Continuous Improvement in Steel Plants

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In the competitive global business environment, steel plants that can learn, innovate, and have a Continuous Improvement (CI) strategy based on research and knowledge generation can gain a competitive edge.

CI methods are designed to make the steel plant more profitable by:

- Providing a reliable process that ensures customer satisfaction
- Focusing improvement efforts where they will have the greatest immediate impact on the bottom line.

This presentation is based on the experience of Technovations International Inc., with some US American companies in introducing CI.

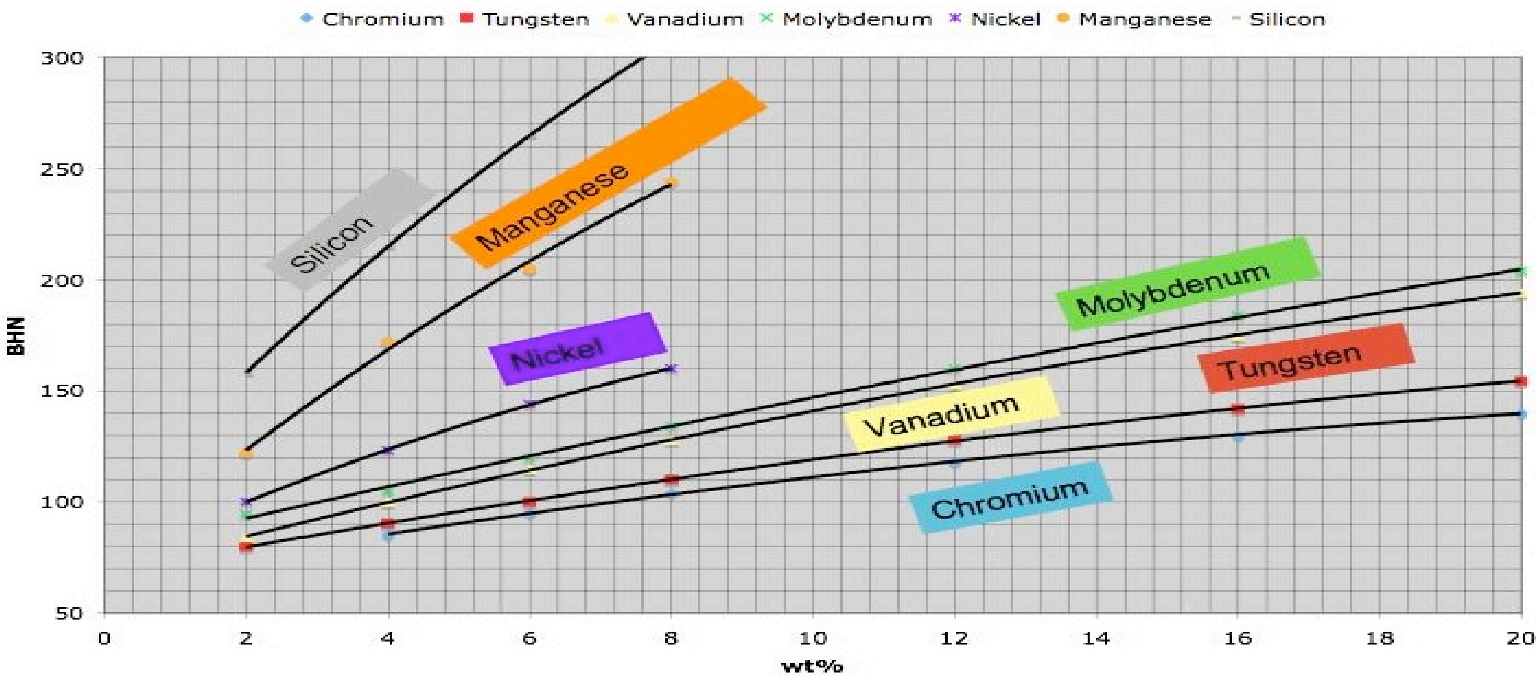
Steel is one of as the most versatile engineering material because of its properties, ease of fabrication, and cost.

