONCLUSION	60
12.	BIBLIOGRAPHY	61

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	DESCRIPTION UNIT LIME STONE	
	LIME MUD	12
2.2	FURNACE OIL CHARACTERISTICS	13
2.3	BIOGAS CHARACTERISTICS	13
2.4	LSHS OIL CHARACTERISTICS	14

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	RECOVERY CYCLE	6
2.2	LIME KILN MODEL	10
5.1	GENERAL BLOCK DIAGRAM	22
7.1	LIME KILN OVERVIEW	24
7.2	APC AT DISCHARGE END	26
7.3	APC AT FEED END	28
9.1	BURNING OIL CONTROL FLOW	29
9.2	ATM STM/OIL TO BURN CONTROL	30
9.3	ID FAN DRAUGHT CONTROL	31
10.1	DISTRIBUTED CONTROL SYSTEM	32
10.2	EXPERION PLATFORM ARCHITECTURE	34
10.3	BASIC EXPERION SYSTEM TOPOLOGY WITH C200 PROCESS CONTROLLERS	38
10.4	BASIC EXPERION SYSTEM TOPOLOGY WITH C300 PROCESS CONTROLLERS	39
10.5	C200 CONTROL PROCESSOR	42
10.6	C300 CONTROL PROCESSOR	43
10.7	REDUNDANCY MODULE FOR C200 CONTROLLER REDUNDANCY	44

0.8	MODULE REDUNDANCY FOR C200 CONTROLLER IN REDUNDANCY SUPERVISORY CONTROLNET NETWORKS	44
10.9	C300 CONTROLLER REDUNDANCY IN SUPERVISORY FAULT TOLERANT ETHERNET NETWORK	45
10.10	TYPICAL ROUTING OF INTERNAL WIRING BETWEEN I/O MODULES AND FTA-T VIA SIC-CS	47
10.11	BONDING OF SHIELDED CABLES (FTA-T)	49
10.12	TYPICAL ROUTING OF INTERNAL WIRING BETWEEN I/O MODULES AND FTA-E VIA SIC-CS	50
10.13	BONDING OF SHIELDED CABLES (FTA-E)	52
10.14	TYPICAL LAYOUT OF A SIC-P CABLE	53
10.15	BONDING OF SHIELDED CABLES (TERMINALS)	55

COMPANY PROFILE

Indian Pulp and Paper mills

Introduction:

Pulp and paper production is an important contributor to national economy with a production of 2.4 million tons in 1993, it accounted for 3% of the value output from the manufacturing sector. There are over 300 mills in the country using a variety of raw materials ranging from bamboo and forest based wood to agro residue, bagasse etc.

The paper industry is one of the oldest industries in India, dating back more than a century. Starting from a moderate volume of 19,000 tons/year at the beginning of the 20th century, Indian paper production had risen to 2.4 million tons/year in 1993. With increasing emphasis on literacy and the expansion of services sectors, the demand is likely to increase much faster in the future.

About TNPL:

Tamilnadu Newsprint and Papers Limited (TNPL) were established by the Government of Tamilnadu during early eighties to produce Newsprint and Printing & Writing Paper using bagasse, a sugarcane residue, as primary raw material. The Company commenced production in the year 1984 with an initial capacity of 90,000 tonnes per annum. Over the years, the production capacity has been increased to 2,45,000 tonnes per annum and the Company has emerged as the largest bagasse based Paper Mill in the world consuming about one million tons of bagasse every year.

TNPL exports about 1/5th of its production to more than 30 countries. Manufacturing of quality paper for the past two and half decades from bagasse is an index of the company's technological competence. A strong record in adopting minimum impact best process

technology, responsible waste management, reduced pollution load and commitment to the corporate social responsibility make the company one of the most environmentally compliant paper mills in the world.

Technology

There is no finishing line in the race of Excellence

TNPL is an acknowledged leader in the technology of manufacture of paper from bagasse – the sugar cane residue. Started with an initial capacity of 90,000 tonnes per annum (tpa) on a single Paper Machine., the Mill doubled the capacity to 180,000 tonnes per annum in the year 1995 by addition of one more Paper Machine. Under the Mill Development Plan (MDP) completed during May 2008, the pulp production capacity has been increased from 520 tpd to 720 tpd. The pulp being produced by TNPL, in post-MDP is Elemental Chlorine Free (ECF). Along with this, the upgrade of the Paper Machines has resulted in reaching the paper production capacity to 2, 45,000 tpa. TNPL has completed the Mill Expansion Plan (MEP) in December 2010 to raise the mill capacity to 400,000 tpa.

Mill Expansion Plan (MEP):

The project being implemented comprises installation of a new state-of-the-art Paper Machine with a production capacity of 1,55,000 tpa, backward integration of bagasse ECF bleach plant for increasing the pulping capacity and installation of a high pressure multi-fuel boiler of capacity of 125 tph. The project was completed in December 2010. The Mill Expansion Plan has enabled TNPL to emerge as a world class mill with a capacity of 4, 00,000 tonnes per annum at a single location.

De-inking Plant :

To meet the additional requirement of pulp after implementation of Mill Expansion Plan, TNPL has preferred the option of going in for environmentally benign de-inking pulp produced from waste paper. TNPL has planned to install a state-of-the-art de-inking plant of capacity of 300 tonnes per day (tpd). The project is under implementation and shall be completed by March 2012.

Lime sludge and fly ash management :

The lime sludge generated from the recovery cycle and the fly ash generated from the power boilers are issues of concern in solid waste management. An innovative solution combining these two solid wastes and converting them into high grade cement has been drawn through installation of a 600 tpd cement manufacturing plant abutting the mill premises. The project is currently under execution and completed by December 2011. This project would be a beacon for other mills, in the direction of converting wastes into wealth besides addressing the concerns being faced in the disposal of solid wastes.

Revamping of steam and power system :

To improve the energy efficiency, three low pressure boilers of a total capacity of 180 tonnes per hour (tph) will be replaced with a new, energy efficient and environment friendly Circulating Fluidized Bed Combustion Boiler of 125 tph steam generation capacity at a high pressure of 105 atm. In addition, three old Turbo Generator sets of total capacity of 36.5 MW will be replaced with a new high efficiency TG of 41 MW to meet the additional requirement of power. The project is expected to go on stream by March 2012.

On-site Precipitated Calcium Carbonate (PCC) Plant :

TNPL is in the process of setting up a PCC Unit through OMYA, Switzerland on BOO basis within the mill premises. This would enable the Company to source the PCC on an online basis with substantial savings in the cost besides utilizing the flue gas presently let out to the atmosphere from the Lime Kilns.

Ozone treatment of Waste water :

As a tertiary treatment to reduce color of the final treated waste water, an Ozone treatment plant has been commissioned by TNPL during August 2010. TNPL is the first mill in the country to implement such a treatment for the waste water.

1.INTRODUCTION

The objective of the lime kiln optimization process is to produce uniform quality of lime with low energy consumption. It is achieved by controlling the temperature profile of the kiln and residual carbonate of lime, which is measured by laboratory analysis. The fuel(s) of the kiln and ID fan speed are adjusted based on the temperature profile, excess oxygen in flue gas and residual carbonate. The filling degree of the kiln is controlled by the kiln rotation speed. The production rate is controlled based on the lime mud tank level. The control takes into account secondary energy flow (if it is not controllable) and moisture of the lime mud as a feed forward. Model predictive control technology is used to improve the lime kiln process and quality management.

These innovative solutions address increasing business complexity and profitability pressures by effectively managing all aspects of control and optimization, from improving regulatory loop control to optimizing the entire process. The lime kiln optimization process improves lime quality (residual carbonate), reduces energy usage and maximizes lime kiln efficiency, while integrating the entire lime kiln process to drive mill-wide optimization.

1.1 PROBLEM

At present the process control variables are controlled individually irrespective of operator skills through DCS. Firing end temperature is considered as primary basis in temperature profile control.

The problem with the existing method is that operators are Unable to reduce fluctuation of burning zone temperature due to long dead time associated in the process between fuel oil flow and burning zone temperature. The Fluctuation in burning zone temperature which is not an optimized operation results in more consumption of fuel oil per ton of product (lime). Increased Residual carbonate variations due to fluctuations in feed end temperature. Excess oxygen in flue gas being maintained on the higher side ($> 5\%$).

1.2 OBJECTIVE OF THE PROJECT

Apply advanced process control application in existing lime kiln linear control system to obtain improved quality and to produce products in consistency with maximum utilization of available bio-gas.

1.3 CHALLENGE

Long dead time cannot be handled by DCS level PID controllers.

Fuel oil flow affecting both burning zone temperature and excess oxygen in flue gas which is a multivariable problem and same cannot be addressed by basic level controllers.

Disturbance in the unit demands for frequent changes in the operating parameters to maintain the critical operating parameters with good judgment.

1.4 SOLUTION

The Long dead time process can be effectively handled by Advanced Process Controller.

Multivariable control problems can be addressed.

Control is based on models which are derived from actual plant test over a period of time (base case data).

Have the advantage of predictability (Feed Forward).

In APC feed end temperature is taken as primary basis for temperature profile control.

APC sets temperature for feed end based on residual carbonate test results which decreases residual carbonate variation and increases lime availability in the product.

ID fan speed is manipulated to maintain oxygen content of the flue gas within the range (2-3%) thus controlling temperature profile across the kiln.

APC responds to disturbances in the plant and takes corrective action typically every minute around the clock.

APC- controls the entire lime kiln to increase throughput, reduce burned lime quality variability and optimize energy usage.

2. PROJECT AREA

SODA RECOVERY PLANT

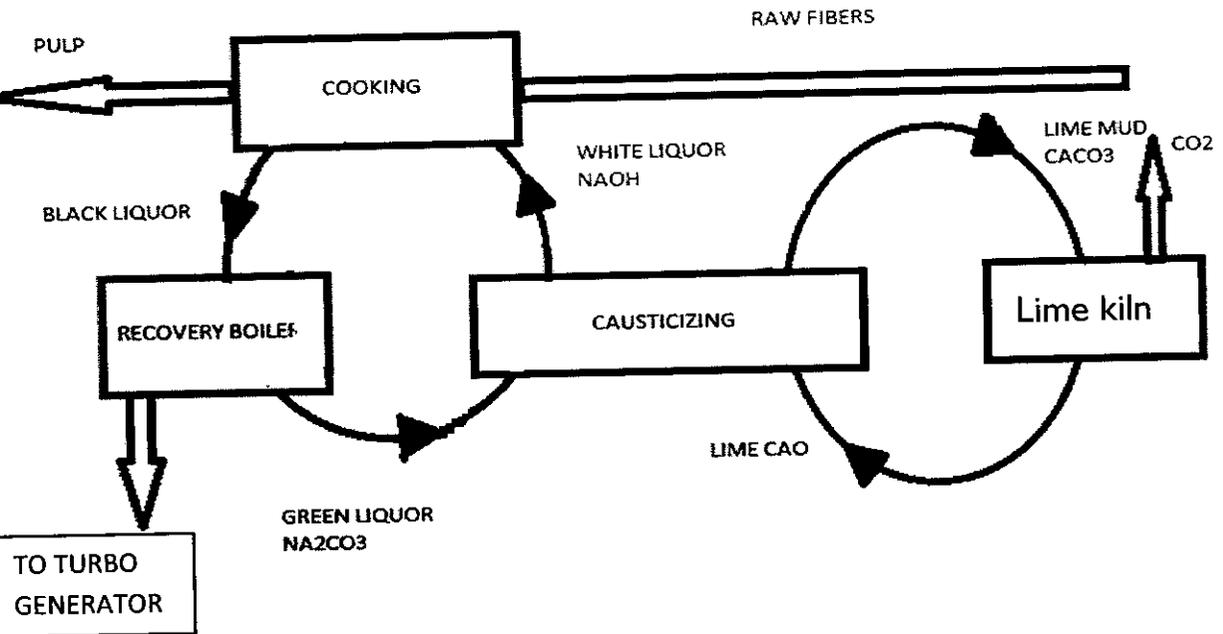
2.1 INTRODUCTION

The primary function of Soda Recovery Plant in a pulp and paper mill is to recover and reuse the chemicals used for chemical pulping of various raw materials viz. Softwood, Hardwood, Bagasse, etc. The main objective of the unit is to minimize, as efficiently as possible, the loss and subsequent make-up of the chemicals used in the preparation of cooking liquor, commonly called as “White Liquor”, which comprises mainly of Sodium Hydroxide, Sodium Sulphide and Sodium Carbonate. The sodium and sulphur loss in the Kraft recovery cycle is made up with Sodium Sulphate (salt cake) and Sodium Hydroxide.

The various steps in the Kraft recovery process is as follows:

- Concentration of Weak Black Liquor (WBL) in Evaporation plant
- Incineration of Concentrated Black Liquor (CBL) in Chemical Recovery Boiler to remove organics
- Conversion of Sodium carbonate to Sodium Hydroxide in Reausticizing Plant
- Calcination of Lime mud (Calcium Carbonate) to lime (Calcium Oxide) in Lime Kiln for use in Reausticizing Plant

Fig2.1 RECOVERY CYCLE



2.2 LIME MUD REBURNING KILN

Lime Sludge Reburning System

Lime sludge reburning system is supplied by Fuller KCP Ltd and has capacity of 170 tpd burnt lime at 82 % purity for which 283.2 tonnes of sludge at 40% moisture content and 117 tonnes of lime stone at 3% moisture are required.

The different systems of the lime mud reburning kiln are given below.

