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ENERGY EFFICIENCY ACCELERATOR

Pengenalan kepada peluang penjimatan tenaga bagi kawalan proses dan bacaan

Introducing energy saving opportunities in process and measurement control

Garis panduan kecekapan tenaga dalam sektor makanan & minuman

Energy efficiency guidance for the food & beverage sector

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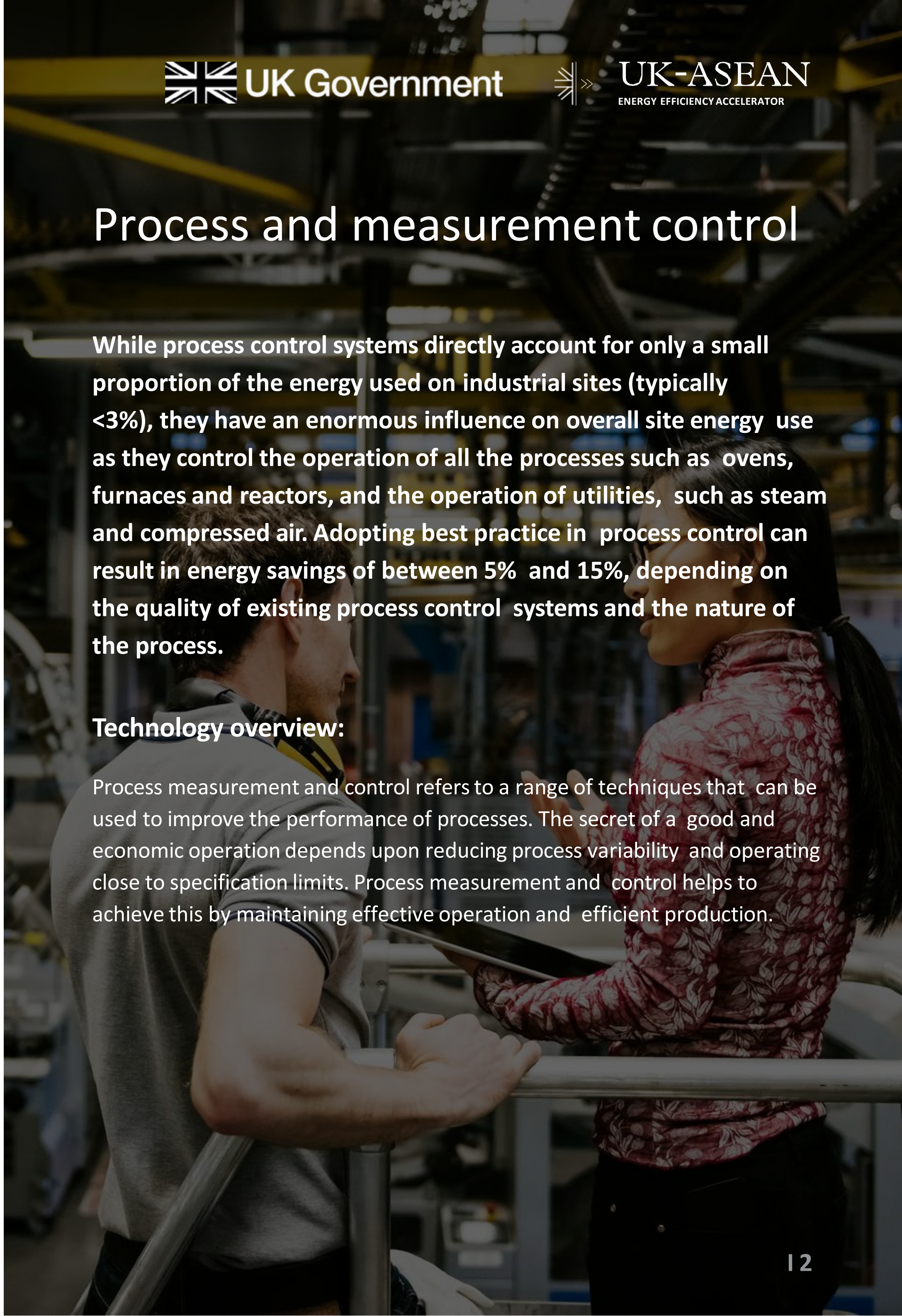
Kawalan proses dan bacaan

Walaupun sistem kawalan proses hanya menggunakan sebahagian kecil dari jumlah penggunaan tenaga di tapak perindustrian (biasanya <3%), ia mempunyai pengaruh yang amat besar ke atas penggunaan tenaga keseluruhan kerana ia mengawal kesemua proses seperti ketuhar, pembakar dan reaktor, dan pengendalian utiliti seperti stim dan udara termampat. Pengenalan rejim amalan terbaik bagi kawalan proses boleh memberi penjimatan antara 5% hingga 15%, berbanding pada kualiti sistem kawalan proses serta ciri-ciri proses.

