Antti Perälä

WÄRTSILÄ TURBOCHARGER WASH AND DEW POINT CONTROLLER INTE-GRATION

Technology and Communication
2013

FOREWORD

The thesis was done at Vaasa University of Applied Sciences in the Degree programme in Electrical Engineering. The client of the thesis was Plant Automation unit in Wärtsilä Services. I would like to thank members of the team for providing the topic and supporting me in this thesis project. The topic of the thesis was interesting and I felt comfortable to be a part of the team. I would like to thank also Olli Tuovinen, my thesis supervisor and Sanna-Liisa Koski, my language consult from the UAS.

Vaasa 10.5.2013

Antti Perälä

VAASAN AMMATTIKORKEAKOULU
Sähkötekniikan koulutusohjelma

TIIVISTELMÄ

Tekijä	Antti Perälä
Opinnäytetyön nimi	Wärtsilä Turbocharger Wash and Dew Point Controller integration
Vuosi	2013
Kieli	englanti
Sivumäärä	36
Ohjaaja	Olli Tuovinen

Wärtsilällä on tällä hetkellä laivakäyttöön kaksi erillistä moottoreiden yhteyteen asennettavaa ohjauskeskusta, yksi turboahtimien pesulle ja toinen ahtoilman lämpötilan säädölle. Molemmat keskukset on toteutettu samanlaisella ohjelmoitavalla logiikalla, johon on liitetty tarvittavat I/O-kortit sekä ohjausta ja valvontaa varten kosketusnäyttö.

Työssä pyritään löytämään ratkaisu kahden erillisen ohjausjärjestelmän järkevään yhdistämiseen yhdeksi kokonaisuudeksi. Tällöin säästetään materiaalikuluissa, tilassa ja työmäärässä. Työn tavoitteena on luoda yleismalli, joka soveltuu mahdollisimman moneen erilaiseen asennusympäristöön. Lisäksi käytettävät ratkaisut pyritään toteuttamaan siten, että käyttöönotossa tarvittavat säädöt voidaan tehdä ohjauspaneelin kautta ilman tietokonetta.

Työn lopputuloksena syntyi alkuperäisestä suunnitelmasta muunneltu versio. Ominaisuuksia lisättiin työn aikana ja yhteensopivuutta erilaisiin asennusympäristöihin kehitettiin alkuperäistä suunnitelmaa pidemmälle. Lisäksi vikatilanteiden toimintoja muutettiin vastaamaan annettuja vaatimuksia.

Avainsanat   Turboahdin, kastepiste, jäähdytysjärjestelmä

VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES
Sähkötekniikan koulutusohjelma

ABSTRACT

Author	Antti Perälä
Title	Wärtsilä Turbocharger Wash and Dew Point Controller integration
Year	2013
Language	English
Pages	36
Name of Supervisor	Olli Tuovinen

There are two separate control cabinets used in Wärtsilä marine solutions, Turbocharger Wash Control and the Dew Point Control. The cabinets contain similar PLCs with I/O-cards needed in the system and touch screen for monitoring and controlling purposes.

The purpose of the thesis was to find and implement a solution for integration of the control cabinets. The advantages of the integration are savings in material, space in the engine room and amount of work. The aim of the project was to create a general model which is suitable for different configurations and simplify the commissioning process so that the programming laptop is not needed.

The result of the project is a version which has many functions that were not in the initial plan. New functions were planned and implemented during the project and the compatibility with the different configurations was developed. More advanced alarm handling was designed to the system.

Keywords Turbocharge, dew point, cooling system

INDEX

LIST OF FIGURES AND TABLES

1   INTRODUCTION

1.1 Wärtsilä Business Units

Wärtsilä provides power solutions, support and services for energy and marine markets all over the world. Wärtsilä has operations in 70 countries in nearly 170 locations. The net sales in 2012 totalling EUR 4.7 billion grew by 12% over a year.

The business is divided in three fields: Power Plants, Ship Power and Services. Power Plants supplies power plants allowing seamless integration with intermittent renewable power generation. Multi-fuel power plants are offered for various purposes such as base load generation, ultra-fast grid reserve and many others. The power plant field earned 32% of net sales in 2012. Ship Power provides solutions for the marine, oil and gas industry. The product line contains complete offering of product in the marine field. Ship power earned 28% of net sales in 2012. Services support its customers everywhere in the world for energy and marine markets. They provide services over the lifecycle of the installations by optimizing efficiency and performance. 40% of the net sales were earned by Services in 2012. /14/

1.2 Plant Automation

The thesis was ordered by Plant Automation unit which is part of Service in Wärtsilä. The unit is part of the technical service and provides technical support for automation systems used in Wärtsilä products except automation system of the engines. The unit takes care of software support, training arrangement, site audits and technical requests, for example. /17/

1.3 The Purpose of the Thesis

The topic of the thesis was the integration of Wärtsilä Turbocharger Wash and Dew Point Controller. The purpose of the thesis was to find and implement a solution for the integration of the two separate control systems, the initial devices were in separate cabinets with own PLCs (Programmable Logic Controller) and HMIs (Human Machine Interface). The functions of the two systems should be integrated into the common PLC and HMI in the common cabinet. This includes designing new functions and modifying the application in the PLC to a simpler structure. The HMI application also needs to be modified to meet the requirements of the both devices.

2 CONTROL FUNCTIONS

There are two separate control cabinets used today, one for Turbocharger Wash Control and one for Dew Point Control. Both cabinets contain Schneider Electric Modicon M340 PLC with I/O-cards needed in the solution. Turbo Wash control is implemented with Mitsubishi E1061 panel and Dew Point Control with Schneider Electric Magelis panel, the Magelis panel will be used in this project because of its reasonable price compared to Mitsubishi. The Dew Point Control system is quite a new product; there is only one pilot system in use today where the Magelis panel has been tested with success.

2.1 Turbo Wash

The purpose of the turbocharger is to produce compressed air for the combustion process in the engine. More compressed air can be squeezed into the cylinder and more fuel can be added, more fuel and air means more power. The construction of the turbocharger is quite simple; the device consists of a compressor, a turbine, a shaft connecting previous parts and bearings (Figure 1). The turbocharger uses waste energy of the exhaust gases of the engine for producing charged air for the engine. /3/
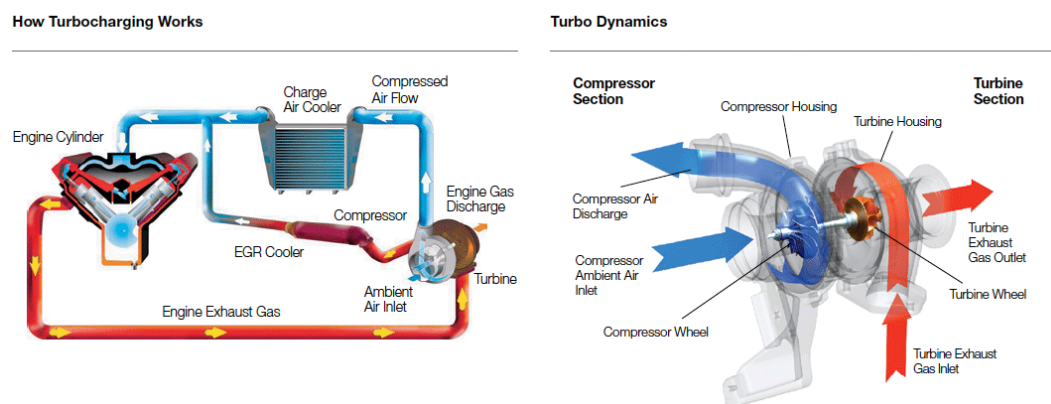

Figure 1. The construction of the turbocharger /4/

Hot exhaust gases are routed to the turbine side of the turbocharger. The gases make turbine rotate when flowing from the engine to the exhaust pipe. The turbine wheel and compressor wheel are connected by a shaft; thus the turbine spun by the exhaust gases also spins the compressor wheel. The rotating compressor pulls air into the engine, the process is called turbo charging. The temperature of the intake air rises in the turbocharger, therefore the air is passed through a cooler which reduces the temperature and increases the density. /3, 4/

The intake air contains particles which catch in the compressor and forms a layer, reducing the efficiency of the turbocharger. The air passes also through the cooler and causes a similar dirt layer which increases the pressure loss and increases the temperature of the intake air. Exhaust gases contain some residues depending on the fuel burnt and type of the lubricant oil. The residues flow into the turbine with the exhaust gases and form a dirt layer there, the dirt layer reduces the efficiency of the turbocharger. The residues in the exhausts gases can contain corrosive components initiating corrosion in the turbine. Trouble free operation can be ensured with regular washing to prevent slowly developing problems in turbine and compressor.