CI involves the continuous application of an integrated strategy to increase overall efficiency, reduce consumption of resources, and reduce risks to humans and the environment by:

- Meeting and exceeding the specified properties and performance of the steel products
- Conserving energy and reducing materials, and workforce's* effort by increasing efficiencies and reducing wastage of resources
- *Workforce: All personnel engaged in producing steel products and providing services to the customers
- Eliminating unsafe and dangerous conditions
- Reducing all emissions with the minimum environmental impact

Energy and material conservation

Alloying elements are used to increase the strength and hardness of steel.



Optimum use of these elements is necessary to reduce cost, and environmental impact while ensuring the steel product's performance requirements.

This can be achieved by control of temperature, rate of thermal-mechanical processing, and cooling rate to produce the required microstructures, which determines properties of the steel product

Wastage of any resource has a negative economic value

In general waste is due to:

Poor quality of inputs e.g. defects in products to be processed

Inadequate instructions (process know-how) and controls

Inefficient machine or equipment, processing or operation

Waiting for materials, machines, or instructions (JIT)

Rework, repair, and rejects

Inadequate transportation or material handling

Excessive inventory of products to be processed

Inadequate housekeeping

Waste reduction involves:

Improvement in operation, process or equipment.

Energy efficiency

Research and innovation for continuous improvement is a low risk and high return strategy that provides immediate results to the bottom line by:

Developing, improving and providing solutions to enhance manufacturing efficiencies and reduce waste to:

- **Meet and exceed the customers' requirements**
- **Reduce operating expense and increase efficiency**
- **Increase productivity and plant equipment /machine utilization**
- **Enhance product value, cash flow and return on investment.**

Strategic alliances with expert organizations provide capabilities to:

Analyze processes, using their expertise in:
- Manufacturing technologies
- Information management
- Statistical analysis and mathematical modeling.

Generate and provide accurate information and data for:

- Knowledge based decision making.
- Strategies for efficient resource optimization
- Improvements in manufacturing efficiency.
- Identify and/or develop innovative processes,
- improved or best practices and new products.
- Apply mathematical simulation modeling and information technology for process optimization and control
- Introduce total quality management (TQM) methods to the critical manufacturing cost centers.

Workforce development and just-in-time information are critical to continuous improvement efforts

A knowledgeable and well-informed workforce is an asset that enables the steel plant to increase efficiency and ensures better use of resources to continuously meet the specific requirements of customers.

Communicating and sharing information in real time throughout the plant and at all levels ensures that the employees know what the key goals and targets are and are able to track their exact status to sustain continuous improvement.

Provide the workforce with the specific information:

- Where and when needed
- Delivered just-in-time
- In the most appropriate manner.

Technovations International Inc., has implemented a multimedia based interactive system that provides specific knowledge, information, instructions, data and documentations to support:

- Best practices
- Quality control,
- Scheduling and planning,
- Maintenance management
- Procurement and inventory management,
- Waste and energy management

Benchmarking sets and elaborates the standards, and identifies the best practices.

- It enables comparing the steel plants' performance metrics with industry best.
- The metrics used are throughput, quality, process dynamics, efficiency in resources utilization, inventory, and operating expense.
- It is an essential activity in CI.