Lime Stone Handling System

The system consists of a service hopper of 20 t capacity and a belt conveyor to feed the lime stone to a crusher which crushes the lime stone to a size of 10-20 mm. The crushed limestone is taken to a bin through a bucket elevator. From the bin the limestone is fed to the kiln feed screw through a belt conveyor and a

Lime Sludge Handling System

The lime sludge coming out of the filter is transported to the kiln feed screw through a belt conveyor and weigh feeder.

LIME KILN

Lime kiln has a size of 3.2 m inside diameter and 82 m length. There are seven (7) tube coolers. The kiln speed is 1 to 1.4 rpm. The kiln is lined by different types of refractory in the chain zone, drying zone and burning zone. Kiln is rotated by a drive system. An auxiliary drive is also provided for emergency purposes. A thrust roller is provided to arrest the movement of the kiln to downhill. The kiln is divided into three (3) zones. The material fed to the kiln reaches chain zone where it is dried by the heat of the flue gas, which is flowing counter current. The partially dried material travels to the drying zone where the lime mud gets further dried by the heat of the flue gas. In the combustion zone the calcium carbonate dissociates into calcium oxide and carbon dioxide. A temperature of 1100 to 1200 °C is maintained at this zone.

Burner System

Burner system consists of the oil pumping, heating, filtering system and the burner. The oil is heated to about 120 °C. The filters are duplex basket types. The required pressure has to be maintained for fuel oil and atomising steam. The interlocks for the burner are to be checked before starting the system.

Burnt Lime Cooler and Burnt Lime Handling

Seven (7) burnt lime coolers are incorporated with the limekiln. These are known as planetary coolers. The burnt lime coming out of the burning zone of the kiln is cooled by counter current air coming through the cooler. The product lime is cooled and simultaneously the air is heated. The secondary air is used as

fan speed. Excess air will cool the kiln while insufficient air will result in unburned fuel. The oxygen content in the flue gas is maintained about 2 to 3%.

The temperature of lime coming out of the lime coolers will be about 100°C. Larger lumps in the product lime are directed to burnt lime pressure, which reduces the size of burnt lime to about 10-20 mm. The product lime is transported to the burnt lime silo through a bucket elevator.

Flue Gas Cleaning System (ESP)

The flue gas coming out of the feed end of the kiln will contain lime dust. This dust has to be recovered for pollution control as well as economic reason. ESP is used for this purpose. The collection efficiency of ESP will be about 99.5%. The collecting electrodes collect the less particles emitted by emitting electrodes. The collected dust is transported outside of the ESP by a scrapper conveyor and is fed to the main kiln feed screw through a screw feeder.

2.3 FUNCTION OF THE SYSTEM

Lime Stone Handling

The function of lime stone handling system is make-up the production of burnt lime as a part of the product burnt lime is used for bleach liquor preparation and to make-up the losses through grits from the causticising system.

Sludge Handling System

The function of the system is to feed the lime kiln with available lime sludge from the filter.

Lime Kiln

The function of the system is to convert calcium carbonate in lime mud and

Burner

The function of the oil burner system is to generate heat required for dissociation of CaCO_3 into CaO and CO_2 . The size and shape of the flame are very important the operation of the limekiln. The flame should be medium long. The life of the refractory mainly depends upon the size of the flame and a temperature maintained at the firing zone. Burnt Lime Cooler and Burnt Lime Handling systems are seen here. The function of the lime cooler and burnt lime system is to cool the product lime to design temperature and to transport it to burnt lime silo to be used for Reausticizing. The burnt lime crusher reduces the size of larger lumps in the discharge.

Electrostatic Precipitator (ESP)

The function of the ESP is to collect the fine lime particles from the flue gas. The electrically charged electrodes collect the particles and through suitable conveyors the dust is fed back to the system. Normally the flue gas inlet to ESP will have a dust loading of 20 gm/Nm^3 whereas the flue gas outlet will be having only 100 mg/Nm^3 dust loading.

Lime Stone Handling System

The amount of the limestone to be fed to the lime kiln is to be predetermined as per the requirement. The running of the different pieces of equipment is to be monitored now and then. The size of the output of crusher should be checked for the correct size. The connected instruments are to be checked occasionally for the accuracy.

Lime Sludge Handling

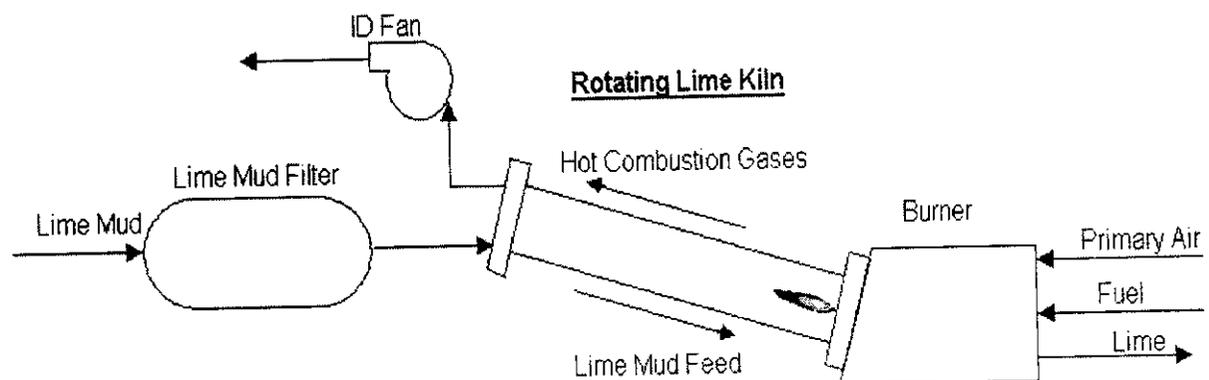
The running of lime mud filter, belt conveyors etc. are to be checked
The moisture content of the lime mud is to be checked and if

Lime Kiln

The feed to the limekiln is to be maintained uniform has any frequent change in the quantity of feed will affect the purity of burnt lime. The load on the drive motor has to be checked frequently. The movement of the kiln is to be checked periodically. If the kiln is moving unusually forward and backward as indicated by the thrust roller pressure, necessary mechanical adjustment has to be done on the supporting rollers.

The product quality has to be checked once in two hours by analysis of either available CaO or residual CaCO₃.

Fig 2.2 LIME KILN MODEL



Burner

The primary air pressure, quantity and fuel temperature pressure etc. are to be checked very frequently. The shape of the flame is to be maintained as per the norms and a temperature of the firing zone should not exceed 1200 °C. A very high temperature will produce over burnt lime and a low temperature will produce low purity burnt lime. All safety interlocks are to be checked for proper functioning. Under no circumstances should the flame board enough to hit the refractory lining. The shell temperature in the firing zone has to be monitored very frequently. The size and shape of the flame are adjusted by the primary air.

Burnt Lime Cooler and Burnt Lime Handling

The inlet of secondary air is to be adjusted to maintain oxygen content of 2 to 3% in the flue gas. This is done by adjusting the ID fan speed. The running of the crusher, the conveyor and bucket elevator is to be checked occasionally. The interlocking system and other instruments are to be checked often.

Electrostatic Precipitator (ESP)

The rectifiers of the ESP are to be checked for design current. The conveyors are to be checked occasionally for the smooth running. The interlocking system and other instruments are to be checked frequently.

The Lime Kiln supplied by ENMAS

2.4 RAW MATERIALS FOR LIME KILN

Analysis of Lime Mud and Make-up Lime Stone

Tab 2.1 Description Unit Lime Stone Lime mud

DESCRIPTION	UNIT	LIME STONE	LIME MUD
Moisture	%	0.5	30.00
Analysis on dry basis	%		
Loss on ignition	%	43-44	36-39
Acid insolubles(Silica)	%	<1.0	5-6
Mixed oxides (R ₂ O ₃)	%	1.0	1.5- 2.0
Calcium as CaCO ₃	%	96-97	85-87
Magnesium as MgCO ₃	%	1.0	1.6- 2.0
Sodium compound as Na ₂ O	%	1.5
Free CaO	%	0.5- 1.5

Consistency of lime mud slurry at inlet of mud tank 33 – 36%

2.5 FUEL FOR LIME KILN

Tab 2.2 Furnace Oil Characteristics (Typical)

DESCRIPTION	UNIT	VALUE
Specific Gravity at 15°C	No unit	0.92-0.95
Kinematic Viscosity at 50 °C	m ² /sec	410
Lower heating value	kcal/kg	10120
Flash point (min)	°C	66
Sulphur content (max)	%	4.5
Ash (max)	%	0.1
Water (max) vol.	%	1
Pour Point	°C	27
Sediment (max)	%	0.25

Tab 2.3 Biogas Characteristics (Typical)

DESCRIPTION	UNIT	VALUE
Methane	%	65-70
CO ₂	%	25-30
Moisture	%	0.5-5
Calorific value	Kcal/m ³	5500-6000
Available pressure at Kiln end	Mm wc	3000

Tab 2.4 LSHS Oil Characteristics (Typical)

DESCRIPTION	UNIT	VALUE
Specific Gravity at 15°C		0.92
Kinematic Viscosity at 98.9°C	m ² /sec	75
Lower heating value	Kcal/Kg	10120
Flash point (min)	°C	93
Sulphur content (max)	%	1.2
Ash (max)	%	0.1
Water (max) vol.	%	1
Pour Point	°C	60
Sediment (max)	%	0.25

2.6 EQUIPMENT DESCRIPTION

Make-up Lime Stone Feeding System

The kiln is provided with the make-up limestone feeding system up to the kiln feed screw conveyor in the limekiln. The make-up limestone feeding system is comprised:

- Feed hopper with grizzly screen at the inlet of hopper and vibrating feeder at the bottom of hopper
- Feed conveyor to feed limestone to crusher
- Magnetic separator
- Crusher with screen at the discharge Crusher shall have adjustable rotor or stator. 85% of the crushed stone shall be 12-18 mm size
- Bucket elevator from crusher outlet to storage silo, located in kiln feed

- Conveyor from storage silo to lime kiln feed end including weigh feeder with VFD
- Storage silo for crushed lime stone
- Vibrating feeder for lime stone silo

The size of the makeup lime stone will vary from 75 to 150 mm (feed to crusher). The dust is not formed in the burnt lime handling area. A dust control devices is also provided.

Lime Mud Reburning Kiln

Lime Kiln Feed Screw Conveyor

A lime kiln feed screw conveyor of suitable size to feed the lime mud, makeup lime stone and ESP ash to the feed end of the lime kiln are provided. The feeding screw is provided with proper air seal to prevent external air ingress into the lime kiln.

Kiln Proper

One (1) heavy duty lime mud reburning kiln with the required number of lime coolers is provided. The kiln shell & coolers are of boiler quality carbon steel. The types of chain system are straight hung, garland and combination of both.

The kiln includes the following:

- Feed end housing with air seal
- Chain system
- Two (2) sampling ports
- Lifters and tumblers,
- Discharge end dam
- Shell temperature scanner

- Lubrication arrangement for kiln drive bearings and support rollers
- AC variable frequency drive
- Discharge end housing
- Mono rail for kiln drive
- Burner support assembly

Auxiliary Drive System

One auxiliary drive consisting of a diesel engine suitably coupled and with all required supporting structures, is provided. A self-starter is provided for the auxiliary drive.

Fuel oil/LSHS oil Burner

An energy efficient fuel oil/LSHS oil burner with support assembly is provided. The supply included a pilot burner unit and high energy igniter. A flame scanner is included. Provision is made to incinerate non-condensable gases generated in the pulping and recovery operations and also for burning biogas from biomethanation plant. A burner management system is provided. The quantity of bio gas available is 24,000 m³/day.

Refractory Materials

The complete set of refractory and insulating bricks required for double layer refractory lining for the lime mud reburning kiln is provided. The kiln has double layer refractory with insulating bricks at the exterior layer. The selection of refractory materials is ensuring that the shell temperature in burning zone does not exceed 150 °C.

Lime Coolers

Lime coolers to meet the required duty condition provided to reduce the temperature of hot lime coming out of the kiln. The product lime temperature around 130°C.

Lime Lump Breaker

One (1) lime lump breaker of hammer mill type is provided for burnt lime to meet the size requirements of 15-20 mm in Recausticizing plant.

Primary Air Fan and Ducting

The primary air fan with necessary ducting's are provided. The fan is of energy efficient design and provided with damper, actuator, base frame and drive. The primary air fan capacity considers the firing non-condensable gases (NCG) and biogas.

Induced Draught Fan

An energy efficient induced draught (ID) fan for the required duty conditions is provided with an AC Variable Frequency Drive (VFD) motorised operation. A damper is provided at the inlet of ID fan. The fan capacity takes into consideration the NCG and bio-gas firing. The complete exhaust ducting for the system from the kiln up to the chimney is provided in suitable material of construction and with necessary bracing, expansion joints and supports. Bleed off damper at the inlet of the ESP is provided with control facilities to maintain the inlet temperature of gas inlet to the ESP at the required level.

Furnace oil/LSHS oil System including heating, filtering & pumping unit

Furnace oil/LSHS oil will be available at the inlet of day oil tank at 30- 35oC in the case of fuel oil and 70oC in the case of LSHS oil. An oil spray nozzle of

- Day oil tank
- Pumping, heating and filtering unit with necessary insulation & cladding.
- Steam tracing for the oil lines.
- Steam atomising arrangement

Electrostatic Precipitator (ESP) with auxiliaries and MCC

The ESP is provided to restrict the emission levels to 50 mg/Nm³ (maximum). The ESP of suitable size is designed for a flue gas dust concentration of 50 mg/Nm³ at the outlet of ESP under maximum dust loading conditions.