Lower turbocharger efficiency causes higher exhaust gas temperatures, lower charging pressure and smaller air flow. The reduction of the efficiency progresses very slowly with time (Figure 2). The turbocharger will be washed in certain intervals to improve efficiency and extend the intervals between mechanical cleaning. Turbine and compressor of the turbocharger can be cleaned with water wash during the part-load operation. They will be dismantled for cleaning purposes in 8000-16000 hours intervals in normal conditions. /8/
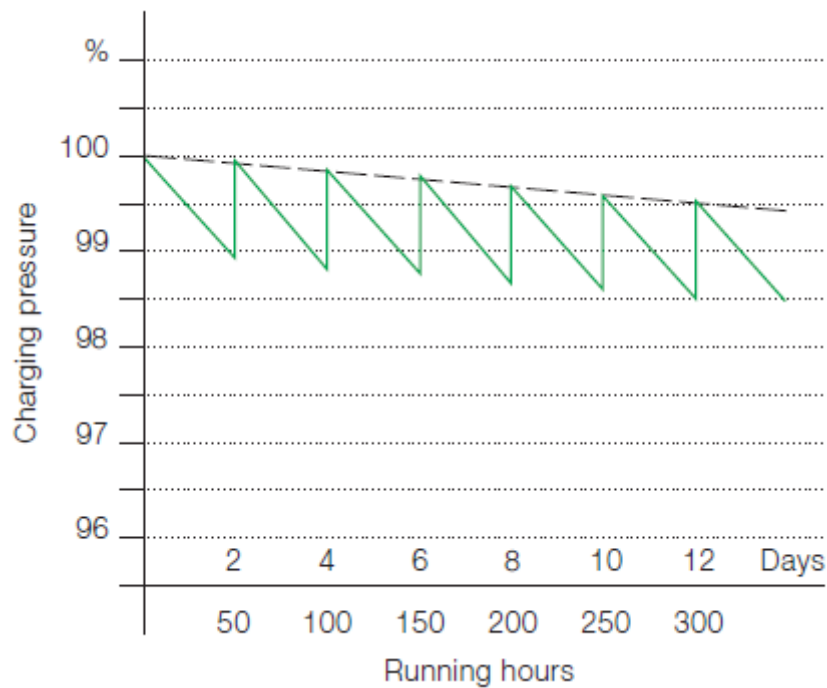
Figure 2. Efficiency of the turbocharger /8/

2.2 Turbo Charger Wash control

The washing unit is used in engines running on HFO (Heavy Fuel Oil) which forms more residues than other fuel types. The device uses magnet valves to control turbocharger washing. The washing will be executed when the interval time has elapsed and the conditions, such as the load of the engine and the temperature of the exhaust, are suitable for washing. The load of the engine and the temperature of the exhaust have to be within certain limits for washing. The washing sequence has two separate parts, one for turbine wash and one for compressor wash. The turbine wash has the following sequence:

- The exhaust temperature has to be under certain value sufficient time to start the process.
- Water is injected for the predefined time into the turbine for cleaning the parts.
- Air is blowed to ensure the evacuation of the water.

- The load of the engine is kept at low level for a predefined time before setting it back to the initial level.

The compressor wash is simpler; it has only two steps in the sequence: water is injected to the compressor and the evacuation of the water is ensured with air blow. /15/

2.3 Dew Point

The maximum amount of the water vapor in the air depends on the temperature and pressure of the air. The temperature at which the maximum amount of the water vapor equals to current amount of the water vapor in the air is called dew point temperature. The condensation of water occurs when the water content of the air reaches the saturation point, in other words the relatively humidity tries to exceed 100%. Lower air pressure and lower humidity ratio means lower dew point temperature. /1, pp. 176-178/

2.4 Dew Point Control

The Dew Point Controller adjusts charge air temperature to prevent the condensation in the charge air receiver. The condensation depends on the temperature of the charge air and the dew point of the charge air, and the dew point is calculated in the PLC from humidity and charge air pressure. The controller is needed to compensate variable conditions such as engine load and suction air humidity to reach the optimized temperature and efficiency. The advantages of the system are fuel saving and also the optimization of NOx emissions. The disadvantage of condensation is the corrosion caused by the water in the charge air receiver, which can be prevented with the controller.

The Dew Point Controller controls the temperature of the charge air by a 3-way valve in the cooling water system called the LT-valve (Low Temperature) which is part of the cooling system (Figure 3). The temperature of the charge air is continuously controlled in order to achieve optimal temperature over the current dew

point temperature. The conventional control solution keeps the temperature at a constant level despite the conditions around; therefore the temperature of the charge air is on optimal level only under certain conditions. The conventional controller can also be used as a backup system if sensor fault occurs.
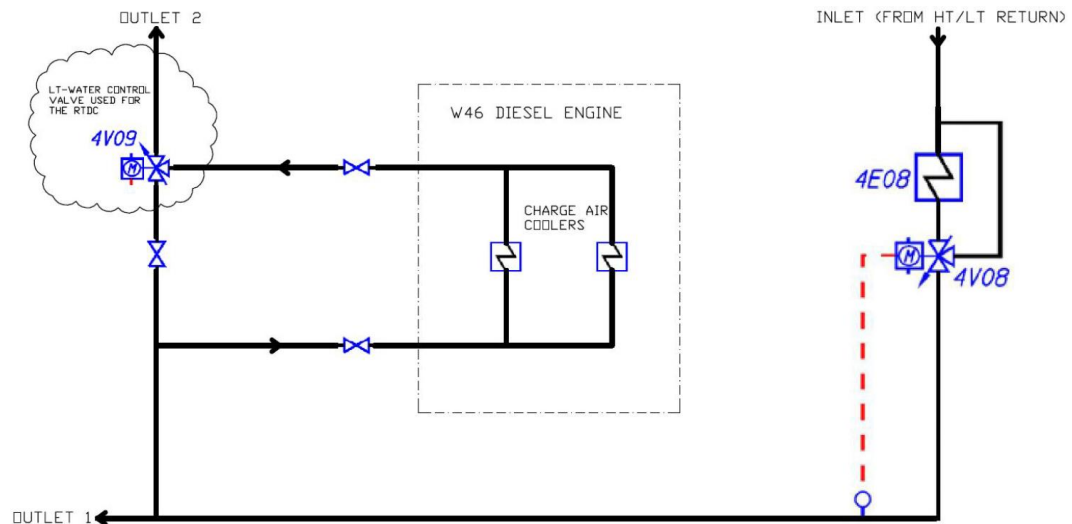