Ringkasan teknologi:

Bacaan dan kawalan proses merujuk kepada beberapa teknik yang boleh diaplikasi untuk mempertingkat prestasi proses. Rahsia bagi operasi yang baik dan cermat adalah pengurangan variasi proses serta beroperasi hampir pada had spesifikasi. Bacaan dan kawalan proses membantu dalam hal ini dengan mengekalkan tahap operasi yang berkesan serta tahap pembuatan yang cekap.



Process and measurement control

While process control systems directly account for only a small proportion of the energy used on industrial sites (typically <3%), they have an enormous influence on overall site energy use as they control the operation of all the processes such as ovens, furnaces and reactors, and the operation of utilities, such as steam and compressed air. Adopting best practice in process control can result in energy savings of between 5% and 15%, depending on the quality of existing process control systems and the nature of the process.

Technology overview:

Process measurement and control refers to a range of techniques that can be used to improve the performance of processes. The secret of a good and economic operation depends upon reducing process variability and operating close to specification limits. Process measurement and control helps to achieve this by maintaining effective operation and efficient production.

Kawalan lingkaran tertutup mudah *Basic closed-loop control*

Kawalan lingkaran tertutup mudah adalah asas bagi hierarki kawalan kilang, yang biasanya mengandungi ratusan lingkaran kawalan individu.

Tugas lingkaran kawalan adalah mengekalkan sesuatu pemboleh ubah proses (contohnya, kelajuan pengadun atau suhu ketuhar) pada nilai yang dikehendaki, atau pada nilai yang tertetap. Ini boleh ditentukan oleh peringkat yang lebih tinggi pada hierarki kawalan atau oleh operator. Lingkaran kawalan perlu melaksanakan perubahan dalam nilai tertetap dengan segera, lancar dan cekap tanpa mengganggu operasi proses.

Lingkaran kawalan terdiri dari tiga komponen utama (Rajah 1):

Basic closed-loop control is the main building block of any plant control hierarchy, which typically includes many hundreds of individual control loops.

The task of a control loop is to hold a particular process variable (for example, the speed of a mixer or the temperature of a baking oven) at its desired value, or its set-point. This is either determined by higher levels in the control hierarchy or by the operator. The control loop must implement changes in set-point quickly, smoothly and efficiently without disturbing process operation.

The control loop consists of three main components (Figure 1):

Rajah 1: Komponen utama lingkaran kawalan.

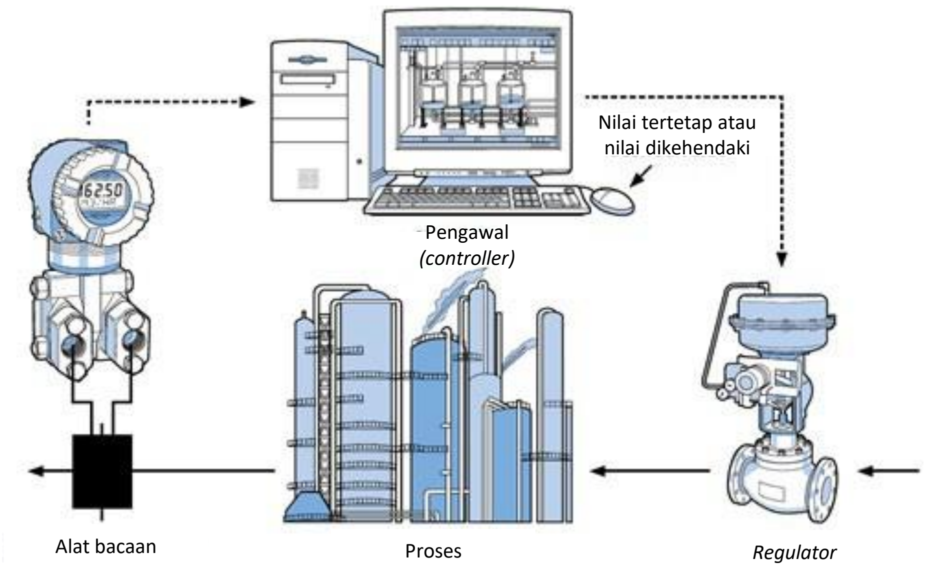
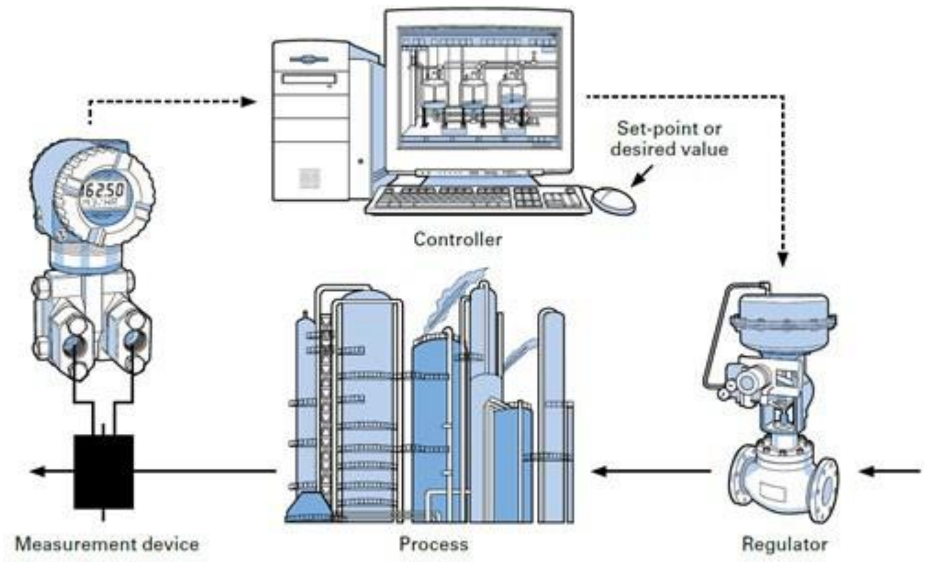