Benchmarking Parameters

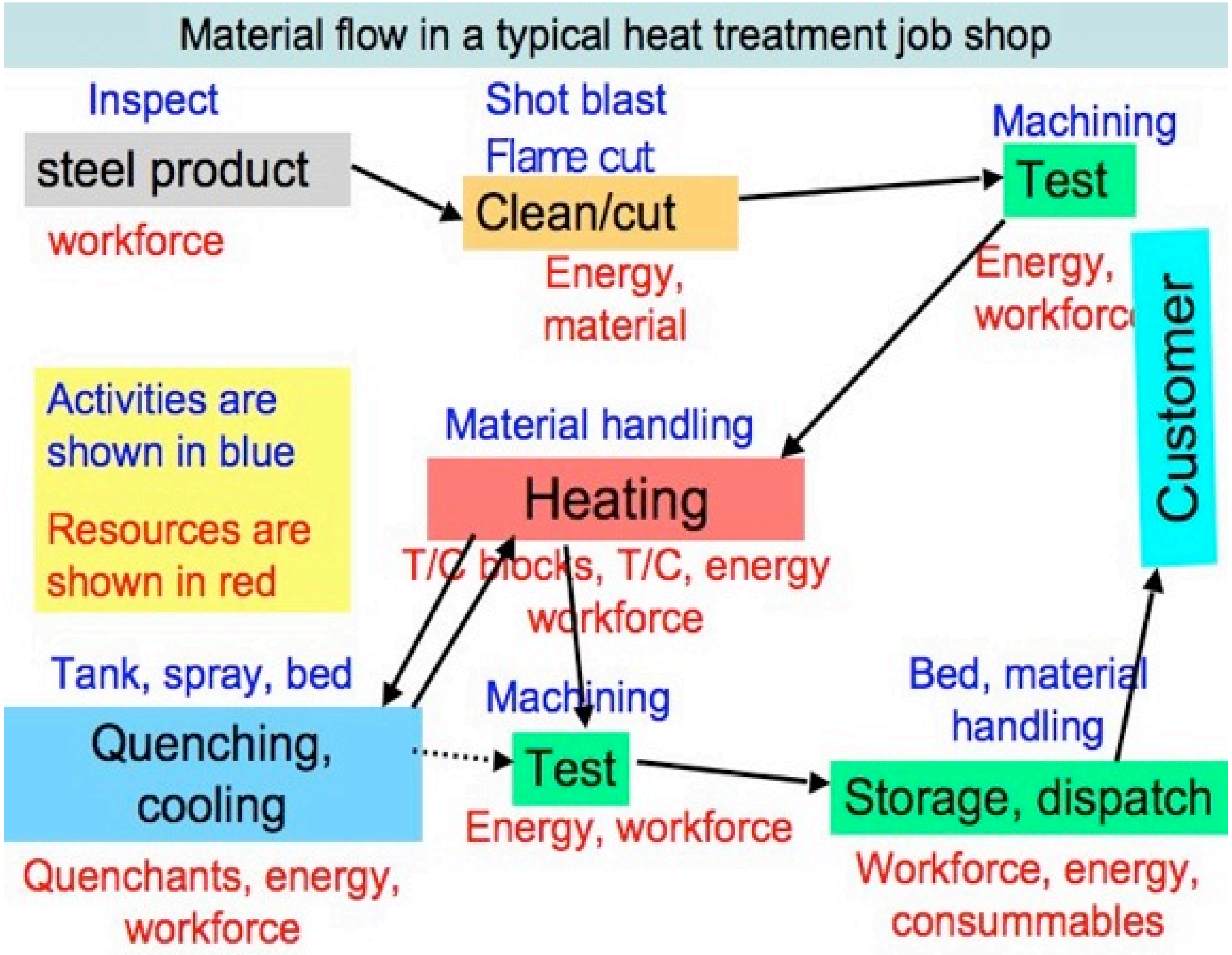
	Material			Workforce	Energy			
HT Step	Typ e	quantity/yr	Price/yr	Cost/hr	Quantity/hr	Total cost	Goal	Score1-5
Steel product								
Clean/ cut								
Testing								
Heating								
Quenching/ cooling								
Tempering/Stress relieving								
Testing								
Storage/ dispatch								
Customer service								

The score for each parameter will demonstrate the state of the plant and the need for CI.

Score: 1 = Good, 5 = Unacceptable

Outputs from Benchmarking

Flow sheet



Areas of shortcomings

Consumption of materials, energy and other resources

Generation of waste and identification of causes for inefficiencies

Product specific:
After quenching, the hardness in the interior of the steel product is not be the same as the hardness at the surface when the dimensions of the steel product are large.