Figure 3. Cooling system

The system is available in several different versions depending on the level of the automation system of the engine and the type of the LT-valve actuator. Separate sensors for charge air pressure and temperature measurements must be installed on the charge air receiver, or the existing sensors can be used with signal multiplier, if the automation system of the engine does not provide the measurements via Modbus. In Unic C2 and C3 automation systems the measurements are available via Modbus TCP/IP for the Dew Point Controller without additional sensors in the charge air receiver. The ambient air temperature and humidity are measured with a separate sensor located near to the air intake of the engine. The LT-valves are either 4-20mA or pulse controlled. /16/

3   INTEGRATION

The purpose of the project was to find and implement a solution for integrating the control cabinets; all functions will be combined in the same PLC and in the same HMI panel. The hardware was designed for four engines with analog measurements and pulse controlled LT-valve in this thesis, the Modbus/TCP version may be designed later. The programming software used for PLC configuring was Unity Pro XL v6.0 which supports Schneider Electric Modicon line PLCs. The software of the PLC was designed for the four engine system; the number of the engines can be selected on the HMI panel with commissioning authorization. The purpose of the project was to design the PLC software and HMI so that there is no need for a programming laptop in the commissioning, the customer can set up all needed parameters via the HMI with commissioning authorization. The PLC has an internal memory card which can be used for updating the application of the PLC according to Wärtsilä internal document DBAB943255 and the HMI has similar function to update application from USB memory. The update procedures do not require a programming laptop or any special tools so the customer can update applications easily.

3.1 Hardware

The project was started with hardware designing according to initial documentation and the requirements for the integrated system. The system needs relatively many digital outputs, the Turbocharger Wash Control needs six digital outputs for washing valves of the each engine while Dew Point Controller is designed to use pulse controlled valves that needs three outputs for each engine. The system uses many temperature, pressure and valve position measurements and a few digital inputs. The position feedback signal from LT-valves is of potentiometer type which has not been used before so it may need some investigation. The cabinet has a power supply with 230VAC input and the voltage of the system is 24 VDC for inputs, outputs, PLC and HMI. The components used in the cabinet must have

marine classification because the cabinet will be used in ships. The circuit diagram was drafted from the initial circuit diagrams with some modifications for the planner team.

3.1.1 PLC

Schneider Electric Modicon line includes three different PLC series. The most powerful is the Quantum series which is suitable for installations with high requirements. The series has functions needed in process industry, such as continuous operation, redundant backup and optimized cycle time for example. The Premium series is a versatile device with fewer functions and lower price and designed for process and manufacturing controls. The last series of the line is Modicon M340. The M340 is called PAC (Programmable Automation Controller) which has fewer functions compared to the other devices in the family. The M340 is utilized with modern communication functions that allows co-operation with other PLCs, for example. /9/

3.1.2 Schneider Electric Modicon M340

The Modicon M340 has the marine approval which is required in ships. The hardware configuration is made up of different modules fixed to the rack, the modules can be in one rack or distributed in several racks with the rack extender module which has its own slot in each rack. There are different sizes of racks available, the smallest rack has only four slots and the biggest one has 12 slots. The maximum number of chained racks is four depending on the features of the CPU, thus the maximum number of modules is 48 in one system. The maximum length of the rack extension bus is 30 meters; it is not designed for distributed I/O. The power supply has to be fixed in each rack to supply the modules in the rack.

The hardware configuration of the system has a power supply, a CPU and four different types of I/O-cards. The modules are mounted in one rack leaving no free slots for expansions. The type of the power supply is CPS2010, which has 24

VDC and 1 A input. The power module supplies other modules via a backplane. The model of the CPU in the system is P342020 which can process up to 1024 discrete I/O and up to 256 analog I/O; the maximum memory size is 4096Kb. The CPU supports an integrated Ethernet connection and Modbus connection via Ethernet and serial. Each CPU in the series has a real-time clock with four weeks backup time.

The I/O cards used in the project are the following:

- The digital output modules are type DRA 1605 equipped with 16 relay outputs. The nominal voltage for relay contacts is 24 VDC or 24…240 VAC while the maximum current with resistive load is 2 A.
- The type of analog input modules is AMI 0810 which are 8- channel analog input modules; the module supports several ranges of voltage and current inputs. The input type (voltage/current) is selected with different wiring to connection points of the module. The analog inputs use the current signal 4-20 mA in this project.
- Another type of the analog input module in the project is ART0814 which supports temperature, voltage and resistance measurements with different sensors. The module has eight isolated channels which can be configured to different measurement types such as platinum, nickel, copper and thermocouple sensors. Each channel has its own selection of the measurement type via configuration software.
- The digital input module is DDI 1602 which has 16 channels with positive (sink) logic so the direction of the current is from sensors to module. /10/

3.1.3   HMI

Schneider Electric provides also HMI devices. Each device belongs to the Magelis line which has several different models from small panels to HMI controller having integrated I/O. The special feature of the series is the hardware that is easy to install to the control cabinet, only a 22mm hole is needed on the cabinet for the

installation. The devices are composed of two parts; one will be installed inside the cabinet and one outside (Figure 4). /11, 13/
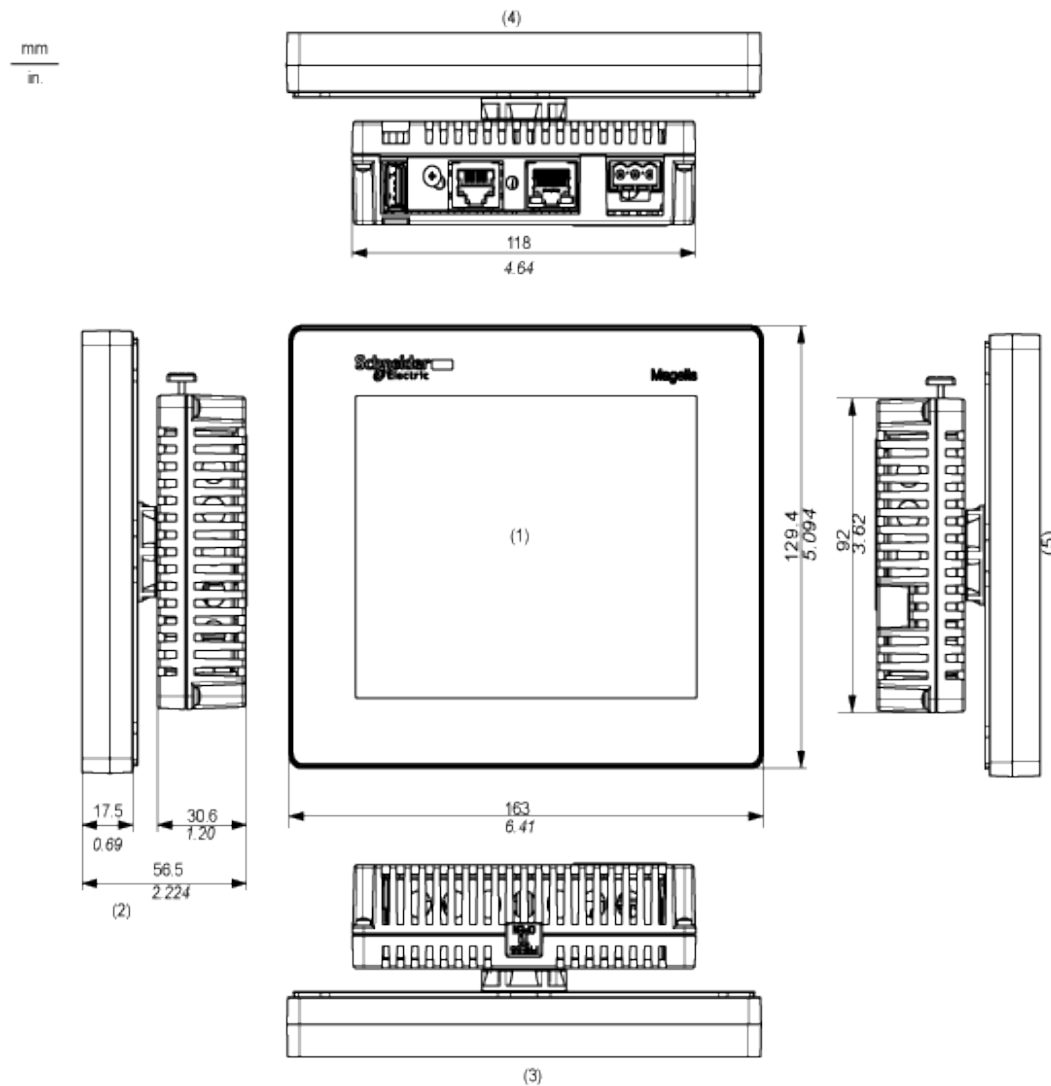