Figure 1: The main components of a control loop.



Kawalan lingkaran tertutup mudah *Basic closed-loop control*

1. Alat bacaan

Untuk mengawal suatu parameter proses dengan jitu, lingkaran kawalan perlu menerima bacaan nilainya secara berkala dan dengan kerap. Ini boleh dicapai dengan menggunakan penderia (*sensor*) yang mengukur atau menyukat sesuatu sifat fizikal jirim (seperti as suhu atau kadar aliran) dan sebuah pemancar yang mengubah output penderia kepada signal kawalan standard. Signal ini kemudiannya dihantar ke pengawal, yang biasanya terletak di dalam bekas pelindung di sebuah bilik kawalan.

Signal ini boleh dihantar ke bilik kawalan secara individu atau dipancar sekali gus bersama signal kawalan lain melalui jaringan khusus, yang dikenali sebagai Fieldbus.

2. Pengawal (*controller*)

Pengawal akan membandingkan nilai yang dibaca dengan nilai tertetap dan, sekiranya berbeza, akan mengubah parameter proses untuk mengembalikan nilai bacaan kepada nilai tertetap. Sebagai contoh, pengawal akan membaca kadar aliran sebenar cecair dalam suatu proses cam membandingkannya dengan kadar yang telah ditetapkan. Sekiranya berbeza, ia akan membuat perubahan yang perlu, seperti menyelaras kelajuan pam, sehingga kadar aliran kembali ke kadar yang dikehendaki.

Pengawal boleh disusun dalam pelbagai bentuk, berdasarkan ciri-ciri lingkaran kawalan, keperluan kejituan dan kecepatan suap balik (*feedback*).

Pengawal berupaya mengendalikan kebanyakan tugasan dalam industri proses, sekiranya dipilih dan terlaras dengan baik. Sebagai contoh, pengawal satu lingkaran (*single-loop controller*) boleh digunakan untuk mengawal suhu ketuhar dalam industri makanan dan minuman. Apabila penderia mendapati penurunan suhu ketuhar, makin banyak bahan bakar akan dihantar ke pembakar untuk meningkatkan suhu ke nilai tertetap.

1. The measurement device

To control a process parameter accurately, the control loop needs to be able to measure its value on a regular basis. This is usually done by a sensor that measures a particular physical property (such as temperature or flow rate) and a transmitter that converts the output of the sensor into a standard control signal. This signal is then sent to the controller, which is usually located in a protective enclosure in a central equipment room.

These signals may be sent to the control room individually or transmitted along with other control signals through a dedicated network, known as a Fieldbus.

2. The controller

The controller compares the measured value with its set-point and, where there is a difference, adjusts the process parameter to return the measured value to its set-point. For example, the controller would measure the actual flow rate of a liquid through a process and compare it with the set flow rate. If there was a difference, it would set in motion appropriate changes, such as adjusting the speed of the pump, until the flow rate returned to the desired rate.

Controllers can be configured in many ways, depending on the characteristics of the control loop, the need for accuracy and the desired speed of response.

The single-loop controller is able to handle most of the control tasks found within the process industries if it is correctly chosen and well- tuned. For example, single-loop controllers may be used to control temperature in baking ovens within the food and drink industry. In this case, when a sensor detects a drop in temperature, more fuel would be sent to the burners to bring the temperature up to the required set-point.

Kawalan lingkaran tertutup mudah *Basic closed-loop control*

Pengawal satu lingkaran biasanya memantau satu bacaan dan menyelaras satu *regulator*, namun boleh digunakan untuk menyelaras nilai tertetap bagi pengawal lain. Ini dikenali sebagai sistem bertindih (*cascade system*). Satu contoh adalah pemanasan susu dalam proses pempasteuran menggunakan air. Sistem bertindih digunakan untuk mengawal dua lingkaran; satu untuk membaca suhu susu, dan satu lagi untuk membaca suhu air pemanas. Dalam contoh ini, pertindihan adalah bersandarkan bacaan suhu susu yang kian meningkat, untuk mengurangkan secara perlahan-lahan suhu air, dan membolehkan susu dipanaskan secara berterusan pada suhu tertetap yang bersesuaian.

