EXPERIENCE FROM MORE THAN 10 YEARS OF WORK WITH STEAMNET CONTROL IN DIFFERENT ENVIRONMENTS

Tomas Eriksson[1], Andreas Krafft[1], Björn Hultman[2], Christofer Löwenberg[3]

[1] Optimation AB, Box 27, SE-941 21 Piteå, SWEDEN
[2] BillerudKorsnäs Skärblacka, Bergslagsvägen 46, SE-617 30 Skärblacka, SWEDEN
[3] BillerudKorsnäs Gävle, SE-801 81 Gävle, SWEDEN

ABSTRACT

The development of process control systems has enabled implementation of advanced process control strategies, also called APC-systems.

Even if the potential has been around for for a while, it is far from all processes that are equipped with an APC-system. And those that are implemented are sometimes taken out of operation after a number of years for various reasons like, for example, complicated operating interfaces and maintenances procedures .

We have studied the implentation of 18 steam net controls and found that the single most important factor for successfull operations of advanced process control strategy is acceptance from the users.

INTRODUCTION

This paper is based on implementations of 18 steam net APC-systems carried out by Optimation during the last 10 years. Hence, our analysis can be based on a relatively large set of installed systems in various environments and at various times.

All installed systems are built on the same concept, and most of them are still running on daily basis. Some of them without undertaking any measures over the years whilst other have been largely modified due to changed conditions.

This study includes the experiences of the project leaders for the APC-systems. Information about the experiences has been obtained through a questionnaire and interviews.

The results and conclusions from the study should be important for those who design, purchase and maintain APC-systems for the process industry. What design criteria for an APC-system is important in order to get the most value out of the system over time?

PROCESS DESCRIPTION

Many process industries depend on heat for their production system to work, some examples are heating and drying, and in many cases steam is the main carrier of this heat. The steam is normally produced by boilers or other steam generating process equipment, called producers. The processes that uses the steam is called

consumers. The steam is distributed in a steam net, which typically can look like shown in figure 1.
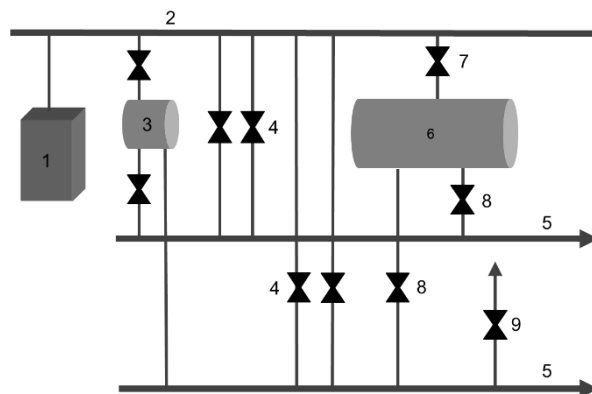

Figure 1: Example of a steam net layout in an ordinary process industry.

1. The steam is produced in boilers
2. The produced steam is collected in steam nets with high pressure.
3. The high pressure steam is reduced to lower pressure by turbines that also produces electricity.
4. In case the turbines are not running or are not capable of handling all the steam, reducing valves are used to reduce the steam pressure to levels suitable for the consumers.
5. Consumers are provided with steam from steam nets with lower pressure.
6. To handle momentary unbalance of production and consumption of steam there may also exist a steam accumulator.
7. In situations where the production is higher than the consumption, the excess steam can be lead into the steam accumulator where the steam is stored in the form of hot water.
8. In the inverse case, when the consumption is higher than the production. Steam could be taken out from the accumulator to the consumers by releasing the pressure of the hot water in the accumulator. The hot water will then start to boil and the resulting steam can be used by the consumers.
9. Excess steam can be released through condensers or directly to atmosphere.

Controlling the steam net

Ideally, variations in steam consumption from the consumption nets (5) should be handled by varying the production(1). However, if this is not achieved, steam can be stored or extracted from the accumulator (6) by opening charging valves (7) or discharging valves (8).

The pressure in both the consumer nets (5) and the production nets (4) has to be controlled. Primarily the pressures are controlled by reduction of steam from the production net to the consumer nets via the turbine (3) or the reducing valves (4). Additionally pressure in the production net can be controlled by charging the accumulator via (7) and pressure in the consumer nets by discharging the accumulator via (8) or releasing excess steam via (9).