ESP does not have a bypass duct.

ESP is controlled from the DCS.

ESP and its auxiliaries consist of the following items.

Housing

The working parts of ESP are enclosed in a gas and weather tight steel housing. The housing is provided with proper supports.

Precipitator Roof

The precipitator roof is designed to accommodate the equipment like HV rectifier units, insulator housing, disconnecting switches etc. and have access for maintenance. A hoisting system, complete with a travelling pulley block, is also be provided on the roof for maintenance of the rectifier.

Collecting and Emitting Systems

The collecting system consisting of collecting electrodes of proven design is of corrosion resistant steel, with good corona characteristics. Emitting electrodes

structure and accurately centred between the collecting plates, is provided. The framework is suspended from insulators. The HT supporting insulators is located in double walled insulator compartments. In order to avoid condensation of moisture on the surface of the insulators, each insulator is provided with provision for hot air blowing.

Rapping System

The rapping system for the collecting and emitting electrodes is employed tumbling hammers angularly placed on the rapping shaft. Micro tappers employed for rapping system. The driving gear is arranged externally. The frequency of rapping for each field is adjustable with a digital programmer relay mounted in auxiliary control panel.

Gas Distribution Screens

Gas distribution screens are so located as to ensure uniform gas distribution. The inlet and outlet screens are of SS construction.

3. ADVANCED PROCESS CONTROL (APC)

It is also well known that any improvement in the performance of control strategies will result in more consistent production, facilitation process optimization, hence less re-processing of product and less waste. Modern process plants, designed for flexible production and to maximize recovery of energy and material, are becoming more complex. Process units are tightly coupled and the failure of one unit can seriously degrade overall productivity.

A systematic studied approach to choosing pertinent techniques and their integration into a co-operative management and control system will significantly enhance plant operation and profitability. This is the goal of advanced process control.

It has been proved that advanced control can improve product yield; reduce energy consumption; increase capacity; improve product quality and consistency; reduce product giveaway; increase responsiveness; improved process safety and reduce environmental emission. By implementation advanced control, enormous benefits are attained and are achieved by reducing process variability, hence allowing plant to be operated to their designed capacity.

The APC solution optimizes the lime kiln operation by providing continuous monitoring of process. The APC solution is designed to achieve excellent control using standard lime kiln field and test measurements.

3.1 OBJECTIVE OF APC

The objective of the APC strategy is to control the temperature profile of the lime product to produce consistent, high quality burned lime. Combustion air enters the hot end and is heated by the flame. As the hot combustion gases move

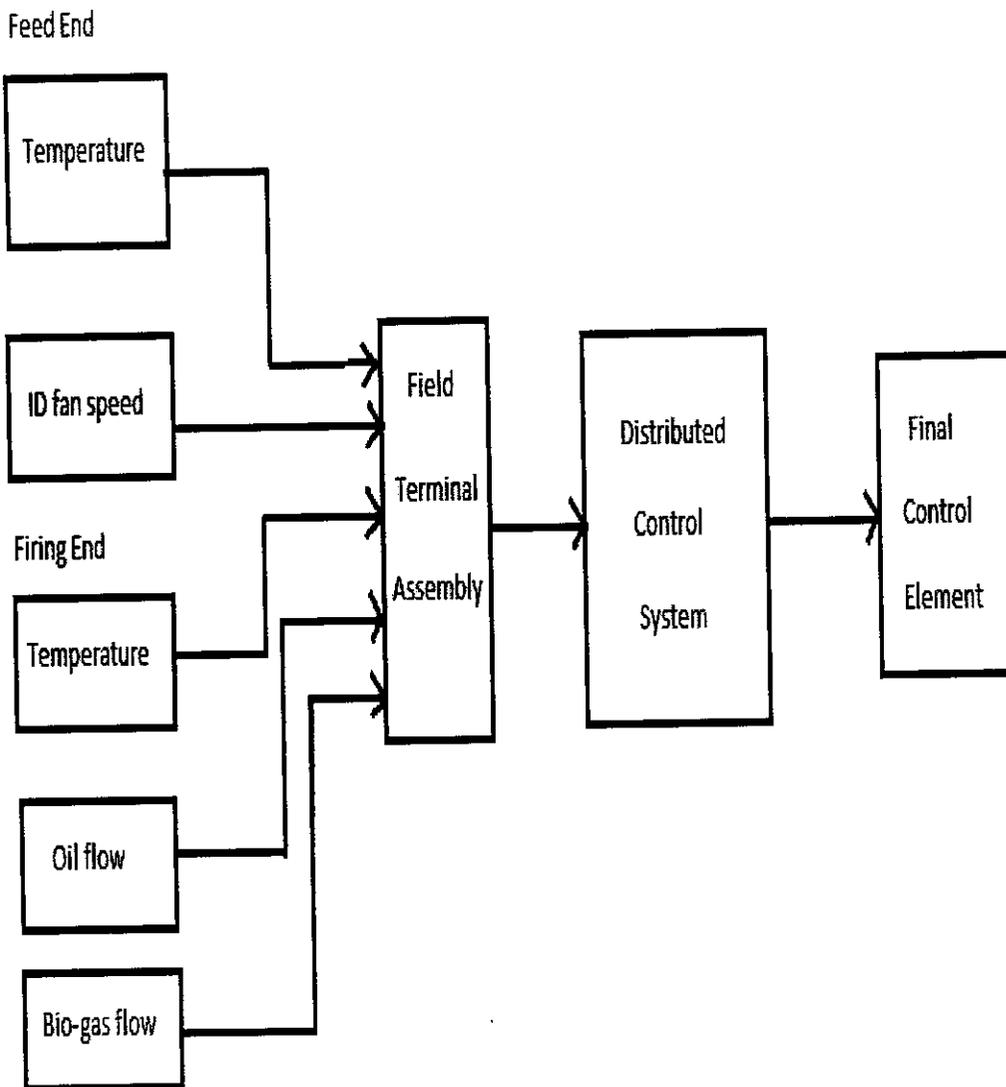
feed end of the kiln, the temperature and excess oxygen of the gases are measured and controlled. The lime product temperature at the hot end is controlled by stabilizing the temperature profile and the excess oxygen at the feed end. Fuel flow and flue gas damper position are manipulated to control excess oxygen, energy input and temperature profile. Advanced Process control solution includes lime Production Rate control with Mud Washer controls. Also, kiln Speed Control, and Lime Temperature Profile control, including Residual Carbonate Control, Excess Oxygen Control, Temperature Profile Control and Heat Input Control.

4. Multivariable Control:

In lime kiln processes, there are many variables that have to be regulated. Multi fuel burner is a typical example where flow, temperature and pressure have to keep at design values – A multi – Loop system. If the actions of one controller affect other loops in the system, then control- loop interaction is said to exist. If each controller has been individually tuned to provide maximum performance, then depending on the severity of the interactions system instability may occur when all the loops are closed. In present individual PID controls in our DCS is not sufficient to handle these kind of Multivariable link parameter control. APC is designed bases on multivariable control algorithm.

5. BLOCK DIAGRAM

Fig 5.1 general block diagram



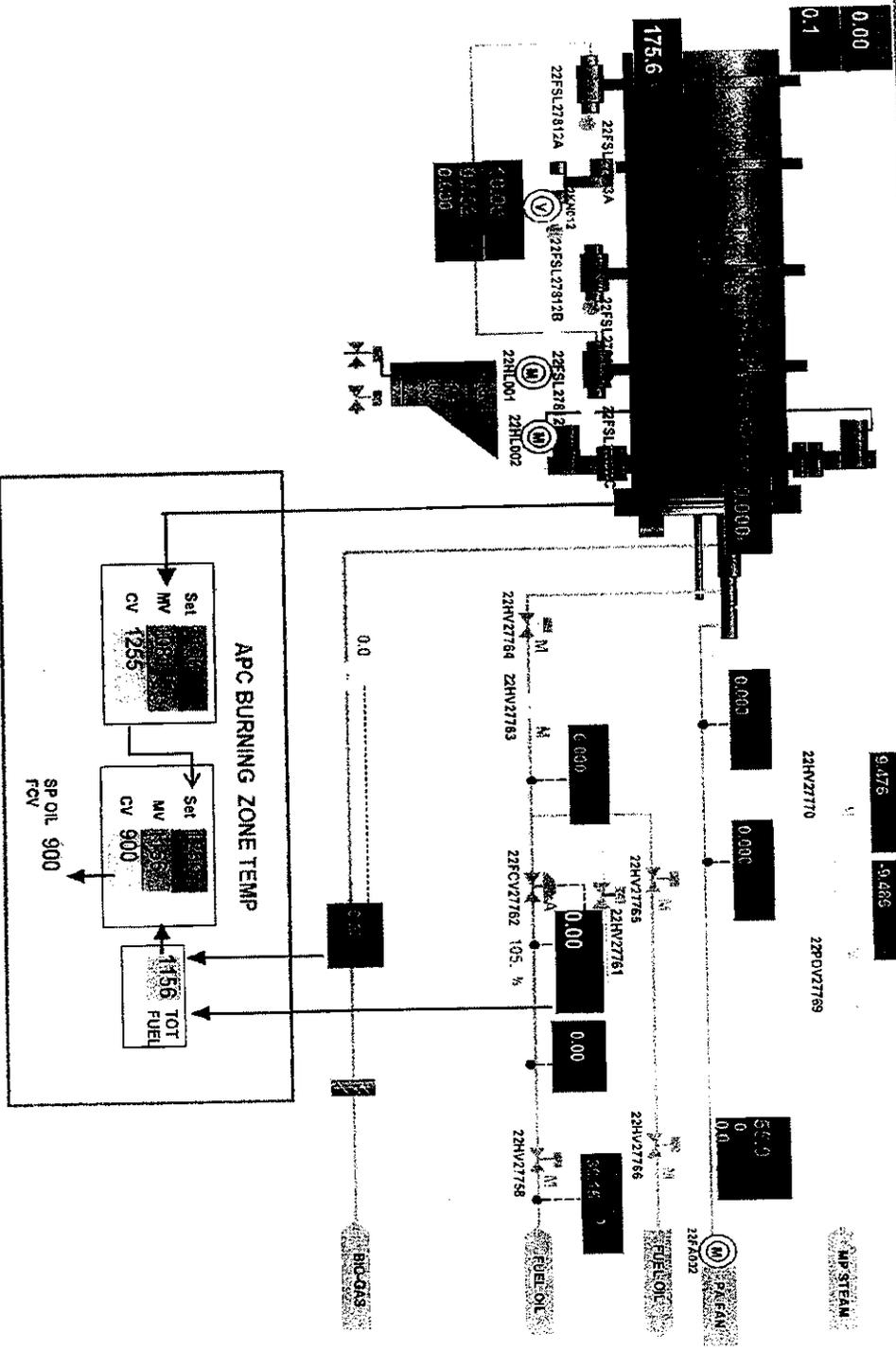
6. CONTROLLING PARAMETERS:

- Feed end
 - Temperature
 - ID fan speed control
- Firing end
 - Temperature
 - Bio-gas
 - Oil flow
 - Oil and steam pressure

8. IMPLEMENTATION OF APC - LIME KILN

8.1 DISCHARGE END

Oil and biogas are the two fuels for the lime kiln. The biogas is obtained from the other sections of the plant free of cost. The temperature of burning zone is controlled to maintain the purity of the product. The APC measures the burning zone temperature and compares with the setpoint given to it. The calorific value is given as setpoint to the total flow. This is the value of fuel required to maintain the required temperature in the burning zone. The flow sensors measure the flow of oil and biogas. The APC sends the available amount of biogas to the burner and calculates the additional amount of oil required to maintain the temperature of the burning zone and gives to the oil flow controller. Now, only the additional amount oil required is sent to the burner with maximum utilization of biogas avoiding wastage of oil. The implementation of APC on the discharge end of the lime kiln is as shown in the following figure.