3. *Regulator*

Regulator digunakan untuk mengawal kendalian sesuatu proses. *Regulator* yang paling kerap digunakan terdiri dari injap pengawal yang menyelaras aliran sebagai tindak balas kepada output oleh pengawal. Sebagai contoh, injap pengawal digunakan untuk mengawal aliran stim dan air dingin untuk mengekalkan suhu reaktor kumpulan bersalut kaca (*glass-lined batch reactors*) yang biasa digunakan dalam proses-proses sektor makanan dan minuman.

Sebaliknya, sebuah pam kelajuan boleh ubah (*variable speed pump*) boleh digunakan untuk mengawal aliran cecair. Ini bukan saja mengurangkan pembaziran tenaga dengan mengurangkan aliran, tetapi juga membolehkan kawalan aliran lebih jitu dan menghapuskan masalah injap.

Sekiranya pengawal digunakan untuk mengawal gerakan bahan pepejal, berbanding dengan cecair atau gas, sebagai contoh: menggerakkan arang lumat sepanjang tali sawat ke dalam sistem dandang, sebuah pemacu kelajuan boleh ubah (*variable speed drive*) boleh digunakan sebagai *regulator*.

The single-loop controller normally monitors one measurement and adjusts one regulator, but it can be used to adjust the set-point of another controller. This is known as a 'cascade system'.
An example is where water is used to heat milk in dairy pasteurisation. A cascade system is used to control two loops; one measuring the temperature of milk and the other measuring the water temperature. In this case, the cascade relies on the measurement recorded by the rising temperature of the milk to slowly decrease the heat of the water, allowing the milk to be continually heated at the appropriate set point temperature.

3. The regulator

A regulator is used to control the throughput of the process. The most common type of regulator consists of a control valve that adjusts the flow in response to the output from the controller. For example, control valves are used to regulate the flow of steam and chilled water to maintain the temperature of glass-lined batch reactors typically used in food and beverage processes.

Alternatively, a variable speed pump may be used to control the flow of the fluid. This not only reduces the amount of energy wasted by throttling the flow, it also allows more accurate control of the flow and eliminates the problem of sticky valves.

Where the controller is regulating the movement of solid materials, rather than a liquid or gas, for example: moving pulverized coal along a conveyor belt into a boiler system, a variable speed drive may be used as the regulator.

Jenis sistem kawalan *Types of control systems*

Selain lingkaran kawalan mudah, terdapat juga pelbagai jenis sistem lain boleh digunakan, berdasarkan pada fungsi dan kerumitan kawalan yang diperlukan. Sistem yang paling kerap digunakan adalah:

- Pengawal tertib (*sequence controller*)
- Sistem kawalan teragih (*distributed control systems* atau DCS)
- Sistem pengawalseliaan dan pengumpul data (*supervisory control and data-acquisition* atau SCADA)

1. Sequence controllers

On some industrial sites, electronic relays and simple on-off controllers are still used to sequence, for example, valve movements and carry out other mechanical operations involved in process start-up and shut-down.

However, these systems are progressively being replaced by sequence controllers such as programmable logic controllers (PLCs). PLCs have a flexible, modular design so they can be expanded in a low-cost way to cover more aspects of process operation as it is automated. Modern PLCs can incorporate single-loop controllers along with more advanced types of controllers. PLCs may be used to carry out a sequence of actions such as adding a colouring dye to cake dough at preset intervals that corresponds with particular consistencies.

As well as basic control loops, there are also different types of system that may be employed, dependent on the functions and complexity of the control required: The most common types are:

- Sequence controllers
- Distributed control systems (DCS)
- Supervisory control and data-acquisition (SCADA) systems

1. Sequence controllers

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Jenis sistem kawalan *Types of control systems*

2. Distributed control systems

Distributed control systems (DCS) are normally used to control large or complex processes. They are modular systems that enable operators to adjust the set-points of many individual controllers from a central control room.
DCS also include capabilities to sequence process start up and shut down operations and to apply advanced control techniques. For example, DCS may be used in the chemical industry to control multi-process sites. This will enable handling of significant numbers of measurement devices and control loops within the one control system.

Modern, digital DCS are built around a highspeed network or 'control bus' that connects each controller to a central supervisory control unit. This unit monitors the operation of each of the controllers and makes data available to
other high-level systems, such as fault diagnosis, process optimisation and production-scheduling systems. This enables the production of high-quality products, while maintaining cost-effective operation and minimising downtime.

3. Supervisory control and data-acquisition systems

Supervisory control and data-acquisition (SCADA) systems can be used to control a wide range of industrial processes and are often used to provide an operator interface for PLC-based control systems. SCADA systems are software packages designed to run on a computer workstation or
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Jenis sistem kawalan

Sistem SCADA juga menggunakan algoritma kawalan canggih yang boleh membantu operator mengoptimumkan proses operasi secara automatik dan mengawalnya. Ini akan mengelakkan keperluan campur tangan manual yang kerap yang mungkin diperlukan pada sistem SCADA asas. Proses mempulpa ubi bit gula adalah satu contoh aplikasi sistem ini. Dalam contoh ini, sistem SCADA canggih akan menyelaras secara automatik kadar kemasukan stim yang diperlukan dengan mengambil kira turut naik kandungan kelembapan ubi bit gula sugar untuk menghasilkan pulpa yang konsisten. Sesetengah sistem SCADA canggih turut mengandungi sistem diagnosis dan penjadualan pembuatan.