Hence the controlled variables in the steam net consists of the pressures (2,5,6) and the manipulated variables consists of the production rate (1), steam flow though the turbines (3) and the valves (4,7,8,9).

Steam nets have traditionally been controlled by one PID controller per manipulated variable. The APC concept used in this study is developed by Optimation [2] uses one PID controller per controlled variable. This solution leads to fewer PID controllers, in the above example this would be 4 vs. 11, which makes it more easy to maintain and understand.

EVOLUTION OF THE DCS SYSTEMS

Some of the DCS-systems used for implementation of the APC-systems in this study has been quite new, others date back more than 30 years. The concept that Optimation developed for steam net control is built on a variety of base controller functions of the controller such as variable output limits, the full PID control algorithm, bumpless transitions between manual and auto and in some cases also feed-forward.

Functionality

Without going into details of different versions, this are the control systems that has been used:

- ABB Xa800
- ABB Freelance
- Honeywell TDC 3000
- Siemens PC S7
- Siemens T300

All of the used systems, regardless of age, supply all the necessary functions needed for the APC-systems.

We have seen that the implementation of the functions is more stable in the older systems. Implementation of the APC systems has in some cases run into severe bugs in the basic control algorithms in recent versions of major control systems of today. The experiences does not however tell if this is because most of the bugs in the older systems has been corrected over time or if they were better implemented from the start.

This study also reveals that hat there has been very little advancements in new functionality regarding to the basic control tasks in the control systems over the past 30 years.

Future demands on the control systems

For the future we would hope to see more tools built into the control systems for the control engineer. The most common support that exist today is auto-tuning algorithms for the individual PID control loops. However, auto tuning does not offer any guidance to how the control loops interact with each other and other parts of the process. Hence using them in an optimal way requires a lot of skill from the designer.

Possibility to store information about the process, its models and structure in the control system would be one way of supporting the user. This could be done much in the same way as the actual control structure and its

individual control loops are stored. In this way the control system would be able to guide the user in the design of the control algorithms [3].

The first version of such process models and structures could be extracted from simulator models that becomes more and more common that suppliers provide with new plants.

CHANGES IN PLANT AND DEMANDS

One of the main reasons why control systems degrade over time, or are put out of use, is the fact that a modern plant is under constant change. The market for the products produced in a mill changes over time, and that drives changes in the product specifications, or even which type of products that are produced. Since the conditions for production are changing, the plant has to be redesigned in order to keep quality and efficiency in the production.

This is clearly reflected in the data from the survey responses. Among the studied systems totally 67% of all the systems were redesigned after commissioning.
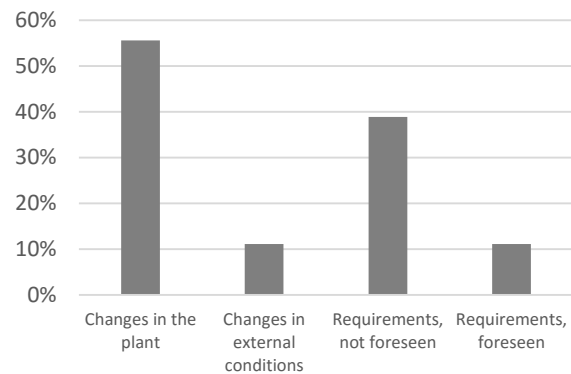

Figure 2. Part of the systems that were the control structure was modified after commissioning, and the reasons why.

The most common reason for redesign was changes in the plant. Figure 2 shows that 56% of all systems were redesigned due to changes in the plant. Another common reason was due to requirements that were not foreseen at design time. These two factors supports the thesis that that the demands changes quite frequently in a plant.

This trend is likely that this is going to be more frequent in the future. Hence the ability to change the process has to be a major consideration when designing new control systems. This includes the structure of the advanced control system, the tuning of the system as well as the user interface.

How to handle changes

If changes in the plant lead to big changes in the APC system there is a risk that it will not be updated. This will ultimately lead to poor control performance, or even discontinued use of the APC system.

This might be one of the reasons why implementation of new and modern control strategies in the process industry has been relatively modest.