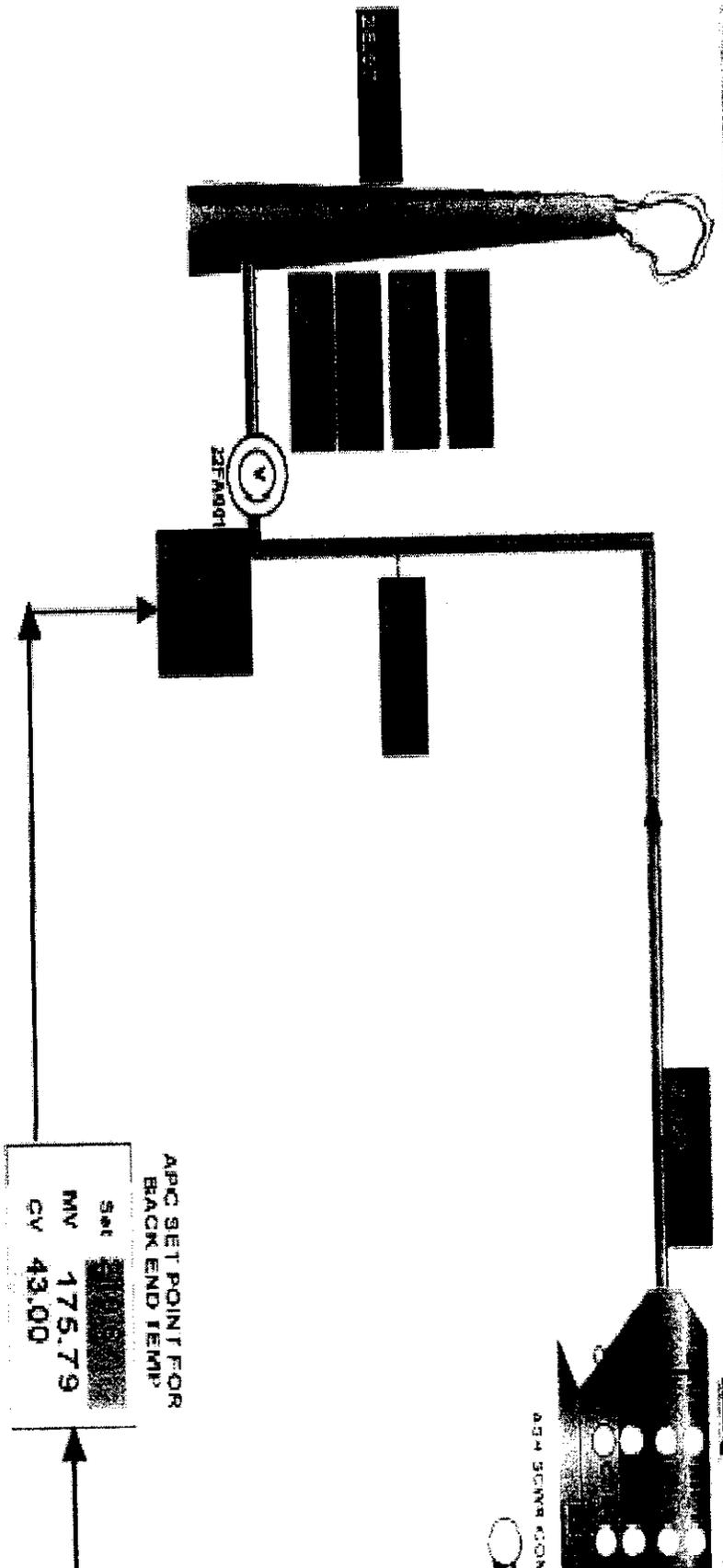


04-Apr-11 17:02:20 RHP 1761JC5049 PVHIGH U 01 WVL Tank Level 75.0094 %
 Date: 04-Apr-11 Time: 17:14:19 Alarm: Alarm Server: SERVER2B Station: Logon: Sini12

8.2 FEED END

In the feed end, the draught should be controlled in order to maintain the uniform distribution of flame throughout the lime kiln. The temperature of the feedend is controlled to maintain the draught. The APC measures the temperature and compares with the setpoint. The APC controls the variable frequency drive and changes the speed of the ID fan to maintain the required temperature.

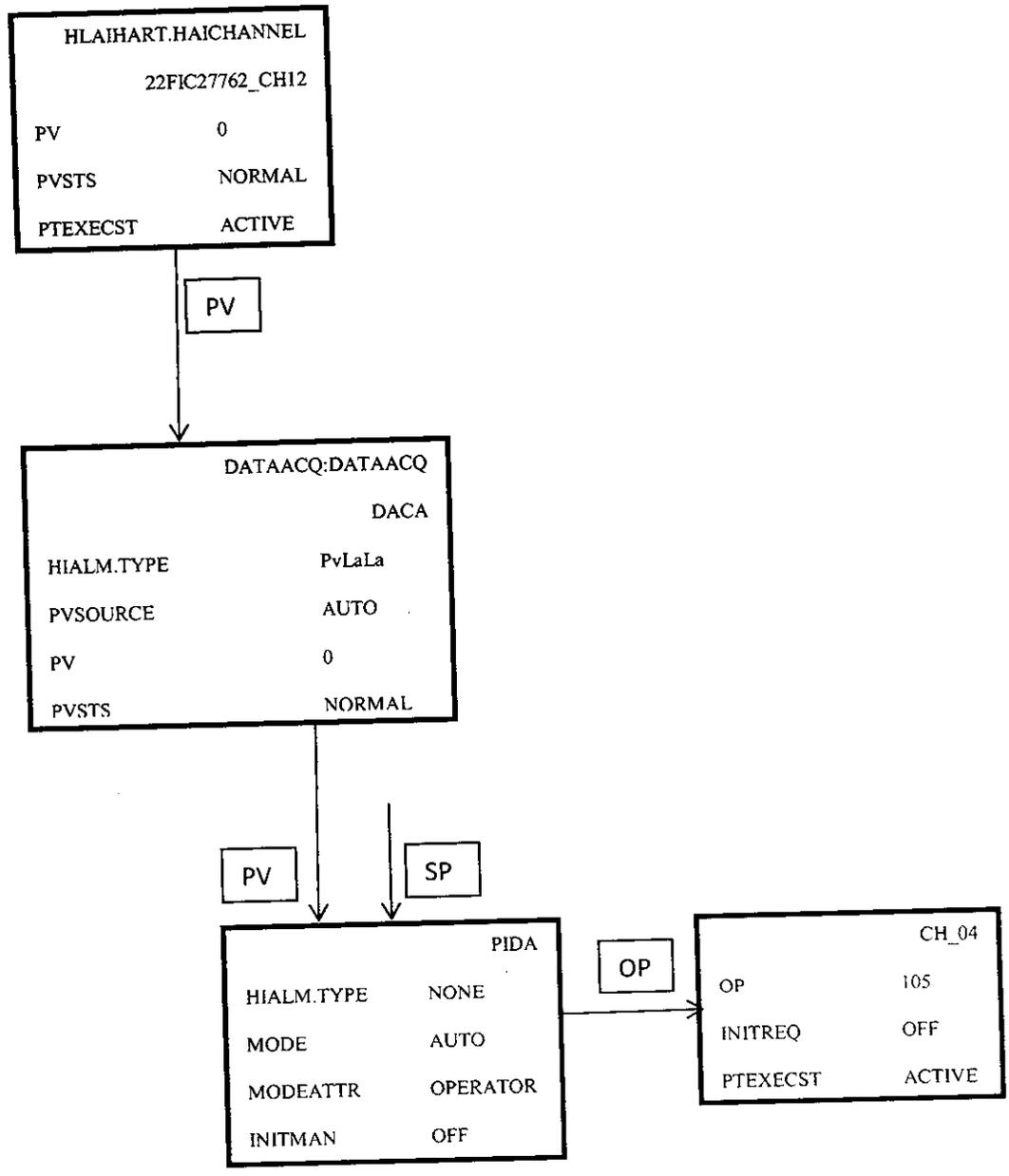
24-Apr-11 17:02:20 RHP 1761.C5049 PVTIICH U 01 WTWL Tank Level 75.0094 %
Date: 04-Apr-11 Time: 17:13:25 Alarm: Alarm Server: SERVER2B Station: Logon: Sln12



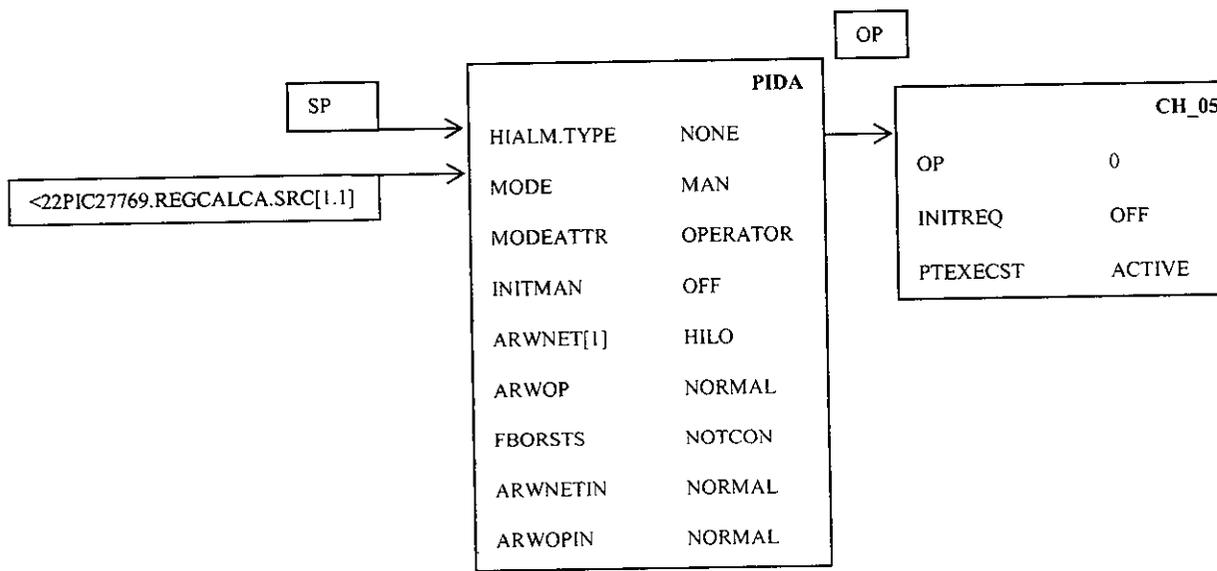
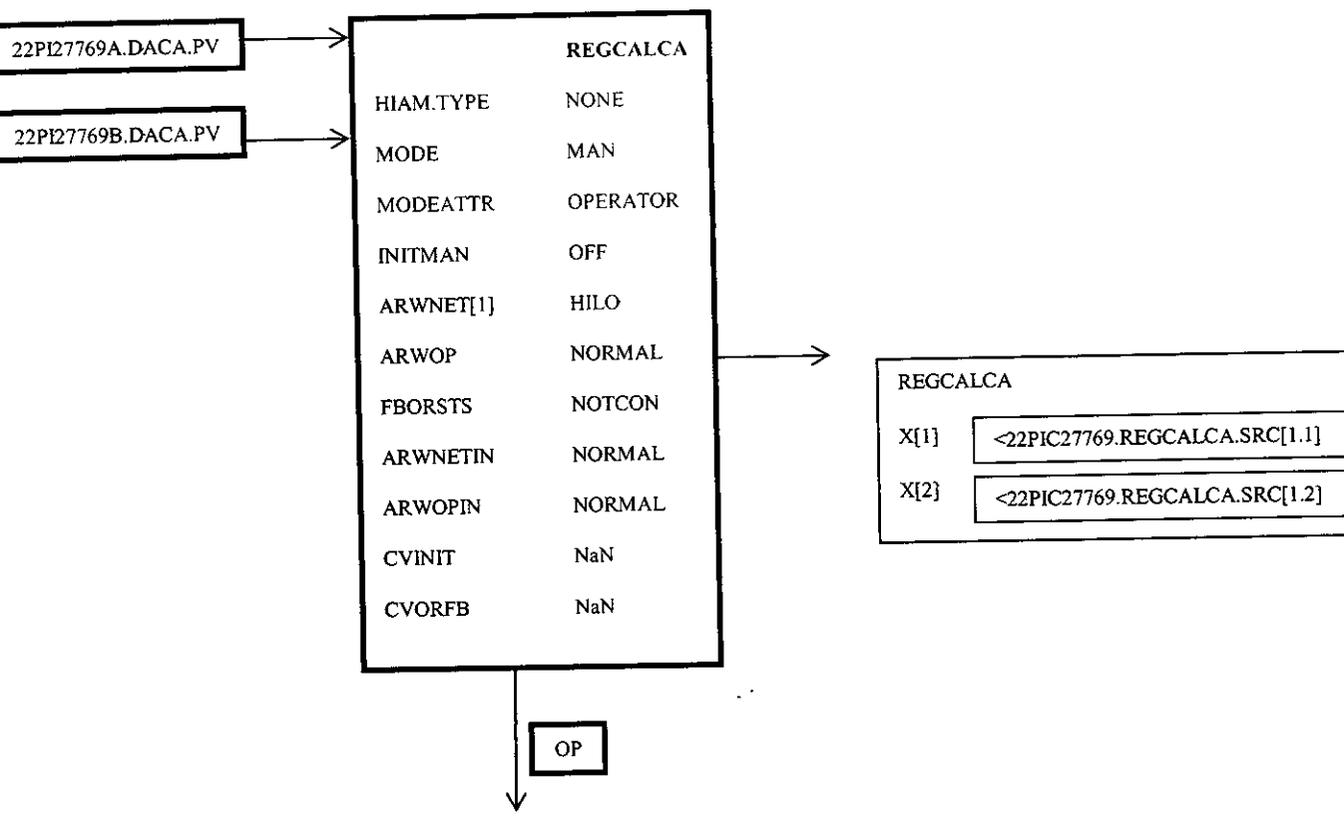
9. APC CONTROLLER MODULE