Sebagai tambahan kepada sistem kawalan yang biasa digunakan dia atas, sektor makanan dan minuman akan semakin banyak menerima manfaat dari teknologi transformatif seperti 'internet benda' ('*Internet of Things*' atau IoT) dan 'Industri 4.0'. Kedua-duanya boleh menjana dan mengguna pakai data untuk mempertingkat kecekapan keseluruhan peralatan ('*overall equipment effectiveness*' atau OEE) dan mengoptimumkan penggunaan tenaga. Ketika memperolehi peralatan proses baharu, tanyakan pembekal anda bagaimana produk mereka boleh dihubungkan kepada pengkomputeran awan dan peranti lain, dan sama ada pembelajaran mesin digunakan untuk mengoptimumkan prestasi.

Types of control systems

Advanced SCADA systems also incorporate advanced control algorithms that can help operators to automatically optimise process operations and to control them. avoids the need for frequent, manual intervention that may be required on more basic SCADA systems. Pulping sugar beet is example of an application for this type of system. In this case, advanced SCADA system would automatically adjust the steam input necessary to take account of the variation in moisture content of sugar beet to produce a consistent pulp. Some advanced SCADA systems also include fault diagnosis and production scheduling systems.

In addition to the above established control systems, the F&B sector will increasingly benefit from transformative technologies such as the 'Internet of Things' (IoT) This and 'Industry 4.0' which generate and exploit data to improve overall equipment effectiveness (OEE) and optimise energy use. When an procuring new process equipment, ask prospective vendors how their an products can digitally connect with the cloud and with other devices and whether use is made of machine learning to optimise performance.

Peluang penjimatan tenaga dalam kawalan proses dan bacaan

Dengan memperbaiki kawalan, syarikat semestinya boleh mengurangkan penggunaan tenaga. Pengurangan ini boleh memberi penjimatan kos tenaga sehingga 15%.

Energy savings opportunities in process and measurement control

By improving control, companies can certainly reduce energy consumption. This reduction in consumption could translate to energy cost savings of up to 15%.

Nilai kualiti bacaan

Kawalan proses yang berkesan perlu mula dengan bacaan yang jitu ke atas penunjuk utama seperti suhu, tekanan, paras, kadar aliran dan penggunaan tenaga. Tanya pendapat operator anda tentang kebolehharapan pelbagai bacaan proses dan siasat lokasi di mana bacaan boleh bermasalah. Contohnya, adalah operator mencatat data? Adakah bacaan betul? Bilakah kali terakhir alat jentera ditentukur?

Operator juga harus maklum sama ada bacaan diambil pada posisi yang betul dalam proses kerana kesilapan dalam kaedah bacaan boleh memberi bacaan yang salah dan selanjutnya membawa kepada tindakan yang salah.

Pemeriksaan lain yang disyorkan termasuk menyiasat perbezaan proses ketika suatu pertukaran yang diketahui dilaksanakan di peringkat awal/hiliran proses. Setelah sesuatu masalah dikenal pasti, dapatkan anggaran tempoh masa sebelum tindakan pembaikan boleh diambil.

Hasil siasatan boleh menunjukkan:

- Alat bacaan tidak ditentukur atau tidak sesuai.
- Signal telah rosak.
- Peralatan tidak dipasang dengan betul atau disenggara dengan betul.
- Bacaan kini tidak mencukupi atau tidak betul.

Sekiranya masalah ini timbul, ia harus ditangani dengan bantuan juruteknik bertauliah.

Assess the quality of measurements

Effective process control needs to start with accurate measurements of key indicators such as temperatures, pressures, levels, flow rates and energy use. Ask operators for their views on the reliability of different process measurements and investigate areas where readings may be problematic. For example, do operators record data at all? Do the readings look about right? When was the last time that the machinery was calibrated?

Operators should also consider whether measurements are taken at the correct position in the process, as incorrect siting may lead to mis-measurement and erroneous actions.

Other recommended checks include considering how they vary when introducing a known change upstream and, once a problem has been identified, asking what is the likely time delay before corrective action can be taken.

Findings may show that:

- A measuring device is un-calibrated or badly chosen.
- Signals are corrupted.
- Equipment has been poorly installed or maintained.
- Measurements are now inadequate or inappropriate.

Whenever these are found they should be rectified with the help of a qualified technician.

Laksanakan program latihan kakitangan dan penyenggaraan pencegahan

Kecekapan proses sering kali merosot disebabkan cara operator bertindak balas terhadap kegagalan. Operator akan menyelaras penetapan kawalan untuk membaiki suatu masalah jangka pendek (seperti mengurangkan kadar kemasukan untuk mengimbangi kesan penapis yang tersumbat) namun kemudiannya gagal melaras semula tetapan setelah masalah dibaiki. Hasilnya, sistem menjadi tidak cekap.