Figure 4. Magelis HMISTU855 drawing /12/

3.1.4 Modbus TCP/IP

Modbus was developed by Modicon (nowadays Schneider Electric) in 1979. It was developed to establish connection between intelligent devices via serial communication. The protocol uses 16-bit registers in integer format but it has

been developed to support higher resolution values with 32-bit registers as well as new transfer media like Ethernet. The basic structure of the data areas or addressing mechanism has not been changed for compatibility. /2, 5/

Modbus/TCP is designed to establish communication between industrial equipment like PLCs and operator panels over network. In Modbus/TCP the original Modbus frame is embedded into the TCP frame without any modifications. Similar Modbus communication can be established as well in the serial line as on Ethernet TCP/IP network. The devices communicating in Modbus/TCP-network are servers and clients, the model based on those uses four different types of messages. The communication procedure has the following steps (Figure 5):

- The client sends request on the network to initiate transaction.
- The server receives request called indication and sends response.
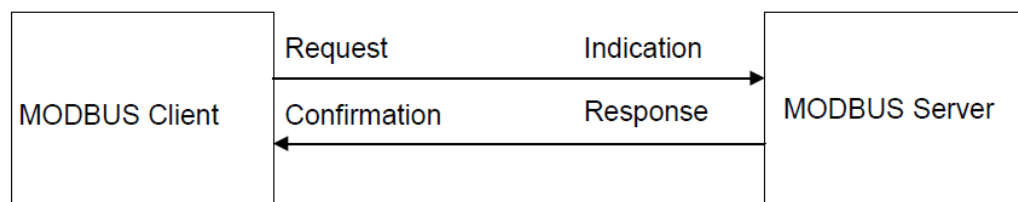- The client receives a response message called confirmation.

Figure 5. Modbus communication between client and server /6/

Modbus communication is used in real time communication between device applications, between the HMI and SCADA systems and devices. The data frame in Modbus/TCP is slightly different compared to the general Modbus data frame but the PDU (Protocol Data Unit) is identical in all communication medias (Figures 6 and 7). Each Modbus/TCP connection uses the TCP port 502 as default, the port can be changed if all devices in the bus support other port. The Modbus messages are designed so that the recipient can check message being complete with error check part. The Modbus/TCP has additional length information in prefix compared to serial communication; the additional information is needed to allow the

recipient to recognize messages received in multiple packets. The Modbus/TCP protocol does not need an error check, such as serial communication, because the TCP protocol has its own error checking. /6, 7/
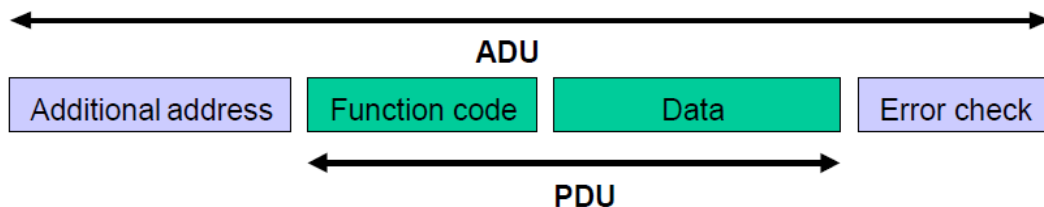

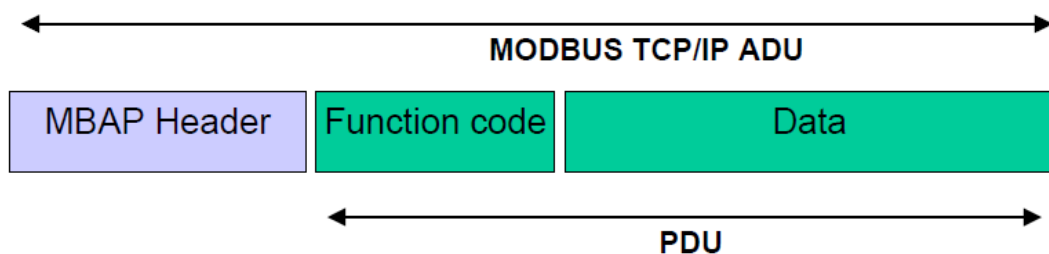**Figure 6**. Data frame in general Modbus connection /6/

Figure 7. Data frame in Modbus TCP/IP connection /6/

There is one potential source of confusion for the user of Modbus, an offset between Modbus register and memory of the PLC. The reference numbers of Modbus have started from 1 and PLC reference numbers start usually from 0. /7/

3.2 Software

3.2.1   PLC Application

The existing application software of the Turbocharger Wash Control was very useful. Only minor modifications were needed; the conversions between integer and real formats were mainly removed. Only few values for washing block are carried in integer format as well as some outputs.

The HMI can work with both real and integer values so there is no need to convert values in PLC for the HMI. The real type values can be used in real scale in the PLC and HMI, therefore the values are always in engineering unit. Decimal values can be presented in integers only by multiplying a decade up. There has to be

more conversion and mathematical blocks in the program if the decimal values must be handled in the integer type values.

The program of the Dew Point Controller was a pilot installation for Modbus TCP/IP model. The program uses real values but values via Modbus were received in the integer format, therefore a lot of conversion blocks were needed. All values were converted to the integer values also for the HMI thus there were quite many blocks for convert values between types and scale. The program was modified to a simpler form and the testing functions were moved from the main program to the analog input section. The measurements were modified to use analog inputs instead of reading values via Modbus from the automation system of the engine. The manual mode for the LT-valve control has been implemented in the new design; the initial system did not have any feature to control the valve manually. The alarm indication was replaced with an alarm processing, including an alarm list which presents active alarms in the HMI; the alarm history is not supported in this setup. The system has functions to drive the process in safe state when certain alarm conditions are encountered, the humidity sensor fault sets fixed temperature set point and other sensor faults set controller to the manual mode with certain set point. The engine can be used during faults with the manual dew point control if the feedback signal from the LT-valve is still working.

3.2.2 HMI

The communication between the PLC and HMI uses Modbus TCP/IP communication. It must use offset of 1 in the HMI to refer to the right register in the PLC although both are from Schneider Electric. The offset is a feature in the Modbus communication as described in the Modbus section.

Pages on the touch screen were designed to be suitable for the integrated system. The operating displays were designed according to the displays in the initial projects; the layout is almost similar with different shapes and colors. The user can use the panel if s/he has used the original panels. Some information was moved to

the other page and some information has been added but the main features are identical to the initial configuration. The turbocharger section had only a few modifications in the HMI while the Dew Point Controller has got more modifications and a new manual mode on its own page.

The HMI is designed for using indirect addresses that reduces amount of work and simplify upcoming modifications. There is only one page for specific functions for all engines except the trend and the alarm pages. The Magelis panel uses a specified offset variable with an indirect access; the offset variable determines the address to access in the PLC. The base variables are created in the HMI referring to the addresses of the first engine in the PLC, thus offset 0 corresponds to the addresses of the first engine. In the project the separate engines use separate parts of the PLC memory, which is not the easiest way with this offset system but allows easy program update with additional address. The engine 1 has the memory area starting from word 100, the second PLC starting from 300 etc. The trend and alarm functions use direct addresses to enable continuous data saving and alarm functions.