Materials related:
Not all steels can be annealed or stress relieved in the same batch.

Process and equipment related:
The temperature of the quenchant at the beginning and end of quenching must be controlled. Agitation of the quenchant and the flow rate across the surface steel product should be large to ensure high cooling rates.

Operating practices:
Changes in properties during tempering depend on both temperature and time. The same change occurs at a lower temperature but with considerably longer time as at higher temperature at a much shorter time.

Planning for Continuous Improvement

Identification of opportunities for improvement of waste and inefficiency areas, which have high impact or ease of rectification

Select first the no-cost or low-cost options

Focus scarce resources on the constraints in the material flow.

Involve the entire workforce, in particular those involved in the daily operations and maintenance on the shop floor, to identify, evaluate and implement the improvements.

Focus attention on specific selected areas for further assessment.

Ensure that the Plant Management commits to a continuous improvement policy.

Organization for CI

Obtain the required authorization from the plant management to organize a project team, which will be responsible for initiating, coordinating and supervising the CI activities

Ensure that the project team has enough process knowledge to analyze and review the current practices process and equipment.

Ensure that the team has enough creativity to research, develop, and innovate changes in the current practices, and enough authority to implement and maintain the proposed changes.

Select cost-effective strategies for implementation.

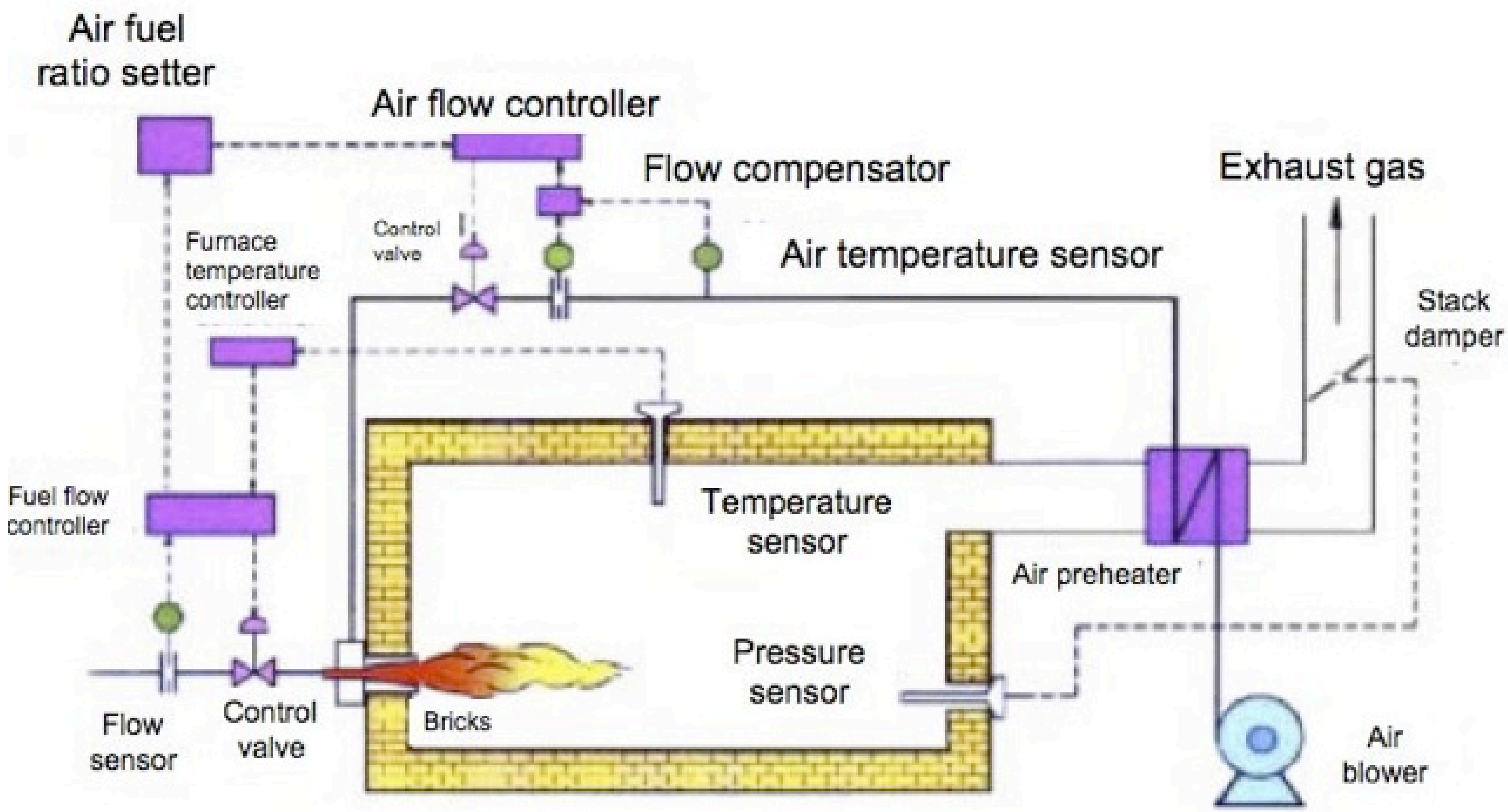
Identify the barriers.