Untuk mengelak situasi ini, laksanakan strategi penyenggaraan berkala, latih kakitangan untuk melaporkan kegagalan proses dengan segera dan pastikan operator sentiasa sedar akan akibat menyelaras tetapan kawalan.

Pertimbangkan automasi, di mana boleh

Kawalan manual boleh memberi kesilapan manusia. Senaraikan semua kawasan di lokasi tapak, di mana kawalan manual digunakan dan pertimbangkan sama ada kawalan automatik boleh dipasang.

Dalam industri makanan & minuman, kawalan automatik boleh digunakan untuk aplikasi seperti mengawal tahap kelembapan produk untuk mengelakkan pengeringan lampau atau untuk mengoptimumkan kualiti produk.

Banyak pembuat makanan & minuman juga menggunakan penderia mudah untuk mengesan sama ada sesebuah produk berada pada tali sawat, untuk mengelak tali sawat beroperasi secara berterusan, dan menjimat penggunaan tenaga.

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Establish a programme of staff training and preventive maintenance

Process efficiency often deteriorates because of the way that operators respond to faults. Operators make adjustments to control settings to overcome a short-term problem (such as reducing the feed-rate to compensate for a blocked filter) but then fail to readjust settings when the problem is fixed. As a result, systems become inefficient.

To prevent this happening, establish a regular maintenance strategy, train staff to report process faults promptly and ensure that operators are fully aware of the consequences of adjusting control settings.

Consider automating where possible

Manual control can introduce human error. List all areas on the site where manual control is used and consider whether automatic controls

In the food and beverage industry, automatic control can be used for applications such as controlling product moisture levels to eliminate over-drying, or optimising product quality.

Many food and beverage manufacturers also use simple sensors to detect when a product is present on a conveyor, meaning that less energy is expended, as the conveyor does not have to operate continually.

Penjadualan bagi kecekapan tenaga

Pemprosesan berkumpulan dan pertukaran produk yang kerap amat sering berlaku dalam industri makanan dan minuman. Oleh demikian, sering kali terdapat perubahan ketara dalam keperluan ke atas sistem dan ini boleh mengurangkan kecekapan keseluruhannya.

Pertukaran produk, sebagai contoh, dari membakar roti kepada membakar pastri, akan membawa kepada perubahan suhu dan tempoh bagi proses pembakaran. Pertukaran produk juga akan meningkatkan permintaan tenaga yang disebabkan oleh penggantian dulang ketuhar yang suam dengan yang sejuk dan pemanasan semula ketuhar kepada suhu yang diperlukan.

Memahami kesan pertukaran produk boleh membantu dalam mengenal pasti peluang penjimatan tenaga. Antaranya adalah mengurangkan bilangan dan tempoh masa pertukaran produk dalam sesuatu jadual dan menggunakan kawalan yang lebih baik untuk memastikan semuanya kekal cekap.

Bacaan dan kawalan proses membantu mempertingkat hasil dan kualiti produk, mempertingkat kapasiti kilang, mengurangkan pembaziran dan sisa, mengurangkan kesan kepada alam sekitar dan sering dan juga memastikan kecekapan dalam penggunaan sumber manusia, bahan dan tenaga.

Scheduling for energy efficiency

Batch processing and frequent product changeovers are commonplace in the food and beverage industry. As a result, there are often marked changes in the requirements placed on the system and this can reduce its overall efficiency.

A product changeover, for example, from baking bread to baking morning goods, will usually result in changes to the temperature and the duration of the baking process. The changeover will also result in an increase in energy demand caused by replacing warm with cold baking trays and the reheating of the oven to the required temperature.

Understanding the impact of changeovers can help identify energy savings. Common opportunities include reducing the number and timing of changeovers in a schedule and employing better control to make sure that each is efficient.

Process measurement and control helps to achieve improved product yield and quality, increased plant capacity, reduced wastage or give-away, reduced environmental impact and often vary efficient use of manpower, materials and energy.

Penjadualan bagi kecekapan tenaga

Selain penjimatan tenaga, kawalan proses juga boleh mempertingkat kecekapan operasi dalam pelbagai cara lain. Manfaat lain termasuk:

- Mengurangkan kos pembuatan dengan mengoptimumkan kendalian dan hasil produk. Syarikat sering kali dapat mencapai output lebih tinggi dari jumlah kendalian yang sama, hanya dengan memperbaiki kawalan ke atas proses operasi.
- Kualiti produk yang tekal, yang dicapai oleh pengurangan ketara dalam perbezaan kualiti produk. Ini akan memastikan penentuan pelanggan dapat dipenuhi dan pembaziran dikurangkan.
- Memperbaiki tahap keselamatan dengan amaran keadaan merbahaya atau dengan mewujudkan pintasan keselamatan untuk menghentikan operasi sekiranya operator gagal bertindak.
- Prestasi alam sekitar yang lebih baik, melalui amaran awal bagi kegagalan pembendungan, atau pelepasan berlebihan kepada persekitaran.
- Maklumat proses yang diraih dari bacaan proses boleh memberi gambaran tentang parameter yang boleh memperbaiki peluang keuntungan.