There are three different user levels in the HMI with different user rights. The level 0 has rights only for reading values and trends. The level 1 is for the user to change settings and to control functions of the device; the user on level 1 has access to all necessary settings under the normal use. The objects available on level 1 are gray on user level 0, the login panel is opened when trying to operate locked objects. Level 2 is commissioning level and has access to all settings. The user on level 2 can change the number of engines, set up scaling of sensors, select engine types and choose presentation mode of the valve position. The user on level 1 or 2 will be automatically logged out after 60 minute inactivity time.

All analog measurements are presented in trends in the HMI for monitoring purposes. The trend presents data ca. 50 minute backwards with logging interval of 12 seconds. The trend in Dew Point Control presents the charge air pressure and temperature, target temperature of the charge air and LT-valve position. The trend

screen of the turbocharger has the charge air pressure and the exhaust gas temperatures. There is one exhaust gas temperature presented with the line-engine and two separate temperature values with the V-engine because the number of the turbochargers.

3.2.3   HMI Configuring

Some points of the HMI programming is presented in this section because it is quite unknown for the team that ordered the thesis. The basic configuration is quite easy and similar compared to the devices from other manufacturers. The points that are explained are communication setup, indirect address configuration, trend setup, user levels, alarm functions, colour animation and button setup with overlay image. The program used for HMI programming is Vijeo Designer v6.0 with SP3. The type of the HMI is HMISTU855 but in the configuration the type must be HMIS5T because the panel has some modifications in the hardware compared to the older version. The version of the Vijeo must be v6.0 SP3 or newer to prevent problems in the configuration and downloading with the new devices.

The communication uses Modbus/TCP as described in the previous chapter. The configuration of the communication is quite easy but there are some points that must be observed. The type of values used in the project is mainly the real value. The real values use 32-bit data area which is called the double word. The order of the words has to be identical in the PLC and HMI, which can be configured in the HMI communication settings. The default setting was "High word first" which caused misunderstanding between the devices. To avoid confusion the setting must be "Low word first" in the equipment configuration window (Figure 8). The IP address, unit ID and type of the communication protocol must be configured in the window also.
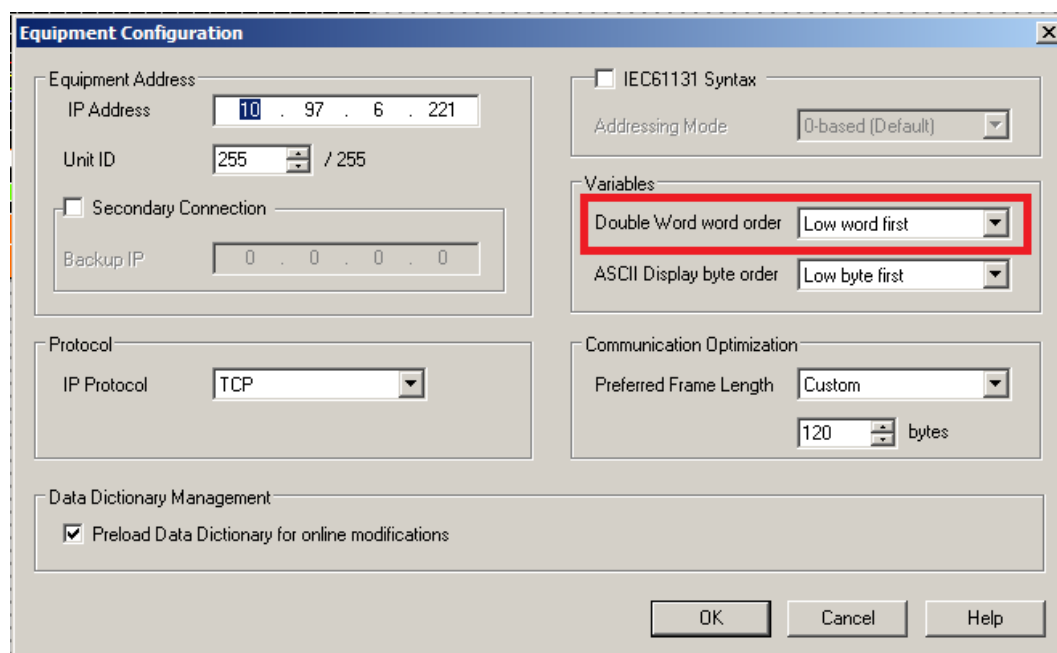
Figure 8. Equipment configuration window

The indirect address configuration needs an internal integer type offset variable which is modified to access a certain address. The configuration of the variable must have the indirect address selection and the name of the offset variable (Figure 9). Each data type must have its own offset variable because Magelis steps up the address determined by the size of the variable type. For example, if the base address is 100 and the offset is 10, the integer type value refers to register 110 and the real type value refers to 120 because the real variable uses two words instead of one. The Boolean variables have a similar offset system, if the base variable is 110,00 and offset is 10, the indirect variable refers to 100,10 (Table 1). The system is slightly complicated because there is an offset coming from the Modbus communication and an offset coming from the indirect addressing.

Table 1. Indirect address logic

TYPE	HMI	PLC, off-set=0	PLC, off-set=10
INT	40101	100	110
INT	40102	101	111
REAL	40103	102	122
REAL	40105	104	124
BOOL	40111,00	110,00	110,10
BOOL	40111,01	110,01	110,11
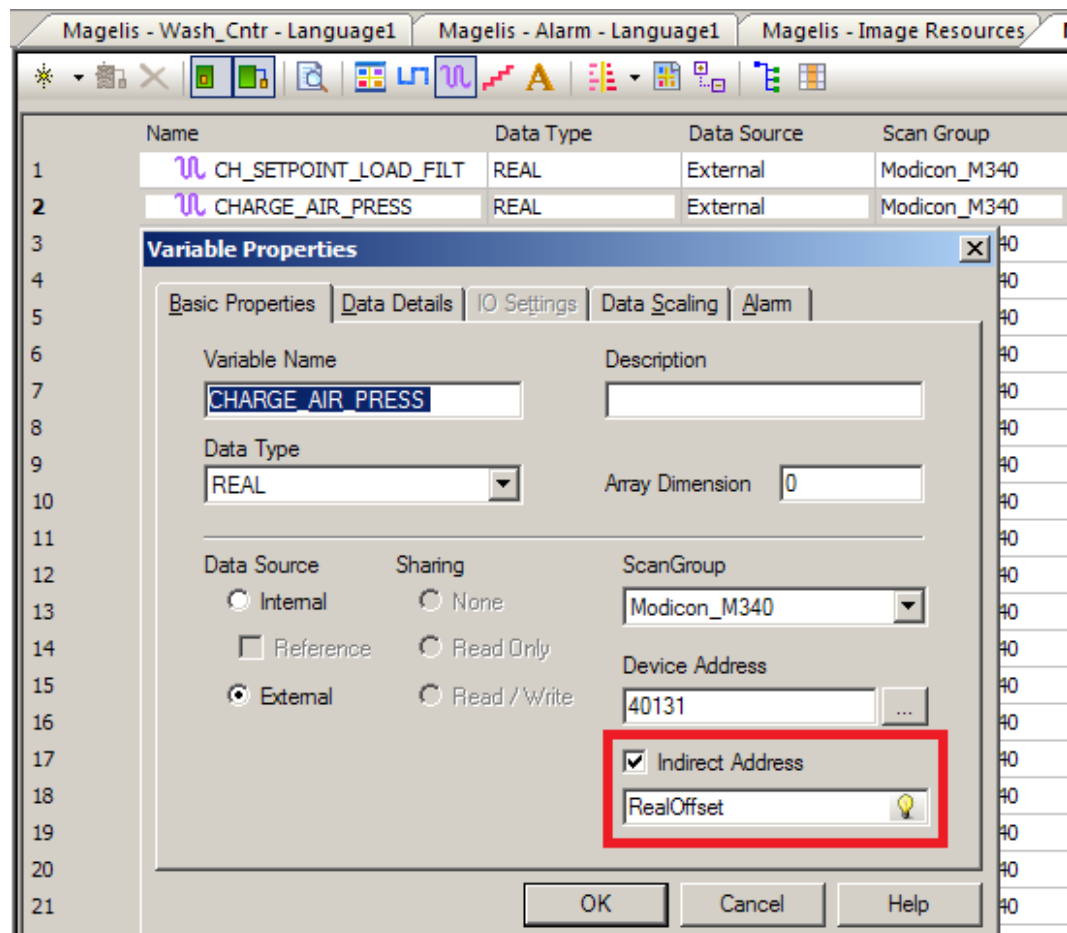
Figure 9. Variable properties window