Barriers to continuous improvement

TYPE OF CONSTRAINTS	SUB-CATEGORIES
FINANCIAL	High cost of capital for investments. Perception that investments in CI present a high financial risk due to its innovative nature. Credit providers do not properly evaluate CI for lending, equity participation etc
ECONOMIC	CI investments may not be sufficiently cost effective compared with other investment opportunities, given present resource prices. Immaturity of the company's internal cost calculation and cost allocation practices. Immaturity of the company's internal capital budgeting and capital allocation procedures
POLICY-RELATED	Insufficient focus on CI in environmental, technology, trade and industry development and strategies.
ORGANIZATIONAL	Perceived management risk related to CI e.g., no incentives for managers to put their efforts into its implementation. General immaturity of the organization structure of the company and its management and information systems. Limited experience with employee involvement and project work
TECHNICAL	Absence of a sound operational basis with well established production practices, maintenance schemes etc. Complexity of CI; e.g., need to undertake comprehensive assessment to identify appropriate CI opportunities. Limited accessibility of equipment supportive to CI e.g., high quality engineering small wares for process instrumentation. Limited accessibility of reliable technical information tailored to the company's needs and assimilative capacities
CONCEPTUAL	Perception regarding the own role in contributing to environmental improvement. Narrow interpretation or misunderstanding of the CI concept. General resistance to change

Systems view to eliminate wasted resources

Adopt a systems approach to identify where to eliminate the main sources and causes of inefficiency and wasted resources and develop a plan for what to do and how to achieve the targets



Systems Approach

Find facts and information that are relevant to the issues by examining each **process and sub process.**

High energy consumption for heating.

Too many rework and customer complaints are indications

Product specific deficiencies

Poor as-received condition of the steel product can lead to inefficient operation, rejects or rework.

Rectification of product requires coordination with the customer

Input related inefficiencies

Quality control and stricter specifications of inputs

Opportunities areas

Good housekeeping

Develop preventive maintenance system based on condition monitoring,
Enforce existing working instructions through proper supervision and training.

Change input material

Replace consumables with more durable materials that have a longer service lifetime.
Reduce quenchants consumption by (1) purification (2) substitution.

Process modification and control

Establish level II control based on mathematical modeling and instrumentation to optimize process and sequence to minimize delay, reduce energy and improve on-time delivery.
Modify heating procedures with oxygen trim control.
Develop product specific efficient heating and cooling/ quenching practices to reduce polymer consumption and waste generation rates.

Equipment modification

Modification existing equipment such as furnace with pulse firing

On-site recovery/reuse/recycle

Reuse waste quenchants, wastewater in the same production process or elsewhere in the plant.