9.1 DISCHARGE END

Fig 9.1 BURNING OIL CONTROL FLOW

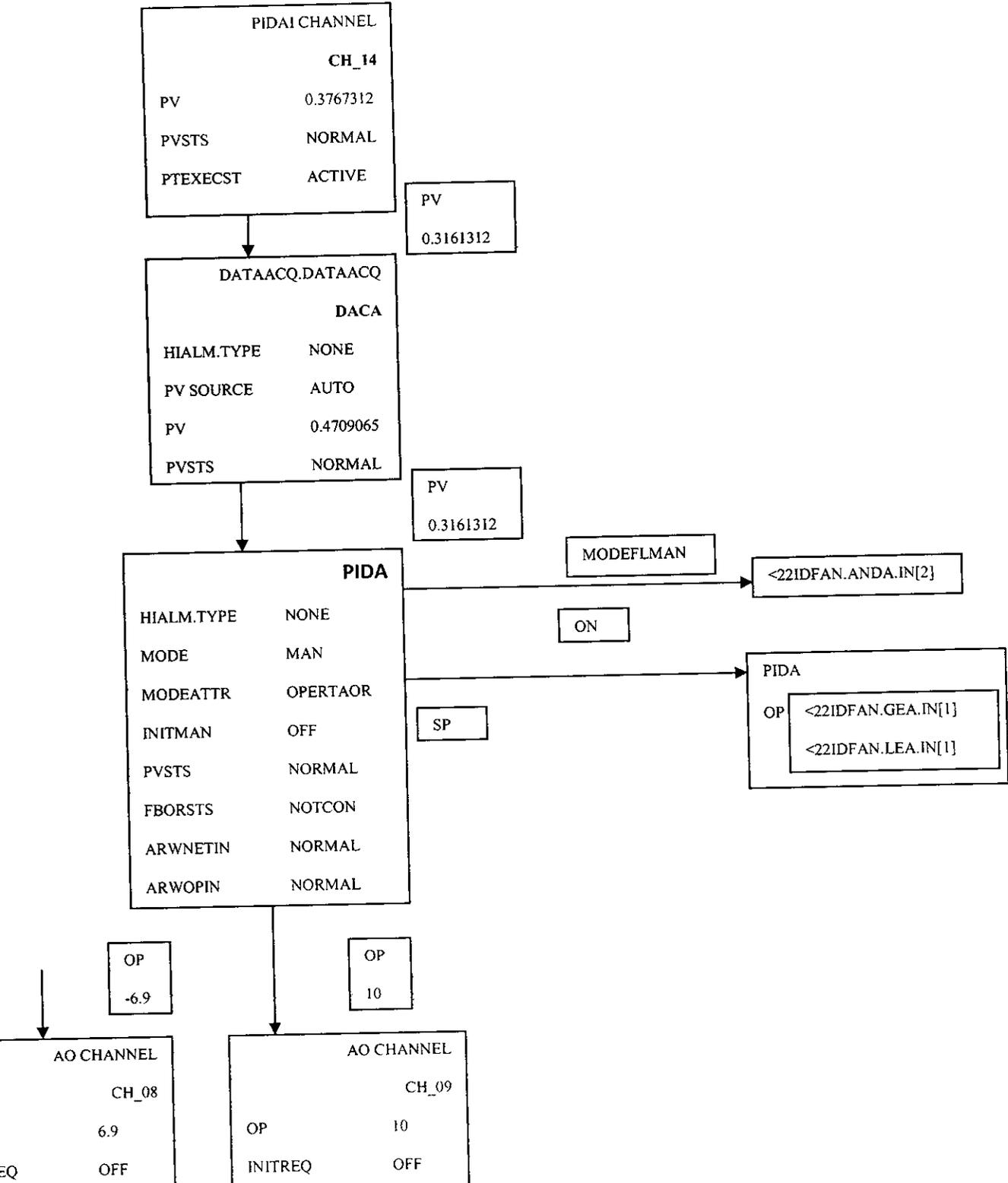


g 9.2 ATM STM/OIL TO BURN CONTROL



9.2 FEED END

Fig 9.3 ID FAN DRAUGHT CONTROL



10. DISTRIBUTED CONTROL SYSTEM

Distributed control has a number of advantages over the electric analog or mainframe digital computer systems and satisfies several requirements that they cannot. First of all, distributed control can reduce installation cost. Less wiring is required when information is transmitted serially across the two wires of data highway, rather than in parallel over many pairs of wire. From the point of view of the operator, the interface with the process is improved. The group display provides a means of combination of control loops that has meanings in terms of process applications. Operators like to read the digital values too.

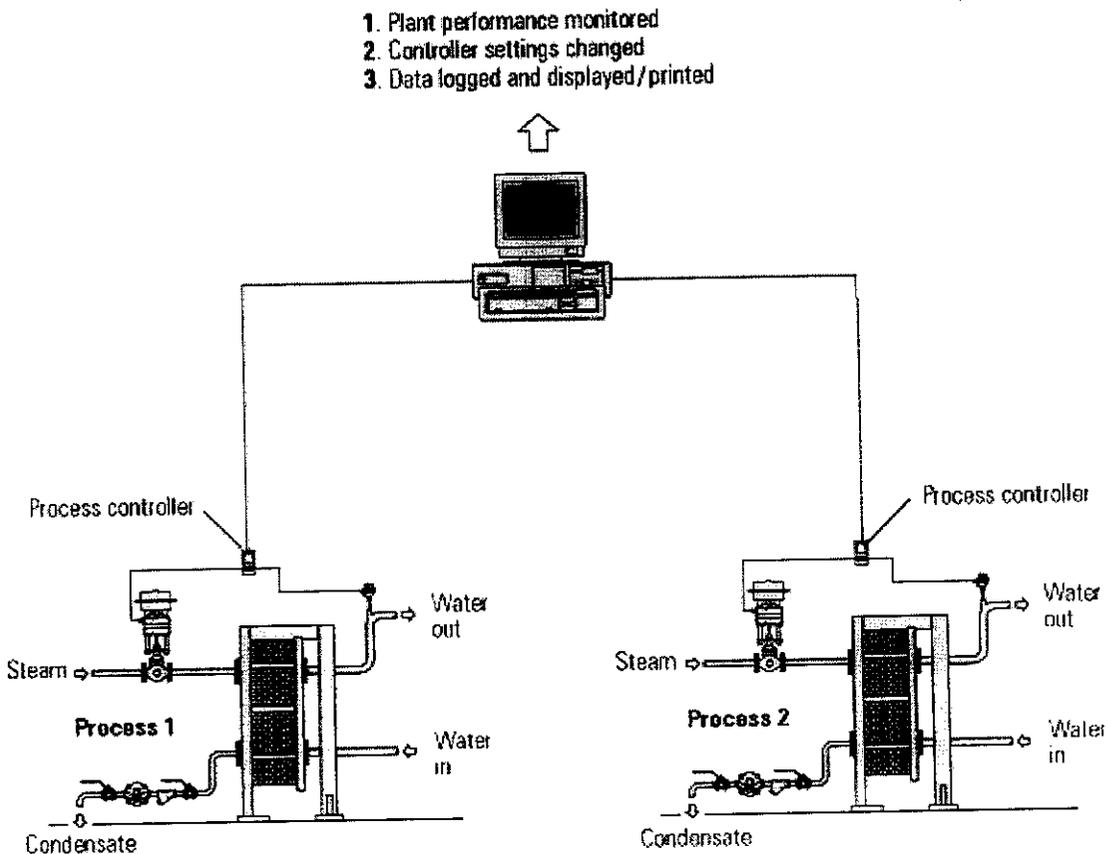


Fig 10.1 Distributed control system

Distributed control systems can be called a computer but no longer a single mainframe. Instead, many small computers are distributed throughout the remote area installations, sharing the work of the mainframe. A minicomputer connected to the system can specialize in two functions such as optimizing, logging, generating graphic displays. It does not have to handle all the information transmittal, data manipulation and system coordination that a single large computer managed. In fact, central station facilities can break down and the remote control operation will continue without interruption.

The programming effort required for the mainframe computer system is also eliminated. Furthermore, the programming required to tailor the system to the needs of the individual processes to which it is applied can be done without knowing a high level programming language.

RELIABILITY

Digital computers are more reliable today than when they were first introduced, but the possibility of failure of a single piece of electronic equipment causing the shutdown of an entire production facility still raises concerns that cannot be ignored.

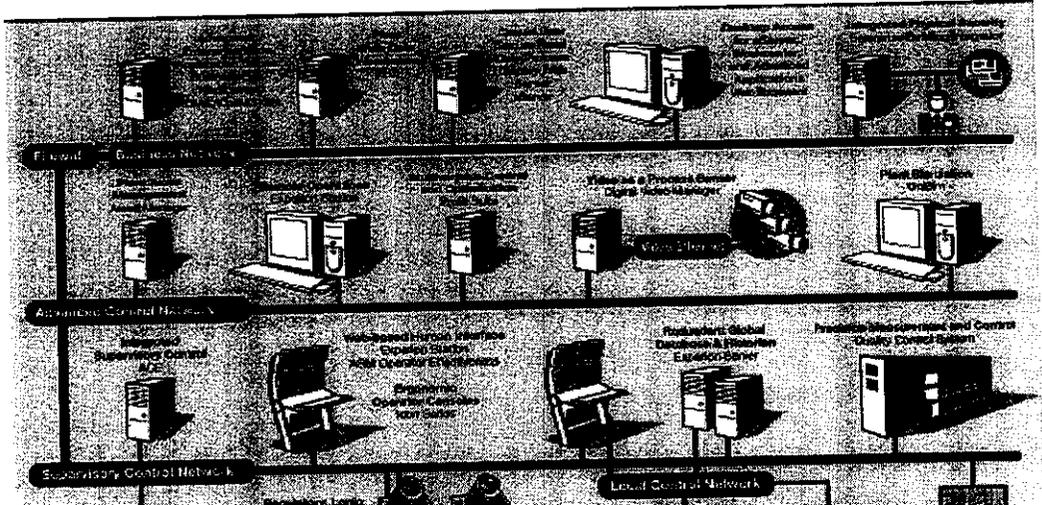
10.1 EXPERION® PROCESS KNOWLEDGE SYSTEM (PKS)

10.1.1 Introducing Experion PKS

Experion PKS is a cost-effective open control system that expands the role of distributed control. It addresses critical manufacturing objectives to facilitate sharing knowledge and managing workflow. Experion provides a robust, scalable, plant-wide system with unprecedented connectivity through all levels of the plant as illustrated in the following high-level view of the architecture. The Experion unified architecture combines DCS functionality and a plant-wide infrastructure that unifies business, process, and asset management to:

- Facilitate knowledge capture
- Promote knowledge sharing
- Optimize work processes
- Accelerate improvement and innovation.

Fig10.2 Experion Platform Architecture



10.1.2 Experion PKS basics

The Experion platform is well suited for both small and large systems. It provides the power and flexibility required to handle the full spectrum of process control applications.

Experion offers state-of-the-art DCS capabilities that include Abnormal Situation Management[®] (ASM[®]), Safety Management, and Information Management technologies. Experion interfaces with **Foundation** Fieldbus, Profibus, Device Net, HART, LON, Control Net and Interbus. Robustness, security, compliance, control, safety, and reliability are plant-wide. Its distributed control features include a complete continuous, logic, sequential, and drive object-oriented control environment hosted on fully redundant controllers.

Experion features include:

- Sophisticated human-machine interface.
- Tightly integrated databases, engineering tools, and control applications.
- Open, deterministic, high-speed control network communications system for predictable and repeatable control linking servers, controllers, and remote I/O.
- A configurable Control Execution Environment (CEE) provides deterministic, consistent, and reliable control application execution.
- A single builder tool, **Configuration Studio**, allows integrated application configuration.

- The **C200 Process Controller** is a compact and cost-effective solution located close to the process with direct IO connections. It is ideal for integrated regulatory, fast logic, sequential, and batch control applications.
- The **C300 Process Controller** is the next generation controller that builds on the reliability and robustness of the C200 controller to provide even more versatile control integration through innovative mounting and connecting techniques.
- The **Application Control Environment (ACE)** is ideally suited for supervisory control solutions and integration with third party control systems. It is hosted on a server grade computer platform.
- The **Simulation Control Environment (SCE)** supports system simulation on computers without requiring dedicated controller hardware or process connections.
- Redundancy support for servers, networks, and controllers.
- Distributed System Architecture (DSA) that integrates multiple servers into a single operational system.
- Support for internationalization/localization.
- Interfaces for wide variety of third-party controllers and protocols.
- A cost-effective architecture that —
 - Makes extensive use of open technologies and commonality of hardware, and

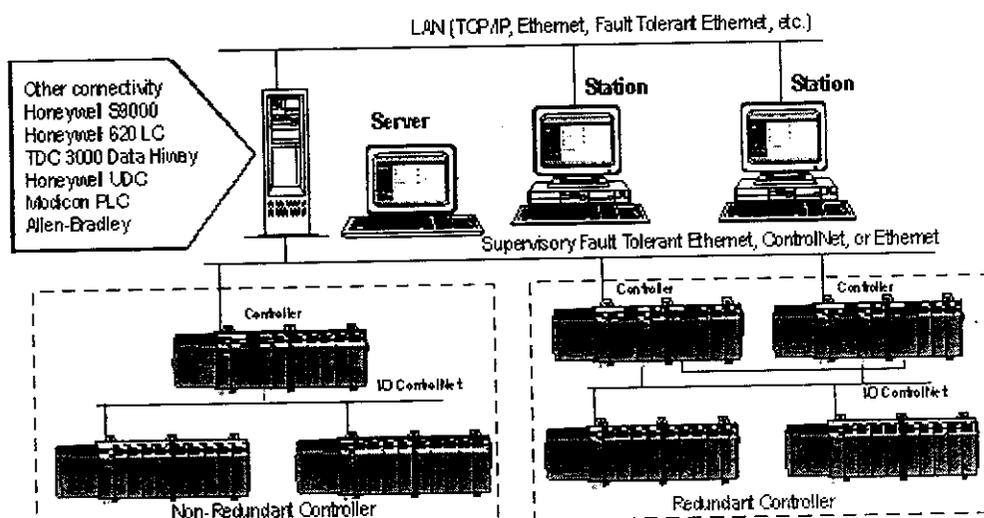
10.1.3 Basic Control System topology

In a basic Experion system topology, the server and C200 and/or C300 Process Controllers share a global database, so you only need to enter data once. This one-step configuration eliminates errors and dramatically reduces configuration time. When you define a control strategy, point detail displays, trends, alarms, and group displays are automatically created, so you instantly have access to the information you need to operate your control strategy. The following figure illustrates the high-level view of a basic Experion system topology. Experion can be segmented into basic sets of hardware component platforms:

- **Supervisory Platform**, which includes non-proprietary computing platforms running Windows operating systems and serving as both server and client Stations. Client Stations are able to serve as both engineering and operating interfaces, depending on the software loaded on each node.
- **C200 and/or C300 Controller**, using a small hardware form-factor supporting a scalable and modular architecture. Commonality and flexibility of hardware components, and their placement within the system, reduce initial cost-to-purchase, and minimize cost-of-ownership.
- **Integrated Controllers**, the server integrates to a number of Honeywell loop controllers and recorders. This integration effectively reduces engineering time by integrating the device configuration tools and/or diagnostic features with the Experion platform.
- **Third -party Controllers**, the server can interface to a number of third party controllers including the Allen Bradley PLC5 and SLC range, Modicon, GE Fanuc and Siemens plus many more.