The button opening the engine page modifies the offset variables to meet the right addresses (Figure 10). The engine 1 has offset 0 for each data types while other

engines have three different offset values for variables (Figure 11). There is an internal variable for the number of the engine also to indicate the engine selected.
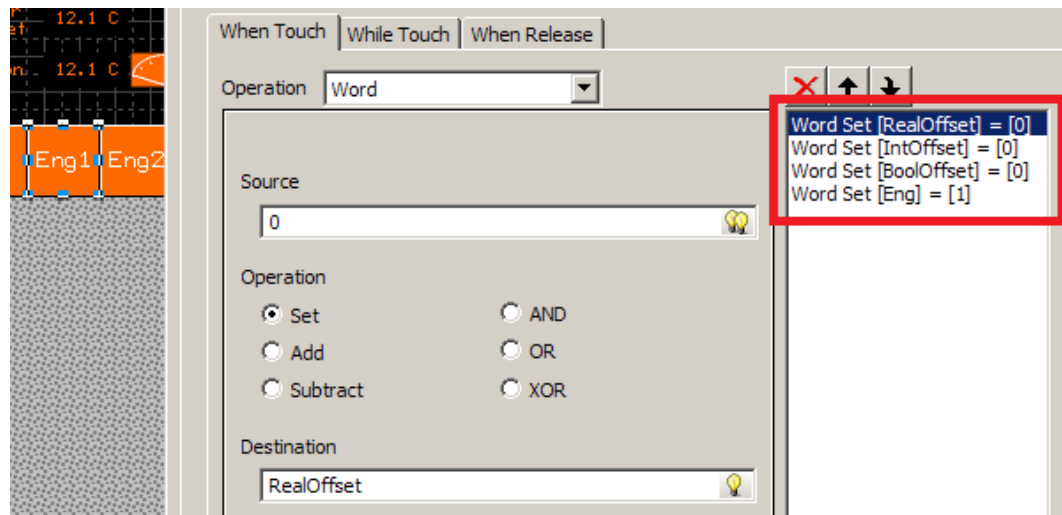
Figure 10. Engine selection button operations when touch

Figure 11. Internal variables used in indirect pointing

The configuration of the real-time trend curves does not have internal time management, the system supports historical trend graph but they have poor graphic design and was not used in the project. The values presented in the trend graph must be logged into the memory of the device; the data logging is configured in the Data Logging menu. The project has five separate logging groups for each engine and one common logging group for suction air measurements. The memory used for data logging in this project is DRAM because of its larger capacity compared to the SRAM memory. The DRAM is volatile on power blackouts but that can be accepted for trend data logging.

The time management needs some calculation to have a real time scale in the trend window. The maximum number of samples in the trend graph is 287 but in the project 280 is used because of the scale of the time axis. The required trend curve history is about 50 minutes which can be reached with the following settings:

- The sample interval of 12 seconds and 280 samples presented in the trend graph meets the requirement with 56 min historical data.
- The number of the divisions in trend graph is 28 which is equivalent of 10 data samples and 120 seconds.
- The parameter Scroll sets the number of samples to scroll when the data area fills up, value 1 is used to maximize the amount of data presented and because of time axis (Figure 12).
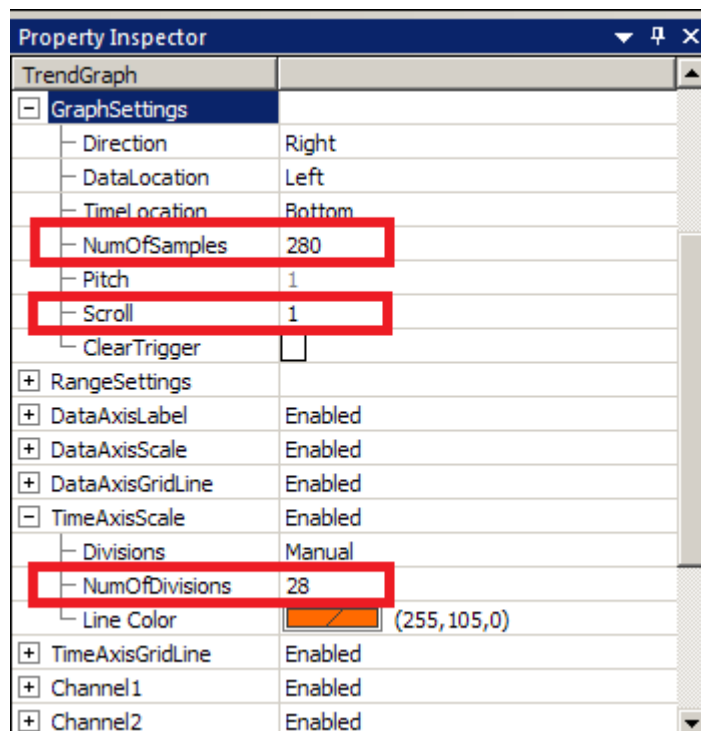

Figure 12. Trend curve settings

The user levels are configured in the Security menu (Figure 13). Each object has a security level setting on the Advanced page in object settings that defines the us-

ers having access to the object. The user on level 1 has access to the objects de-
fined to security level 1, the user on level 2 has access to objects on the security
level 1 and security level 2. The behavior of locked objects and automatic logout
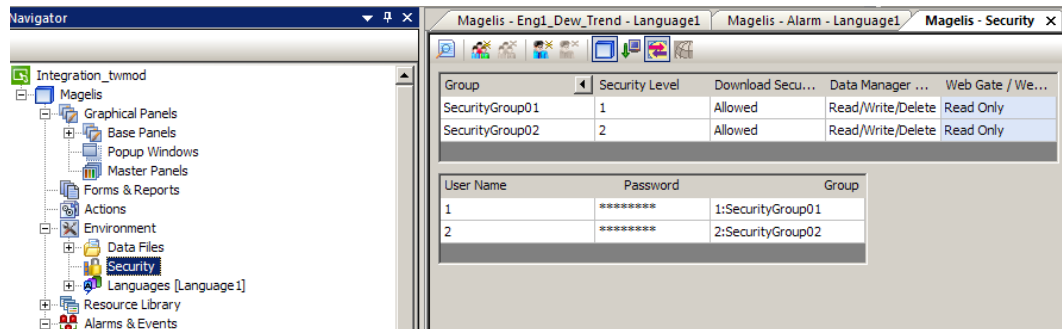are also configured in the Security menu (Figure 14).