Produce useful by-products

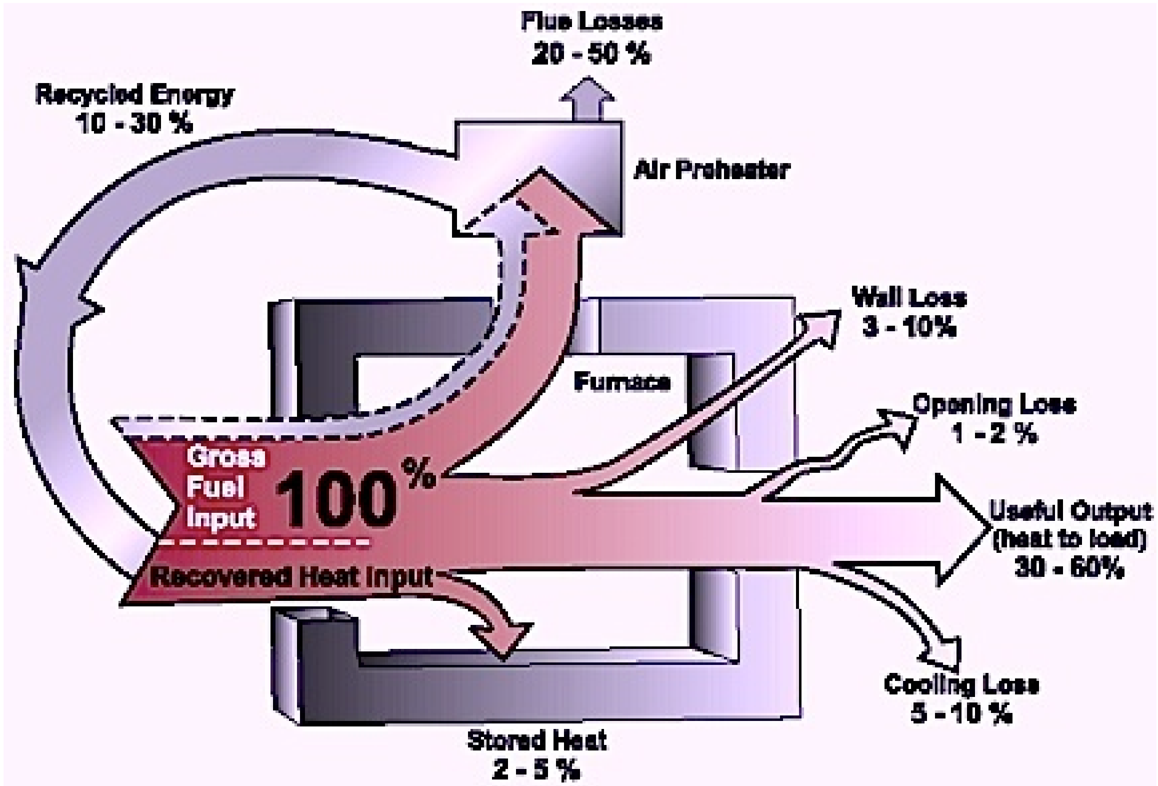
Transform waste into a useful by-product to be sold as input for companies in other sectors.

ACTIONS FOR CONTINUOUS IMPROVEMENT

Make a material flow analysis with quantity of each type of input for each step in the process for a fixed period .

HT Step	CI Option	Benefit
steel product	Electric front loader charged by solar photo-voltaic	Energy reduction
Clean/cut	Plasma or water jet cutting	yield
Test	CNC machining	Cost of specimen
Heating, HT	Burners and firing mode, Waste heat recovery, pyrometer.	Energy, T/C cost
Quench, cool	Agitators, rapid transfer, jet sprays, cooling tower	Product quality, reduced rework
Heating, LT	As above , Modeling for scheduling and thermal control	Productivity, quality
Test	As above, Failure analytical tools	Customer satisfaction
Store, dispatch	RFID, On-line records	Customer satisfaction

Prepare an energy input-output balance (Sankey diagram)



Obtain the quantity and the type of the resulting by-products or waste products.