- **Communications Platform**, which utilizes open network standards, including:
 - Ethernet-or Honeywell's Fault Tolerant Ethernet (FTE) based plant information network (PIN) linking servers and clients together for the purpose of supervisory level communications.
 - Fault Tolerant Ethernet (FTE) network providing the communications link between the C300 Controllers and the supervisory level as well as peer-to-peer communication between Controllers and remote I/O
 - Control Net, Ethernet, or Fault Tolerant Ethernet (FTE) network providing the communications link between the C200 Controllers and the supervisory level, as well as peer-to-peer communications between Controllers
 - Control Net network providing the communications link between the C200 Controllers and remote I/O.

Fig10.3 Basic Experion System Topology with C200 Process Controllers

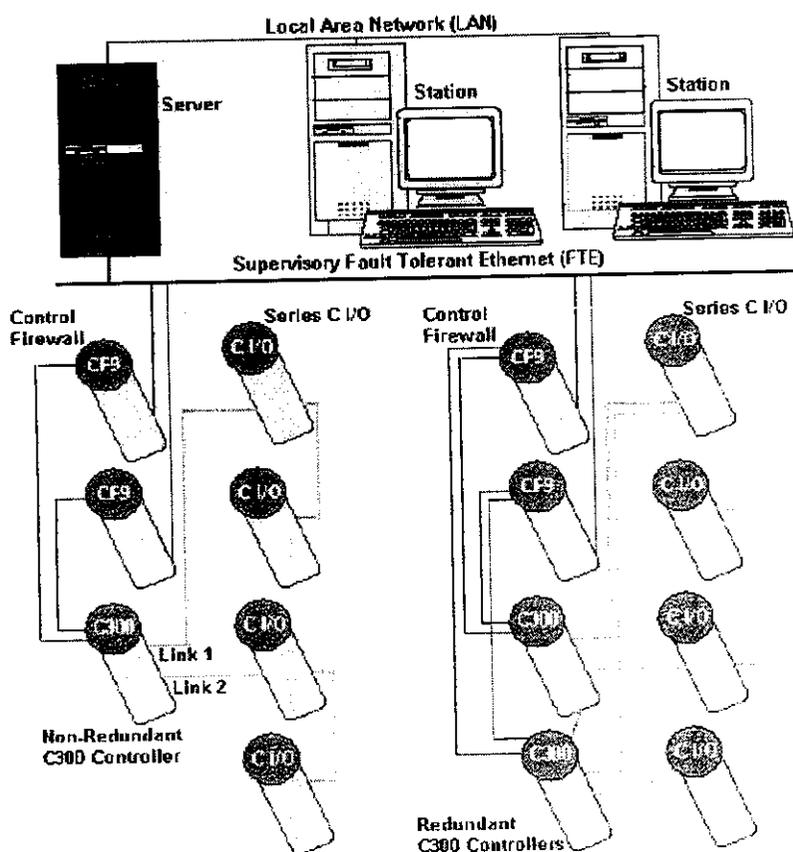


Cost-of-ownership

Experion is designed to lower your total-cost-of-ownership. Examples of how this is achieved include:

- Over 400 pre-built operating displays supporting the needs of operators and engineers.
- Use of open standards including Windows XP/2003, ODBC, OPC (Server and Client).
- Built-in reporting functions.
- Graphical control function blocks that are linked together to build reusable Control Modules.

Fig10. 4 Basic Experion System Topology with C300 Process Controllers



- Support for “as-built” documentation of your control strategy.
- Single control hardware architecture with common components for controllers, I/O, power supplies, and networking.
- Ability to integrate existing control systems.
- Integrated HTML-based Performance Support Tools (PST).
- Advanced diagnostics for simplified troubleshooting and reduced downtime.
- Integration of industry-specific applications such as Smart Grind and Total Plant Batch.

10.1.4 Process Controller

About the controller

The C200 or C300 Process Controller handles all possible control requirements, whether for continuous processes, batch processes, discrete operations, or machine control needs.

The **C200** Process Controller architecture supports one common set of multiple size chassis for both Control Processor and remote chassis I/O configurations. The power supplies are attached, but separate from the chassis and support both 115/230 Vac and 24 Vdc sources. A single ControlNet communications module, available in both non-redundant and redundant media configuration, supports all controller-to-server and controller-to-I/O networking. The Control Processor (CPM) provides the plant-level control execution environment (CEE) for your applications. The I/O system supports discrete, analog, and special

The **C300** Process Controller architecture features an innovative vertical design for more efficient mounting and wiring. It includes integral connections for redundant FTE media and Series C I/O or Process Manager I/O modules. It supports redundant configuration through a dedicated connection and provides the control execution environment (CEE) for your control applications like the C200 controller. The Control Firewall ensures data integrity and an integrated power subsystem distributes power efficiently within a cabinet. The discreet and analog Series C I/O is optionally redundant.

Chassis

Experion supports a common chassis backplane technology that may be used for either C200 controller or remote chassis I/O. This minimizes the cost while maximizing the flexibility of the system.

Five different size chassis assemblies provide you with scalability and flexibility in your control system layout. Each chassis, with cards installed, is 14 cm (5.5 in.) high and 17 cm (6.7 in.) deep. Length is dependent upon the number of slots the chassis provides. Chassis sizes, by number of slots, include:

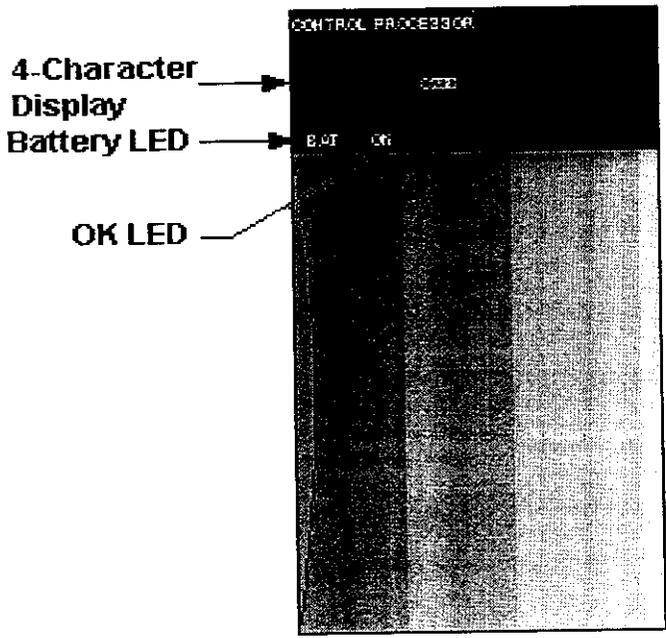
- 4-Slot, 26 cm (10.4 in.) in length
- 7-Slot, 37 cm (14.5 in.) in length
- 10-Slot, 49 cm (19 in.) in length
- 13-Slot, 59 cm (23.5 in.) in length
- 17-Slot, 69 cm (27.7 in.) in length

Control Processor

The C200 or C300 Control Processor is designed for integrated continuous loop, Boolean logic, motor, sequence and batch control functions.

The specific functions of I/O Processing (via IOMs), Modulating/Logic Control (via CMs), and Sequential Control (via SCMs) are selected and defined by configuration prior to process operation. I/O Processing, Modulating/Logic Control, and Sequence Control have access to a common database that includes current parameter values for all IOMs, CMs, and SCMs controlled by all controllers on the supervisory network. The operator also has access to these parameters through Station displays.

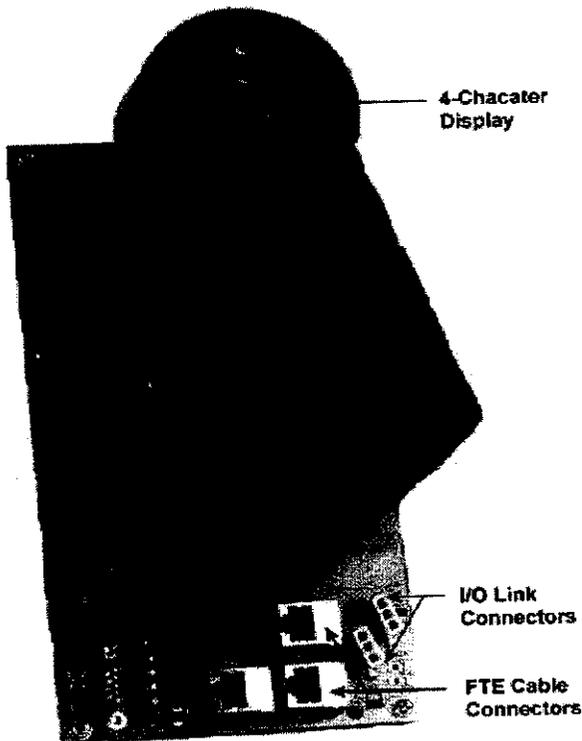
Fig 10.5 C200 Control Processor



Front View

Fig 10.6 C300 Control Processor

Controller redundancy



Process control applications require that the controller recognize when its integrity has been compromised and it should fail over to a backup processor in a bumpless fashion. Honeywell's previous fail over schemes from the Process Manager family of process controllers have been built into Experion's controller redundancy scheme. This patented technology deals with:

- Fault detection
- Guaranteed database synchronization
- Bumpless failure.

The C200 Controller achieves redundancy through matching chassis configurations that include a Redundancy Module with a dedicated link. The Series C form factor components include redundant capability as an integral part of their design. The input/output termination assembly (IOTA) for the C300 Controller includes a connector for a dedicated redundancy link to another C300 Controller. This makes installing and configuring a redundancy scheme in a C300 Controller domain more efficient.

Fig 10.7 Redundancy Module for C200 Controller Redundancy

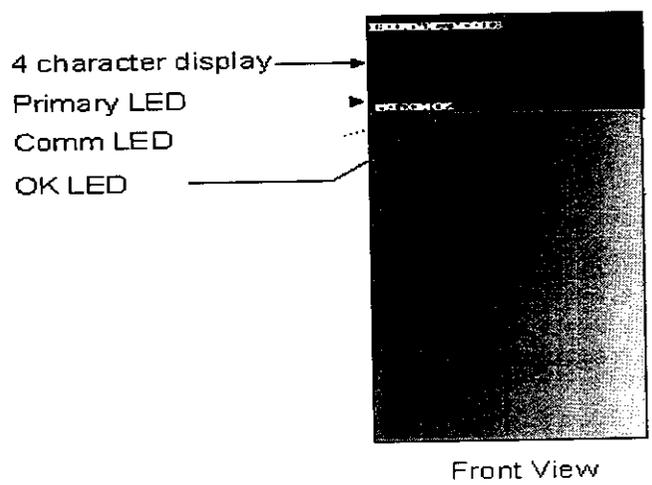
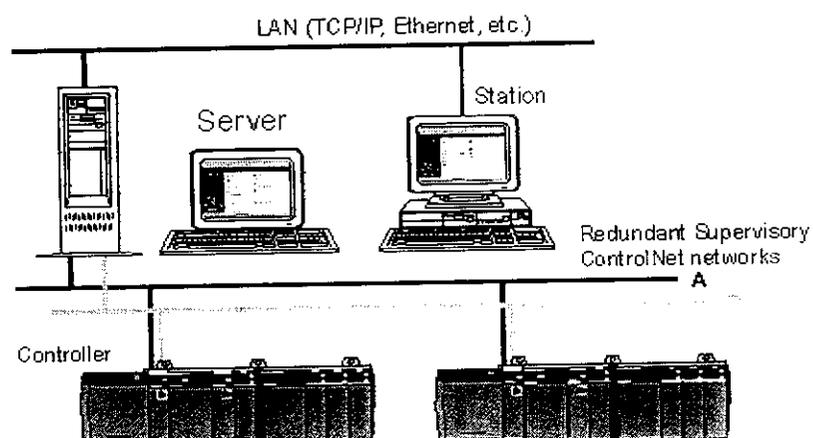