Scheduling for energy efficiency

Beyond energy savings, process control can also increase their operational efficiency in many other ways. Other benefits include:

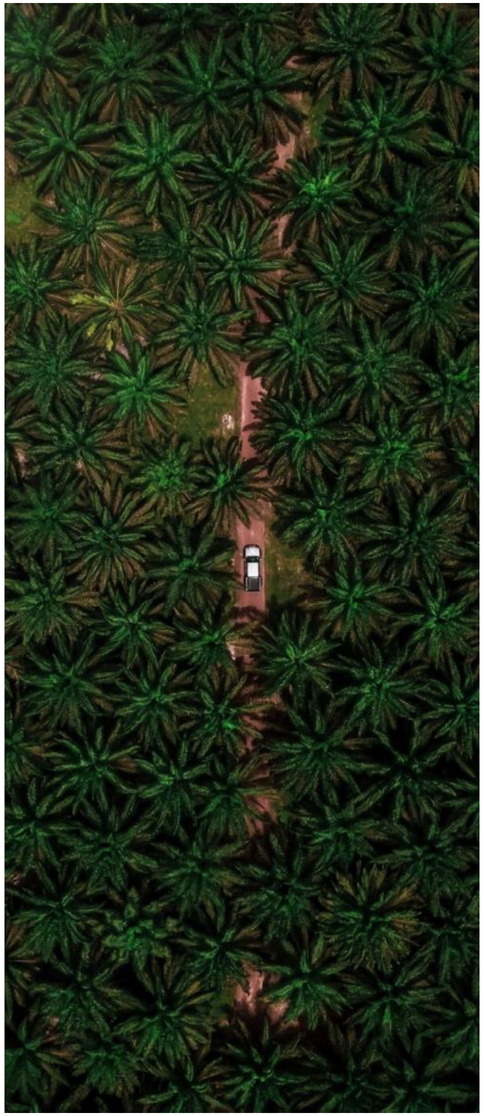
- Reduce manufacturing costs by optimising product throughput and yield. Companies often find that they can achieve a greater output from the same levels of throughput, simply by improving the control on operational processes.
- Consistent product quality by greatly reducing variation in product quality, hence ensuring that customer specifications are met and wastage is reduced.
- Safety improvement by warning of hazardous conditions or safety trips to cease operations if operators fail to respond.
- Better environmental performance through early warning loss of containment and excessive emissions to the environment.
- Process insight gained from measurements providing a 'window' on the process parameters that enhance profit opportunities.

Case study:

Cargill Palm Products, Malaysia[1]

Kilang ini beroperasi tujuh hari seminggu dan mempunyai jumlah output kira-kira 450,000 tan minyak sawit dan produk sampingannya, dan lebih dari 90 peratus darinya dieksport. Minyak sawit mentah melalui beberapa proses di dalam kedua-dua kilang penapisan dan pemeringkatan (*fractionation*) syarikat, untuk menghasilkan minyak boleh makan dan minyak tapisan. Ini memerlukan jumlah tenaga haba dan elektrik yang amat besar dimasukkan ke dandang tekanan rendah dan tinggi, pemanas, kompresor, motor, pam, dan sistem penyejukbekuan dan penyejukan air. Kira-kira 85 peratus tenaga yang digunakan adalah dalam bentuk tenaga haba (stim dan sistem minyak panas) dari bahan bakar, mana kala baki 15 peratus adalah dalam bentuk tenaga elektrik. Bahan bakar merangkumi 61 peratus dari kos tenaga manakala elektrik pula adalah 37 peratus.

Sebagai sebahagian dari **Malaysian Industrial Energy Efficiency Improvement Project,** sembilan pengubahsuaian kecekapan tenaga ketara telah dilaksanakan. Langkah-langkah yang berkaitan dengan kawalan proses dan bacaan termasuk:



Membaiki kebocoran paip udara termampat dalam penekan membran, sambungan dan *regulator* tekanan dalam kilang pemeringkatan yang memberi telah memberi kerugian sebanyak 30 peratus kebocoran udara dalam sistem. Pembaikan segera telah mengurangkan penggunaan elektrik. Langkah penyenggaraan berterusan termasuk mengendali sistem pada tahap tekanan paling rendah, mengekalkan kemasukan udara yang bersih dan sejuk, dan mengurangkan kerugian kebocoran ke tahap maksimum yang boleh diterima iaitu 5–10 peratus.

Meminimumkan kebocoran stim adalah satu langkah tanpa kos yang dicapai melalui program penyenggaraan bulanan. Pemeriksaan sambungan paip dan pembaikan kebocoran kecil telah mengurangkan kerugian haba dan memberi penjimatan tahunan berjumlah puluhan ribu Ringgit Malaysia.

Penyenggaraan perangkap stim juga dilaksanakan dengan memperluas prosedur penyenggaraan dan penggantian am syarikat kepada lebih dari 300 perangkap stim.