When Optimation designed the first control system for steam nets it was a modular design, so that it would be easily adapted to the structure of the steam net for the next customer. This turned out to be one of the major factors of the success. The modular design has made it easy to adapt the APC system to changes in the plant and new demands.

EDUCATION

If the users of the control system do not have enough knowledge of the system there is a risk that they will take measures that will interfere with the control system.

One example of this was a customer where the operators repeatedly complained about malfunction of the APC system. To ensure that it actually was the APC system that was to blame, the operators were forbidden to do any interaction with the APC system during an evaluation period. This experiment showed that there was interaction between the operators and the APC system that was the problem and the solution was a renewed training of the operators, which was successful.

The conclusion is that it is very important with education before commissioning of the system, but equally important is that the operators can have a refresher training when they have been running the system a while. This is especially important when the new strategy is completely different from the previous or if there has been no APC system before, like in new plants.

A good way of training of operators on complex APC systems is via simulators of the actual process where the operator can train operation like it was the real plant [2]. Ideally such systems also gives the opportunity to build training scenarios. Further on, the possibility to run the simulator faster or slower than real-time can prove quite useful depending on the dynamics of the process.

DESIGN OF APC SYSTEMS

Good control design is not just a matter of finding the perfect control algorithm. It is just as much about designing a control algorithm that can cooperate with the operator when unexpected things happens in the process.

In the steam nets installations, this could for example be the ability to handle a faulty reducing station or the need for running the turbine in another control mode than the APC-system desires.

Hence, the operator must be able to do manual operations on part of the system while the rest of the APC system still runs in an optimal way under the new conditions.

Identification of all operation conditions

In figure 2 we can see that the second most common reason to redesign of the APC system is requirements that were not foreseen during the construction of the APC. Nearly 40% of the APC systems in this study were redesigned for this reason.

All systems in the study were thoroughly simulated, but an interesting future work would be to see if there would be an increase in this number if no simulation were used before commissioning. Though it might be tricky to find

customers that are willing to implement a steam net controller without simulating it before.

To verify that the APC system can handle every conceivable situation might be an almost impossible challenge for the constructor. The experience from the installations in this study is that if you test for a lot of known conditions, chances are good that the system also will handle situations that were not foreseen in a good way. This gives us the task to come up with as many known conditions as possible and test those testing.

One way to achieve this, which has proved to be very useful, is to give the operators access to a simulator of the process combined with the APC system and challenge the operators to find situations which the control system cannot handle.

MAINTENANCE

The study included that the project leaders for the APC system has been given the task to rate installations both directly after delivery and today.

By taking the difference between the two rates it was possible to see if the systems have improved or degenerated over time.
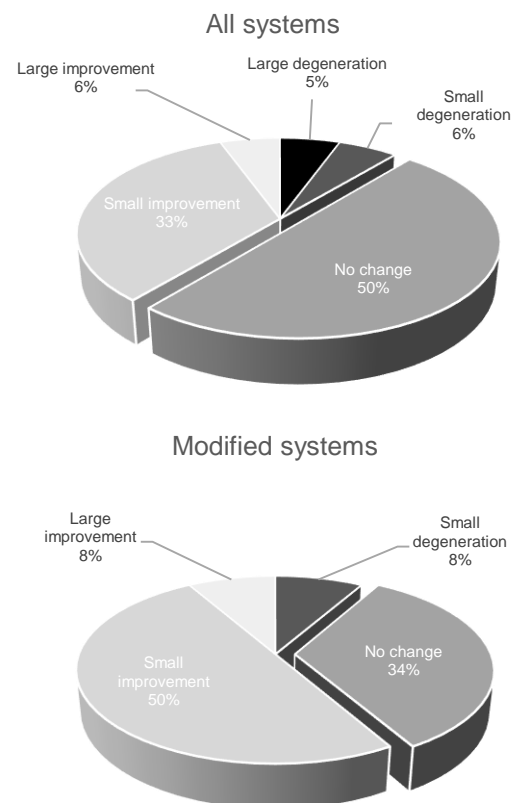

Figure 3. Change in grade of the systems from delivery until today.

We can see, in figure 3, that there are very few systems that has degenerated over time. Only 11% of all systems shows a decrease in grade from commissioning until now, and 39% shows an improvement over time.