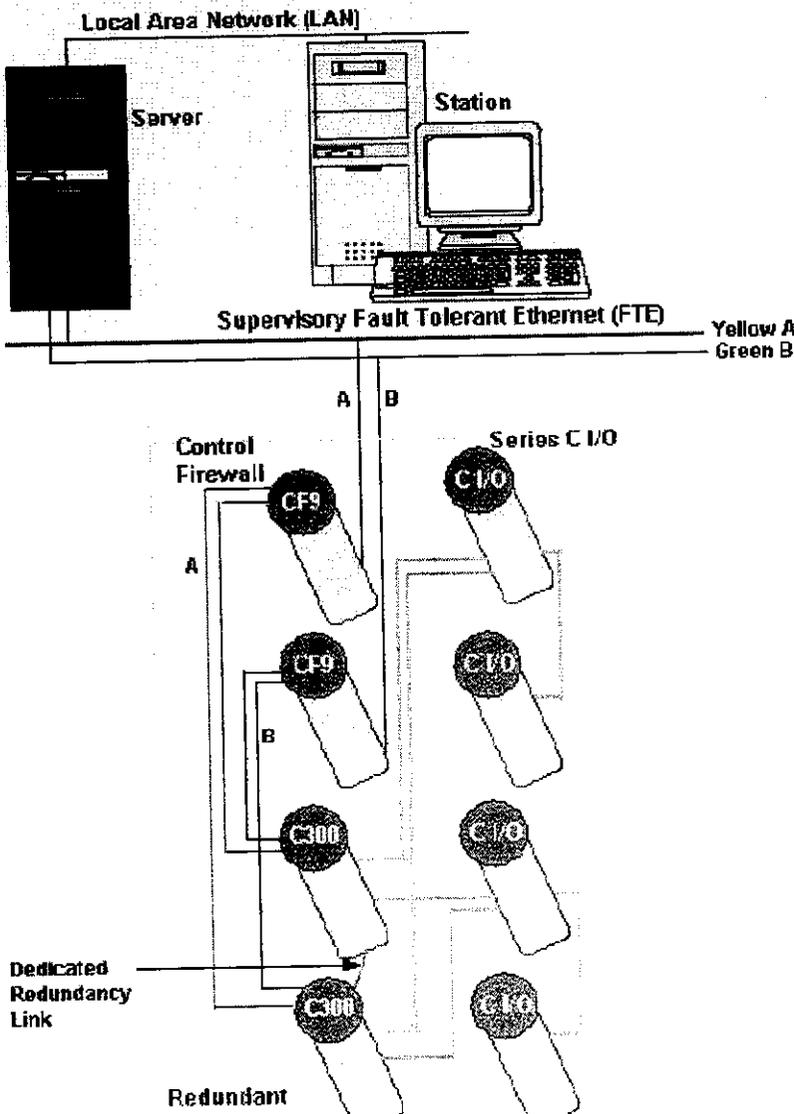
Fig 10.8 Module redundancy for C200 Controller in redundant supervisory ControlNet networks



Bumpless failure

The redundancy aspects implemented in the Experion system are far superior to those available today by PC/PLC systems. The most critical failure task, switching the controller in a bumpless fashion, has been fully implemented in the Experion system.

Fig 10.9 C300 Controller redundancy in supervisory Fault Tolerant Ethernet network



10.2 Field cables

10.2.1 Cable types

The cables that enter the FSC cabinet can be divided into four different groups:

- Earth/grounding cables
- Power/feeder cables
- Field cables, and
- Communication cables

This section deals with the field cables. Field cables are used for interconnection between the FSC cabinets and other equipment, for example marshaling cabinets and/or local panels.

Details on the requirements with regard to separation and routing of cables and wiring are provided in subsection Separation and routing of cables and wiring.

10.2.2 I/O module wiring

Field wiring is not connected directly to the I/O modules themselves. Rather, as illustrated in Figure 10.10, Figure 10.11 and Figure 10.12, these connections are made via:

- Terminal-type FTAs (FTA-T),
- Elco-type FTAs (FTA-E),
- Terminals, or
- Third-party devices.

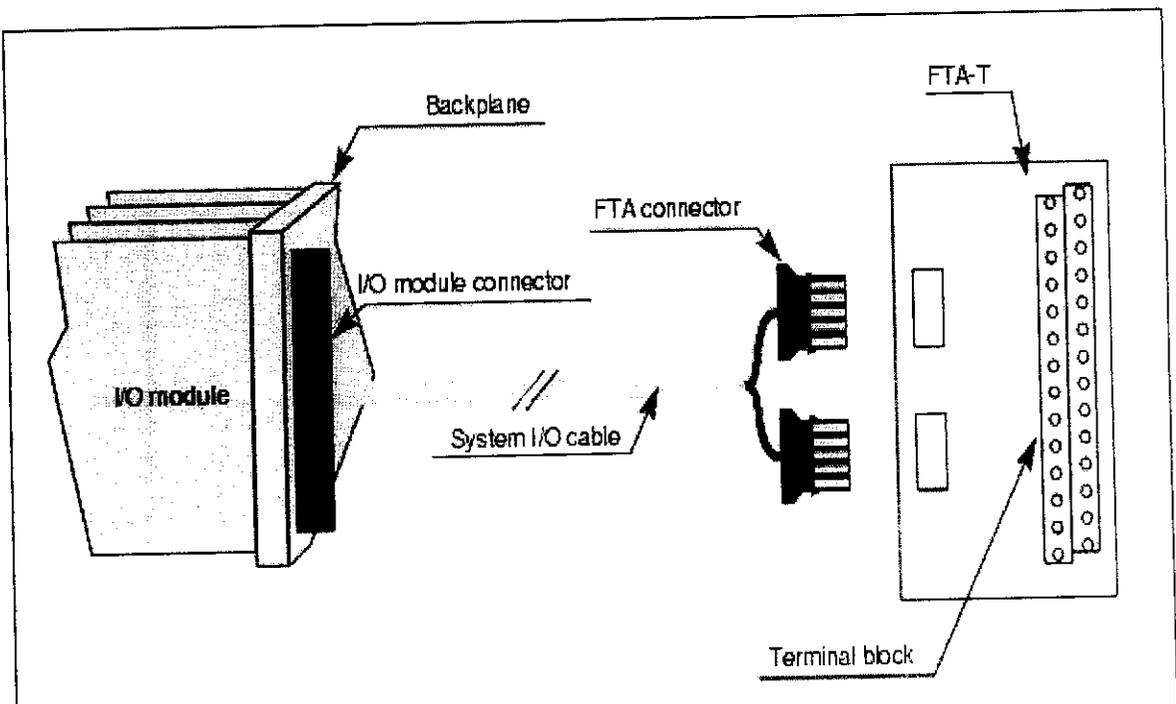
Each of the connection methods is discussed in more detail in the following subsections.

I/O module wiring using FTA-T devices

Using FTA-T

FTA-T modules are field termination assemblies that are fitted with screw terminals to connect field wires directly. They are electrically passive devices which simply pass incoming or outgoing signals between the field and I/O modules. Figure 1 below illustrates a typical routing layout of the internal wiring between I/O modules and FTA-T via system interconnection cables (SIC-Cs).

Fig10.10 typical routing of internal wiring between I/O modules and FTA-T via SIC-Cs



Connecting FTA-T

Fields cables are used for interconnection between FTA-Ts and other equipment, e.g. marshaling cabinets and/or local panels. The FTA-Ts need not necessarily be placed in the FSC cabinet. They can also be placed remotely (e.g. a marshaling cabinet).

Before connecting the field cables, take the following steps to prevent damage to the FSC equipment:

- Open all knife-type terminals installed in the FSC cabinet and/or marshalling cabinet.
- Remove all fuses from terminals which are used for I/O wiring installed in the FSC cabinet and/or marshalling cabinet.
- Remove all fuses from the FTAs.

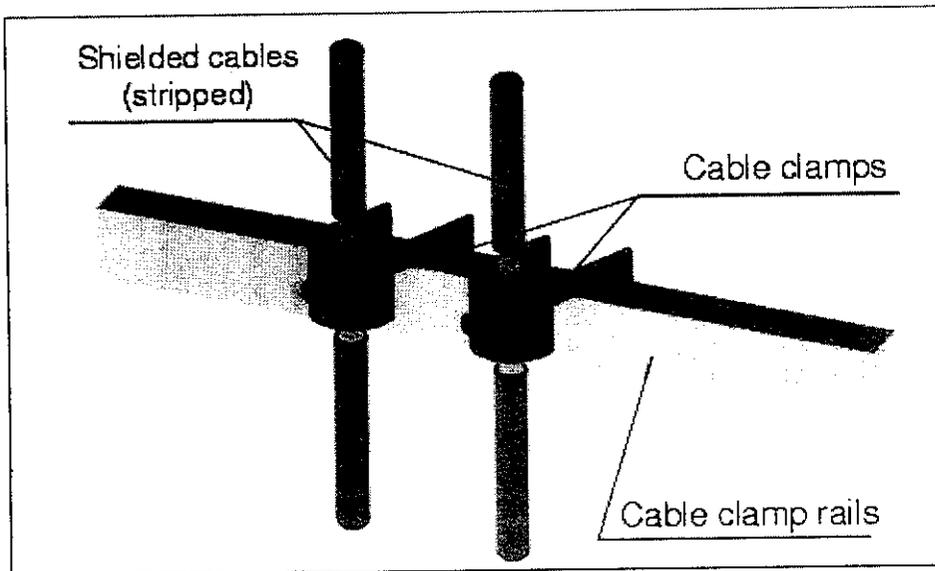
To connect the field cables, take the following steps for each cable:

1. Secure the field cable to the cable support/clamp rail of the FSC cabinet.
2. Route the field cable to the FTA-Ts where the connections should be made.
3. Connect all cores to the corresponding terminals on the FTA-Ts according to the termination details. Leave sufficient slack on the cores to avoid tension on the connections on the FTA-Ts.
4. If required, connect the earth wire from the field cable to the FTA-T.
5. Use tire wraps to tighten the field cable in the cable duct.
6. Close all knife-type terminals and put the fuses back into the terminals used for the I/O wiring and the FTAs.

The next steps are only applicable to field cables carrying signals which are connected via FTA-Ts to the following type of FSC I/O modules:

- 10102/x/x (analog input module),
 - 10214/x/x (loop-monitored digital output module), or
 - 10216/x/x (loop-monitored digital output module).
7. Remove the field cable from the cable support/clamp rail.
 8. Remove the insulation at the height of the cable support/clamp rail.
 9. Secure the field cable with the blank shield to the cable support/clamp rail.

Fig 10.11 Bonding of shielded cables (FTA-T)



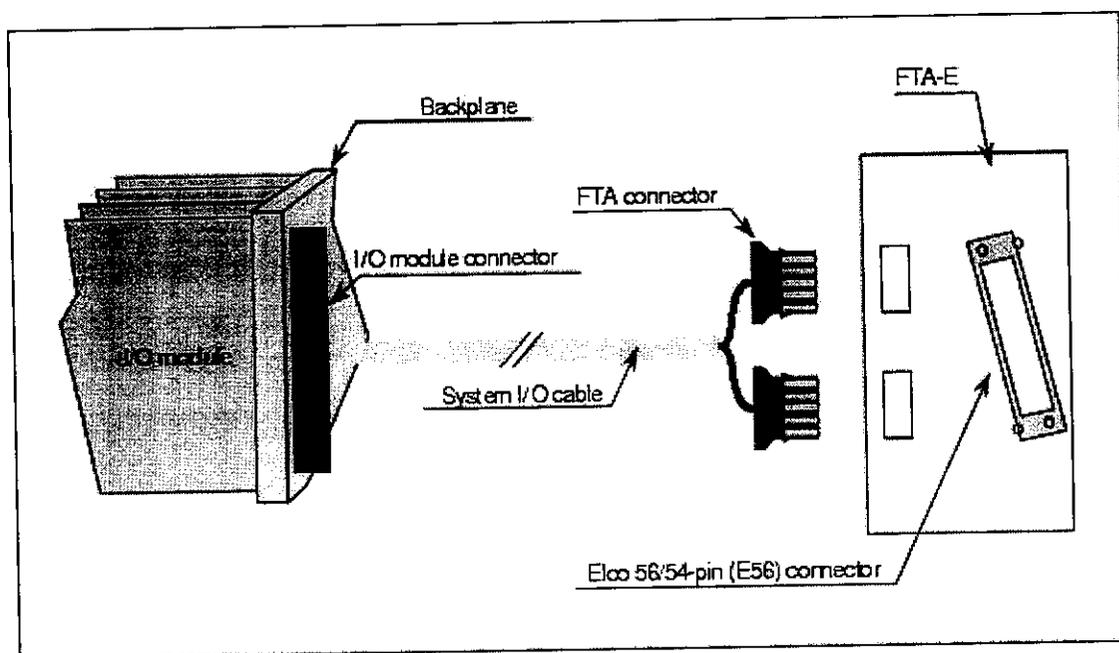
I/O module wiring using FTA-E

FTA-E modules are field termination assemblies that are fitted with a standard

passive devices which simply pass incoming or outgoing signals between the field and I/O modules.

Fig 10.12 below illustrates a typical routing layout of the internal wiring between I/O modules and FTA-E via system interconnection cables (SIC-Cs).

Fig 10.12 typical routing of internal wiring between I/O modules and FTA-E via SIC-Cs



Connecting FTA-E

System cables (Elco cables) are used for interconnection between FTA-Es and other equipment, e.g. a DCS system and/or marshaling cabinets.

The FTA-Es need not necessarily be placed in the FSC cabinet. They can also

If system cables are used, the following is assumed:

- The system cable has not been connected to the external device.
- The system cable end at the external device is a system cable plug or has a termination with crimp pins which are suitable for connection to screw terminals.

Before connecting the system cables, take the following steps to prevent damage to the FSC equipment:

- Open all knife-type terminals installed in the FSC cabinet and/or marshalling cabinet.
- Remove all fuses from terminals which are used for I/O wiring installed in the FSC cabinet and/or marshalling cabinet.
- Remove all fuses from the FTAs.