Calculate the quantity per mass of steel products.

Calculate the consumption of energy and input materials and compare them against the benchmark.

Assess where the most serious problems occur in the process

Review and revise plant layout and materials flow

An optimized plant layout provides a safe working environment and efficient area utilization.

Disorganized flow will result in greater time and effort in some locations and wasted resources.

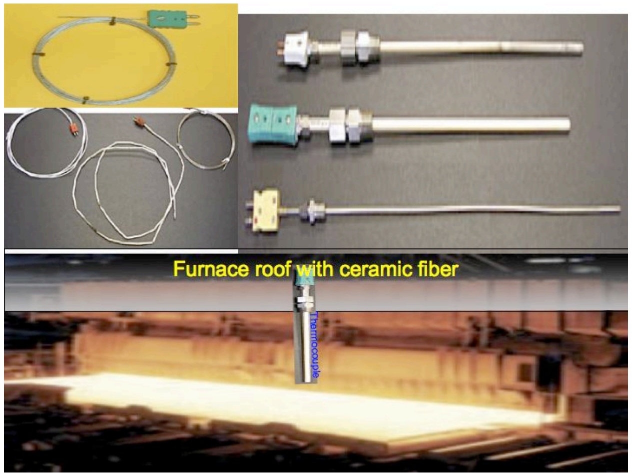
Considerable re-handling would result in damaged articles and higher energy consumption.

Adopt 5S to improve material handling and storage

Introduce Condition based Maintenance of equipment

Poorly maintained material handling systems and improper operating practices with furnaces, quench tank, etc., may lead to:
Off-quality, higher rework
Increased scrap,
Leakage, spills, and waste generation.

Explore if repair, modification or replacement is required for:
Pumps, valves, and pipe systems in the quench tank
Furnace door and roof insulation
Burners and fuel, air controls
Temperature measuring, recording and data acquisition system



Technology change

Technology changes can range from minor changes that can be implemented in a matter of days at low cost such as a more efficient burner system.

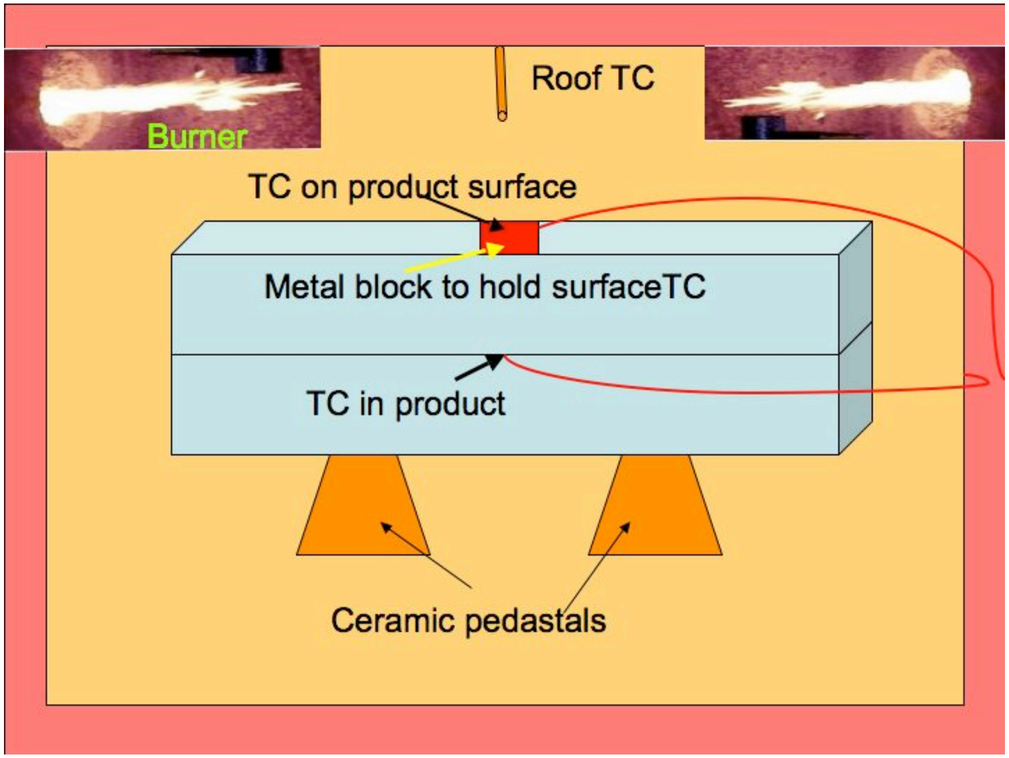
Major Changes such as replacing fuel fired furnace by induction heating for accelerated tempering involve large capital expenditure.