As expected, there is also a clear tendency that systems that has been modified is less prone to degeneration, only 8% of the modified systems shows a degeneration and 58% an improvement. Among the systems that were unmodified, no systems shows any improvement, and one system shows a degeneration.

A tendency that was not so expected is that systems that were only modified due to changes in the plant also shows a significant improvement over time.
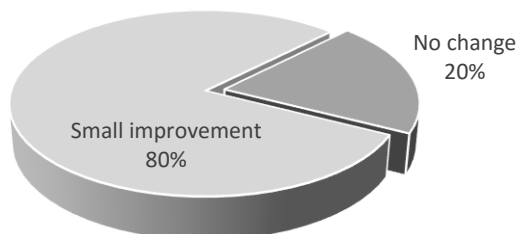

Figure 4. Change in grade from delivery until today for systems changed only due to changes in the plant.

As we can see in figure 4, 80% of the systems that were modified only due to changes in the plant shows an improvement in function over time.

Issues during the lifetime

All APC systems will probably run in to some kind of issues sooner or later. Therefore the survey contained two questions about problems during the lifetime of the system. The questions divided the issues in to two different categories. The first category collected all issues that could be directly attributable to hardware issues, such as faulty valves. The second category collected all other issues, spanning from too small steam accumulators, limitations in boilers etc.
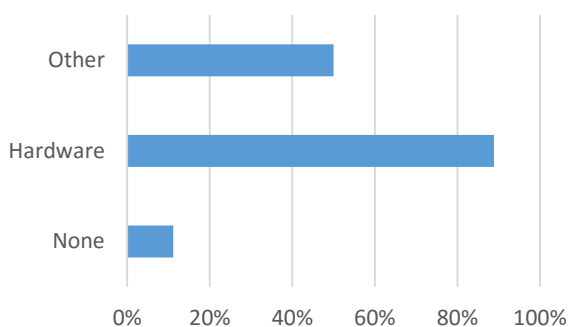

Figure 5. Issues in the systems from delivery until today and their origin.

Figure 5 clearly shows that hardware issues are dominating the problems that occurs in the APC systems included in this study. The survey shows that 89% of all systems have had problems with the hardware. The figure might even be higher if you add possible hidden cases. The main reason to hardware failure seems to be valve problems. This is a long known fact that valves are a problematic area [4].

CONCLUSIONS

The most important key to success, regarding the overall lifetime of an advanced control system is acceptance from the users. There are a number of factors that affects the users' acceptance but the most important are:

- Understanding of the system, the users must feel that they know what is going on.
- Trust in the system, the users must feel confident that the control system can handle the situation.
- The possibility for the user to take action if the controls system goes wrong. Think of the APC like an autopilot in an airplane.

This requires a well-designed system and a well-educated user. Both those two things can be achieved by extensive use of simulators.

Another important factor is the maintenance of the system. A well maintained system is necessary for the users thrust in the system. To make the maintenance of a system effective, the system must support small changes without the need for a complete overhaul of the whole system. Modular design has proven useful here.

References

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Appendices: Questionnaire

1. Approximate time for system acceptance from start of commissioning.
2. Is the APC still in use?
3. What grade would you give the function of the steam net control after initial commissioning?
4. What grade would you give the function of the steam net control today?
5. Have there been any significant employee turnover among the operators?
6. Have there been any significant employee turnover among the process engineers?
7. Have there been any significant employee turnover among the project management?
8. Have there been any alterations in the plant after the delivery of the system?
9. Have the steam network control been modified due to changes in the plant?
10. Have the steam network control been modified due to changed conditions which are not due to alterations in the plant?

11. Have the steam network control been modified due to requirements that have not emerged during the design?
12. Have the steam network control been modified due to requirements that were known at design?
13. Have the steam network control been modified due to new customer requirements?
14. Have the supplier modified the steam net control?
15. Have the customer modified the steam net control?
16. How much effort has the supplier put in to the steam net control after delivery?
17. Number of different steam net pressure levels?
18. Number of steam turbines?
19. Does the net have a controllable producer?
20. Does the net have a steam accumulator?
21. Does the net have a steam condenser?
22. Did any problems arise after delivery that was due to maintenance problem, i.e. valve problems?
23. Did any problems arise after delivery that was due to physical limitations of the plant?