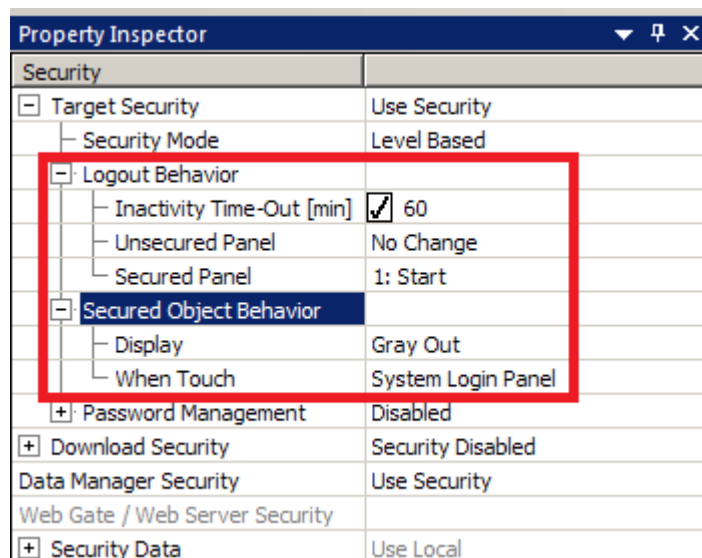**Figure 13**. Security levels settings

Figure 14. Logout and locked object settings

The alarms used in the project and the related messages shown in the alarm list
are configured in the Alarm&Events menu. The alarms used in the project are of
discrete type and active alarm state is 1, the alarm signal logic is in the PLC which
outputs alarm bits to HMI. There is only one alarm list used in the project which
contains alarms of all engines as well common alarms. The alarm list is shown on

the HMI when the alarm occurs; the transition is programmed in the Actions menu. The trigger of the action is the active alarm counter which has at least one active alarm, the operation to execute is change to display 5 which is the alarm list in the project (Figure 15).
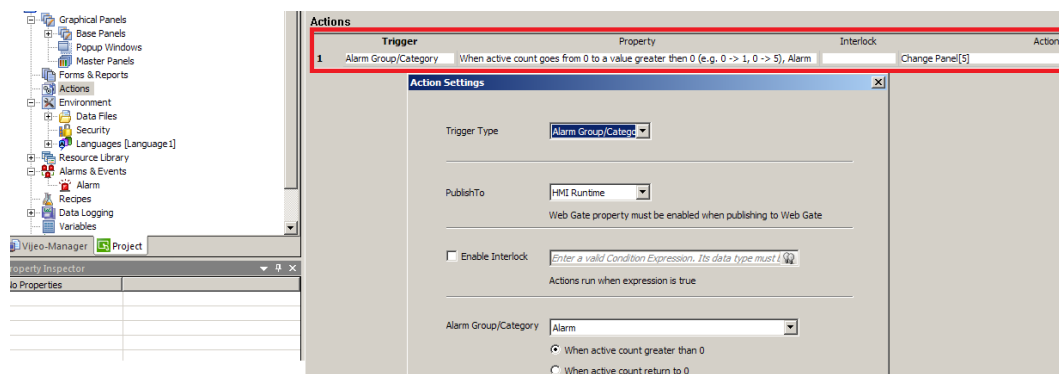

Figure 15. Actions setup

Vijeo has some very handy features like colour resources. The feature allows easy status indication with colour which is used in the valve animation in this project (Figure 16). The colour animation can be enabled via the animation window of the object (Figure 17), the configuration of the colour resources needs only the selection of the colours used in specific states (Figure 18). In this project the animation has only two different states but the function supports more states with analog values.
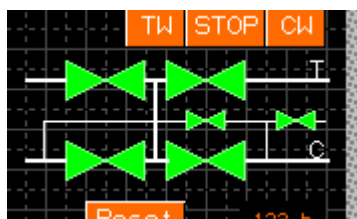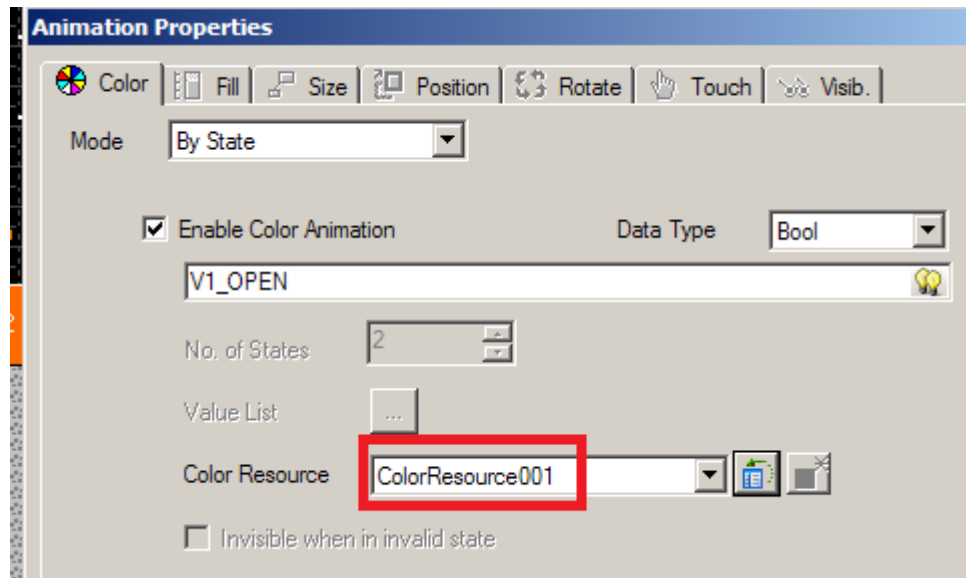

Figure 16. Turbocharger valves

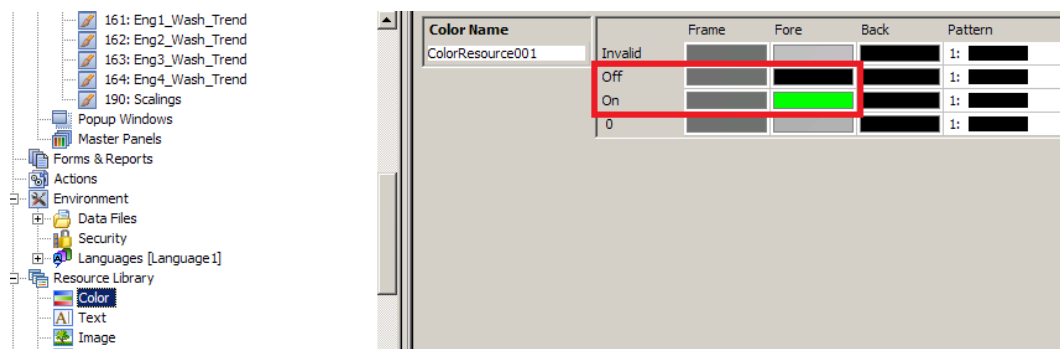**Figure 17**. Animation properties of the object