Penyenggaraan penebat haba telah dikenal pasti oleh pasukan audit sebagai satu isu ketara yang berlaku akibat paip dan lengkapan tidak dipasang penebat. Ini bukanlah satu perkara mudah diselesaikan, memandangkan isu-isu struktur dan penyenggaraan mengelakkan atau tidak menggalakkan pemasangan penebat. Jaket penebat mudah alih dan bekas penebat mudah alih bagi injap dan bebibir telah mengatasi kebanyakan masalah ini.

Langkah-langkah kawalan proses untuk mengelak pemanasan yang tidak perlu ke atas tangki simpanan stearin, telah memerlukan pemasangan *regulators untuk mengekalkan* suhu pada 60°C. Kos Pemasangan ini amat ketara tetapi telah diimbangi oleh penjimatan tenaga dalam tahun pertama.

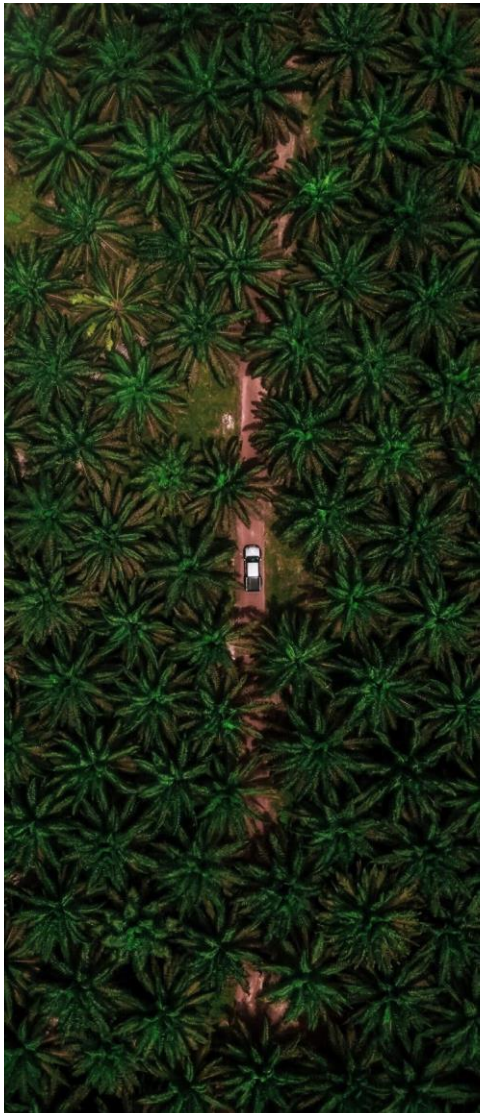
[1] https://www.uncclearn.org/wp-content/uploads/library/undp44.pdf

Case study:

Cargill Palm Products, Malaysia[1]

The plant operates seven days a week and has an overall output of about 450,000 tonnes of palm oil and its by-products, more than 90 per cent of which are exported. Crude palm oil passes through several processes in the company's two refining and two fractionation plants to produce edible and refined oils. These require large amounts of thermal and electrical energy to be fed to high and low pressure boilers, heaters, compressors, motors, pumps, and refrigeration and water cooling systems. About 85 per cent of the energy consumed is in the form of thermal energy (steam and a hot oil system) from fuel, while the remaining 15 per cent is in the form of electricity. Fuel represents 61 per cent of the energy costs and electricity 37 per cent.

As part of the **Malaysian Industrial Energy Efficiency Improvement Project,** nine significant energy efficiency modifications were



undertaken. As part of process and measurement control, the measures included:

Repair of compressed air pipe leakages in the membrane presses, joints and pressure regulator in a fractionation plant that were resulting in a 30 per cent air leakage loss in the system. Immediate repairs reduced electricity consumption. On-going maintenance measures included operating the system at the lowest possible pressure, keeping the air intake clean and cool, and reducing leakage loss to an acceptable maximum of 5–10 per cent.

Steam leak minimization was a no-cost measure that was achieved by a monthly maintenance program. Inspection of piping joints and the remedying of small leaks reduced heat loss and made savings that cumulatively amounted to tens of thousands of Malaysian Ringgit annually.

Steam trap maintenance was also readily accomplished by extending the company's regular maintenance and replacement procedures to more than 300 steam traps.

Thermal insulation maintenance was identified by the audit team as a significant issue that was occurring as a result of uninsulated pipes and fittings. This was not a simple matter to resolve as structural and maintenance issues discouraged or precluded insulation. Detachable insulating jackets and detachable types of insulation housings for valves and flanges overcame most of these problems.

Process control measures to avoid unnecessary heating of the stearin holding tanks required the installation of temperature regulators to maintain the temperature at 60°C. The cost of this installation was significant but was exceeded by the energy savings in the first year.

[1]https://www.uncclearn.org/wp-content/uploads/library/undp44.pdf

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- measures and certifies the environmental footprint of organisations, products and services;
- helps develop and deploy low-carbon technologies and solutions, from energy efficiency to renewable power.

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