To connect these system cables, take following steps for each cable:

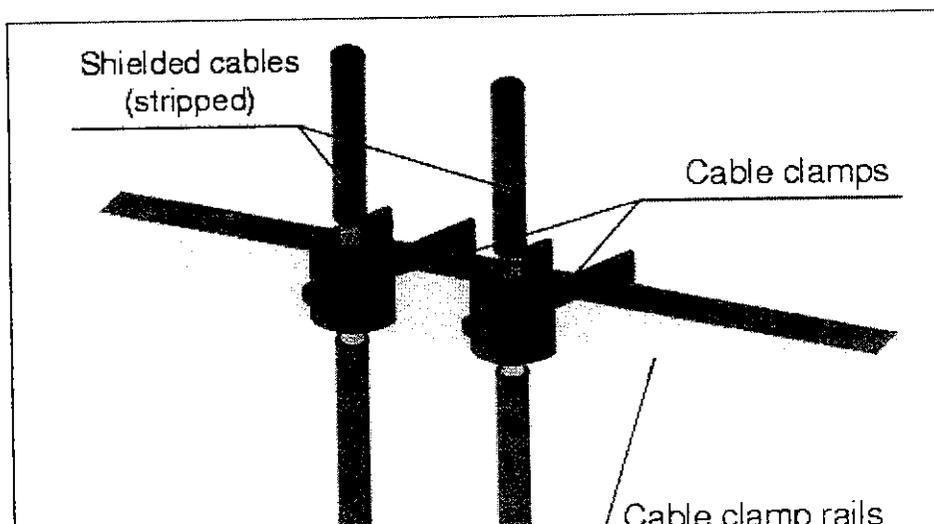
1. Secure the system cable to the cable support/clamp rail of the FSC cabinet.
2. Route the system cable to the FTA-E where the connection should be made. Leave some slack in the system cable to allow connection of the system cable plug to the FTA-E. Do not connect the system cable plug to the FTA-E at this point.
3. Use tire wraps to tighten the system cable to the cable tray.
4. Roll the system cable to the external device (e.g. DCS system or marshalling cabinet).
5. Connect the system cable end to the external device (e.g. DCS system or marshalling cabinet).

6. Secure the system cable to the cable support/clamp rail of the external device (e.g. DCS system or marshalling cabinet).
7. Connect the system cable connector to the FTA-E mounted in the FSC cabinet, close all knife-type terminals, and place back the fuses in the terminals used for the I/O wiring and the FTAs.

The next steps are only applicable to system cables carrying signals which are connected via FTA-Es to the following type of FSC I/O modules:

- 10102/x/x (analog input module),
 - 10214/x/x (loop-monitored digital output module), or
 - 10216/x/x (loop-monitored digital output module).
8. Remove the system cable from the cable support/clamp rail.
 9. Remove the insulation at the height of the cable support/clamp rail.
 10. Secure the system cable with the blank shield to the cable support/clamp rail.

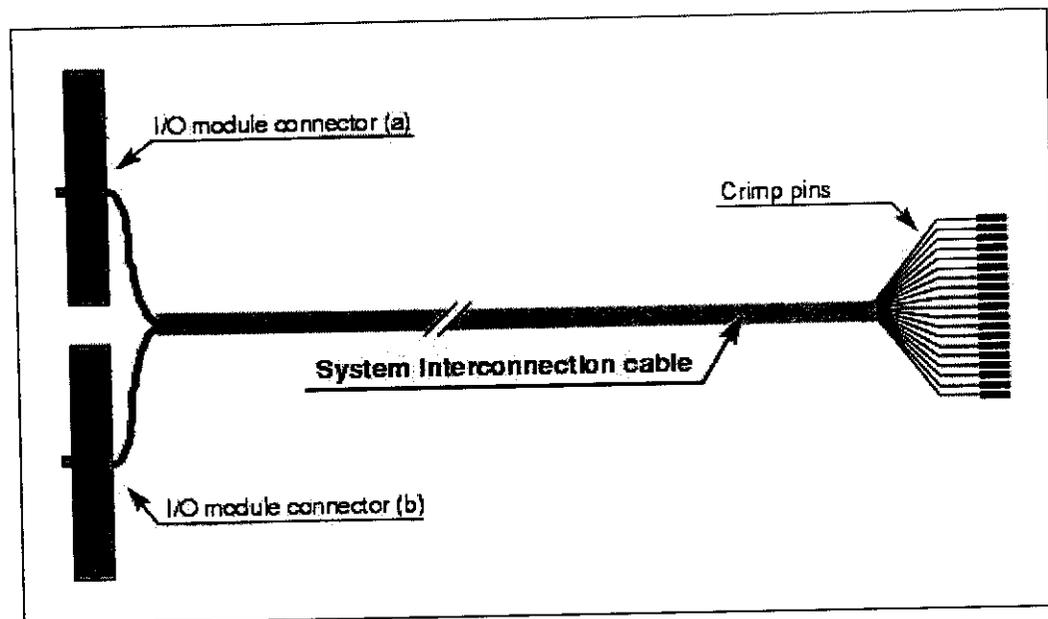
Fig 10.13 Bonding of shielded cables (FTA-E)



I/O module wiring using terminals

Using terminals

Fig10.14 Typical layout of a SIC-P cable



10.2.3 Connecting terminals

Fields cables are used for interconnection between terminals placed in the FSC cabinet and other equipment, e.g. marshalling cabinets and/or local panels. The terminals need not necessarily be placed in the FSC cabinet. They can also be placed remotely (e.g. a marshalling cabinet).

Before connecting the SIC-P and field cables, take the following steps to prevent damage to the FSC equipment:

- Open all knife-type terminals installed in the FSC cabinet and/or

- Remove all fuses from terminals which are used for I/O wiring installed in the FSC cabinet and/or marshalling cabinet.

When the terminals are placed remotely (e.g. marshaling cabinet), take the following steps for each SIC-P cable:

1. Route the SIC-P cables from the FSC cabinet to the marshalling cabinet.
2. Secure the SIC-P cable to the cable support/clamp rail of the FSC cabinet.
3. Secure the SIC-P cable to the cable support/clamp rail of the marshalling cabinet.
4. Route the SIC-P cable to the terminals where the connections should be made.
5. Connect all cores from the SIC-P cable to the corresponding terminals in accordance with the termination details, which are part of the project-related documentation. Leave sufficient slack on the cores to avoid tension on the connections on the terminals.
6. Use tire wraps to tighten the field cable in the cable duct.

To connect the field cables, take following steps for each cable:

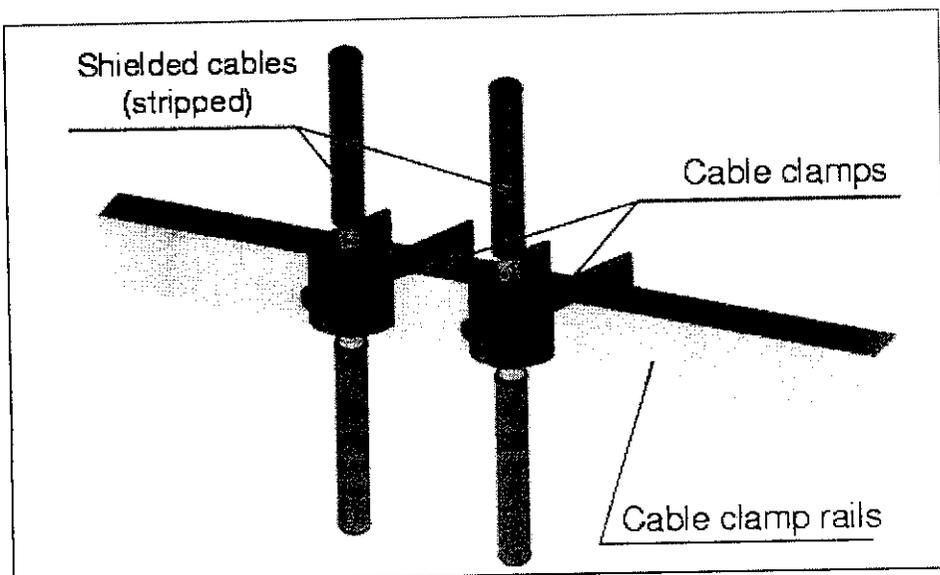
1. Secure the field cable to the cable support/clamp rail of the FSC cabinet.
2. Route the field cable to the terminals where the connections should be made.
3. Connect all cores to the corresponding terminals in accordance with the termination details. Leave sufficient slack on the cores to avoid tension on the connections on the terminals.
4. Use tire wraps to tighten the field cable in the cable duct.

5. Close all knife-type terminals and place back the fuses in the terminals used for the I/O wiring and the FTAs.

The next steps are only applicable to field cables carrying signals which are connected via FTA-Ts to the following type of FSC I/O modules:

- 10102/x/x (analog input module),
 - 10214/x/x (loop-monitored digital output module), or
 - 10216/x/x (loop-monitored digital output module).
6. Remove the field cable from the cable support/clamp rail.
 7. Remove the insulation at the height of the cable support/clamp rail.
 8. Secure the field cable with the blank shield to the cable support/clamp rail.

Figure 10.15 Bonding of shielded cables (terminals)



I/O module wiring using third-party devices

Using third-party devices

Two manufactures currently provide devices (backplanes) which can be connected to the FSC I/O modules using SIC-C cables: Pepperl + Fuchs and MTL.

These backplanes are used for interconnection between the FSC I/O modules and:

- Ex (i) field devices. In this case all field cables should be colored blue and the field cables should be segregated from all other non-Ex (i) field cables. The cables should also be segregated in the FSC cabinet.
- Non-Ex (i) field devices. Standard-colour field cable can be used.

10.2.4 Connecting third-party devices

Fields cables are used for interconnection between the third-party devices placed in the FSC cabinet and other equipment, e.g. marshaling cabinets and/or local panels. The third-party devices need not necessarily be placed in the FSC cabinet. They can also be placed remotely (e.g. a marshaling cabinet).

Before connecting the field cables, take the following steps to prevent damage to the FSC equipment:

- Open all knife-type terminals installed in the FSC cabinet and/or marshalling cabinet.
- Remove all fuses from terminals which are used for I/O wiring installed in the FSC cabinet and/or marshalling cabinet.

1. Secure the field cable to the cable support/clamp rail of the FSC cabinet.
2. Route the field cable to the terminals of the third-party device where the connections should be made.
3. Connect all cores to the corresponding terminals on the third-party device in accordance with the termination details. Leave sufficient slack on the cores to avoid tension on the connections on the terminals on the third-party device. Special field connectors may be required, depending on the manufacturer.
4. Use tire wraps to tighten the field cable in the cable duct.
5. Close all knife-type terminals and place back the fuses in the terminals used for the I/O wiring.

10.3 Communication cables

10.3.1 Cable types

The cables that enter the Safety Manager™ cabinet can be divided into four different groups:

- Earth/grounding cables
- Power/feeder cables
- IO field cables
- Communication cables

10.3.2 Overview

The communication FTAs and Ethernet switches of Safety Manager are placed in the Safety Manager cabinet. This is done in order to achieve easy access to the Safety Manager cabinet for the external communication cables.

The communication FTAs and Ethernet switches can be considered an extension of the communication modules.

External communication cables may be supplied with the Safety Manager cabinet.

All cables are clearly tagged for easy identification and connection.

10.3.3 Communication cables

The communication cables can be divided in three groups:

- Fiber optic cables,
- Ethernet cables.

10.3.4 Fiber optic cables

Fiber optic converter module

To connect the fiber optic cables to the fiber optic converter module mounted in the Safety ManagerTM cabinet, take the following steps:

1. Connect the fiber optic cable to the fiber optic converter module mounted in the Safety Manager cabinet.
2. Clamp the fiber optic cable to the cable tray or cable duct mounted next to the fiber optic converter module in the Safety Manager cabinet. Pay close attention to the following items:
 - Make sure that sufficient slack is available in the fiber optic cable.
 - Check the specification of the fiber optic cable for the minimum bend diameter.
3. Roll the fiber optic cable to the corresponding device.

Considerations

If the fiber optic cables are to be connected to a fiber optic converter placed in the Safety Manager cabinet, the following considerations should be noted:

- The transmitter signal and receive signal between two devices that use communication via fiber optic cables should be swapped.
- Provide a cable duct/tray to route the fiber optic cables to the fiber optic converters.
- Check the specification of the fiber optic cable for the minimum bend radius. Make sure that the fiber optic cable can be routed in such a way that the bend radius in the cable will never be less than the specified minimum.
- Check the maximum allowable transmission loss.
- Check the minimum required transmission loss. To achieve the minimum required transmission loss, fiber optic dampers may need to be installed.

10.3.5 Connecting to Ethernet switches

To connect the Ethernet cables to the switches, take the following steps:

1. Connect the Ethernet cable to the allocated port of the assigned switch located in the Safety Manager cabinet.
2. Clamp the Ethernet cable to the cable tray or duct mounted next to the communication module using tire wraps. Check the specification of the Ethernet cable for the minimum bend diameter.
3. Roll the Ethernet cable to the corresponding device.
4. Connect Ethernet cable in the allocated port of the corresponding device.

11. CONCLUSION

Lime kiln parameters are controlled by a multivariable controller driven by APC. APC controls the entire lime kiln to increase throughput, reduce burned lime quality variability and optimize energy usage. The APC solution optimizes the lime kiln operation by providing continuous monitoring of process. The APC solution is designed to achieve excellent control using standard lime kiln field and test measurements.

12. BIBLIOGRAPHY

REFERENCES

1. Brad S. Carlberg, p.e., Senior Controls & Instrumentation Engineer
Becchtelnational inc.,Richland, wa 99354.
Unit processes and optimisation oppurtunities in the pulp & paper mill
2. Raluca Constantinescu, lead developer, AMEC technologies, inc.
MRAC strategy for the temperature profile control of a lime kiln
3. Serge Naud, PE & Martin Emound, Canada
Lime kiln control using simple advanced regulatory control strategy