Figure 18. Colour resource settings

The last feature presented here is an attachment of the bitmap on the button. The bitmap can be a label of the button instead of text; the configuration can be set up via the colour page in switch settings (Figure 19).
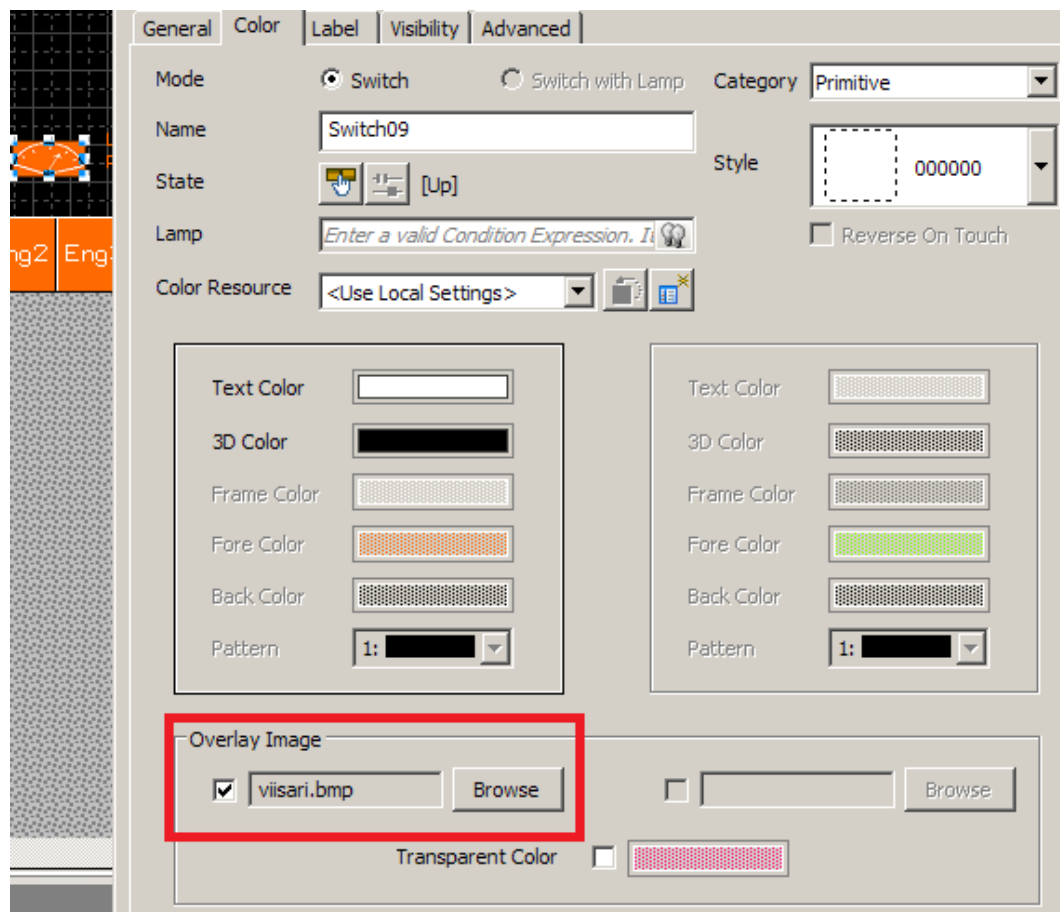
Figure 19. Button properties

3.3 Control Cabinet Assembly

The control cabinet was assembled according to the new design at the end of the project. The sizes of the initial cabinets are 380mm x 380mm and 500mm x 500mm, the integrated system was assembled in the 500mm x 500mm control cabinet which does not have space for any expansion (Figure 20).

Figure 20. Assembled control cabinet

The valve position measurement with a potentiometer had some mistakes in the design and there was not support available in the manual. The measurement worked well with a RTD simulator which can simulate different resistor values, but not with the real potentiometer. The problem was solved with modification in the connection of the potentiometer; the problem was the wire compensation that caused wrong values. The connection uses only two terminals of the potentiometer with three wire measurement type, such as temperature measurement with the PT100 sensor, for example.

4 CONCLUSION

The purpose of the thesis was to integrate the functions of two separate systems into one control system. The initial systems have some duplicated measurements and hardware parts, thus the integrated system needs less hardware in the cabinet and less measurement devices on the engine compared to two separate systems. Some new functions were added to the Dew Point Control system and the integrated system has new functions to simplify the commissioning.

The control cabinet is designed to cover different amount of engines, it has Turbocharger Wash and Dew Point Control functions for four engines but the actual amount of the engines can be configured via the HMI. The integrated system will not replace the separate controllers; it is an option to the customers required both controls. Dew Point Controller and Turbocharger Wash Controller will be available also in separate cabinets.

The target group for the system is ships with simple automation system, conventional charge air temperature controller which has fixed temperature set point and manual or old turbocharger washing system. The LT-valve must be pulse controlled and there must be a position feedback signal with potentiometer available. The functionality of the position feedback will be cleared in the pilot installation because it is a new measurement type used in the solutions of the Plant Automation unit.

The project was challenging because the project has a lot of new components and techniques such as Schneider Electric PLC and HMI and Modbus communication; the function of the turbocharger wash and Dew Point Controller were also unknown to me. The result of the project can be seen on the table and it will be installed in several ships around the world which make the project interesting and practical (Figure 21).

Figure 21. Ready control cabinet

The biggest problem at the end of the project was components with long delivery time which delayed the final testing in the factory. The components should have

been ordered earlier but it was difficult without a finished design. The Vijeo Designer 6.0 does not work in Windows 7, which caused problems at the beginning of the project. VM VirtualBox was tried as a solution to the problem but it had some bugs in my laptop, another computer with Windows XP was used finally with success.

REFERENCES

/1/   Assael M, Goodwin A, Stamatoudis M, Wakeham W, Will S. 2011 Commonly asked questions in thermodynamics. 1st Edition. Boca Raton. Taylor and Francis Group.

/2/   Bauer, C. 2006. Modbus Basics. Accessed 2.4.2013. http://langhofer.at/fileadmin/downloads/sineaxcam /Modbus_Basics.pdf

/3/   Hall, D. 2007. Automotive Engineering. 1st edition. Delhi. Global Media.

/4/   Honeywell. 2011. Turbo Fundamentals. Accessed 18.4.2013. http://turbo.honeywell.com/turbo-basics/turbo-fundamentals/

/5/   Introduction to MODBUS. 2002. Accessed 10.4.2013. http://www.sena.com/download/tutorial/tech_Modbus_v1r0c0.pdf

/6/   Modbus-IDA. 2006. MODBUS Messaging on TCP/IP Implementation Guide V1.0b. Accessed 10.4.2013. http://www.modbus.org/docs /Modbus_Messaging_Implementation_Guide_V1_0b.pdf

/7/   Real Time Automation. 2009. Modbus TCP/IP overview. Accessed 12.4.2013. http://www.rtaautomation.com/modbustcp/

/8/   Schieman J. 1992-1996. Turbo Magazine collection. Accessed 2.4.2013. http://www05.abb.com/global/scot/scot208.nsf /veritydisplay/77547b9dbf02d66ec1257880005681d3/$file /ABB%20Turbocharging_Operating%20turbochargers.pdf

/9/   Schneider Electric. 2010. The Modicon family of industrial PLCs. Accessed 1.4.2013. http://static.schneider-electric.us/docs /Automation%20Products/8000BR1062.pdf

/10/   Schneider Electric. 2012. Modicon M340 Using Unity Pro, Setup Manual. Accessed 15.4.2013. http://www.globaldowload.schneidereletric.com /852575A6007E5FD3/all /E6D45A301A7C24D9852576C000716C48/$File /35012676_k01_000_07.pdf

/11/   Schneider Electric. HMI (terminal and industrial PC). Accessed 2.4.2013. http://www.schneiderelectric.com/products/ww /en/2100-hmi-terminals-and-industrial-pc

/12/   Schneider Electric. HMISTU855. Accessed 15.4.2013.
http://www.ops-ecat.schneiderelectric.com/ecatalogue
/documents/G-SE-0007873.2.2.gif

/13/   Schneider Electric. Magelis STO&STU Panels. Accessed 2.4.2013.
http://products.schneider-electric.us/productsservices
/products/human-machine-interface-hmi/text-terminals
/magelis-sto-stu-panels/

/14/   This is Wärtsilä 2012 Leaflet

/15/   Wärtsilä Finland Oy Service. 2009. The Wärtsilä Automated Tur-
bocharger Wash sequence.

/16/   Wärtsilä Finland Oy Service. 2012. Receiver Temperature Dew
Point Control for Wärtsilä 46 marine diesel engines

/17/   Wärtsilä Finland Oy Service. 2012. Technical Service lifetime
support, Plant Automation. Unit presentation material.