Roller quenching provides uniform temperature distribution for plates

Process Control

Changes and control of process conditions, such as flow rates, temperatures, pressures, and residence times also lead to more efficient processes and/or more benign operations.

Monitor the temperature of the steel products as well as the flow rate and oxygen level of the products of combustion.



Process intensification

Consider the following examples to reduce process time:

Use mathematical model (accelerated tempering)

Use scheduling models to reduce time between change over by adjusting furnace temperatures and speed of travel of the products.

Use a faster cooling system such as mist cooling for products that are normalized after they reach a lower temperature and allow the use of magnets.

Use air knives to blow air at the products that can be cooled rapidly outside the furnace.

Use jets in quench tank to accelerate quenching.

Equipment modification

Regenerative burners, pulse firing	Enables higher turndown ratio, higher fuel efficiency. Use programmable logic control for combustion and temperature
Insulation with ceramic fiber blocks	Reduces heat loss during heating and requires less energy due to low heat capaciy.
Preheat combustion air with waste heat recovery	Improves burner and combustion efficiency, reduce losses in waste gases. Use variable speed drive for combustion air.
Equipment modification for furnace idling	Install high turndown ratio burners or pulse firing for low fire setting when not heat treating. Use variable speed drive for combustion air.
Compressed air management	Install controls for switch off during non-production periods.
Motors and drives	Use high efficiency motors, variable speed drives, install load optimizers on pumps.
Quench tank	Use agitators with variable speed drives; install baffles on pumps to direct quenchant flow.

Best practices

After implementation of CI options the standard operating practices should become the "Best Practices".

Examples:

Control the temperatures precisely within 10 C.

Accurately measure temperature at specific locations in the furnace and steel products using proper sensors and probes.

Establish the temperature profiles in steel products during heating by the use of thermocouples placed at key locations in the furnace and at strategic locations in the steel products.

Alternatively use mathematical models to predict temperatures.

Control the austenite grain size.

Control the heat treatment to produce the required microstructures.

Precipitate the desired carbides, nitrides and carbonitrides when required and not otherwise.

Control the size, distribution and spacing between the precipitates.

Prevention, recovery and recycling

The prevention practices are essential for CI. The table shows some examples.

Waste Generated	CI Option
Cleaning and cutting	Use shrouding for recycling grit and to prevent dust from escaping into environment.
Testing	Use specimens during heat treating to reduce wastage from the main product.
Heating	Reduce temperature during idling period. Recover heat in waste gas. Consider non-disposable temperature measurement.
Quenching, cooling	Provide agitation of quenchant to increase efficiency. Use the lowest concentration of polymer in quenchant. Recover oil and salt for reuse.
Storage dispatch	Control environment to prevent deterioration of the products. Use appropriate packaging to prevent damage to the product during transit.

Design change of products

Collaborate with the customer to select the correct steel composition for the specific design and its application to improve product quality, increase productivity, reduce waste, and emissions during manufacturing the product.

These may include change/s in:

Quality standards

Composition of the steel to increase hardenability, reduce grain coarsening. Design to reduce defects such as distortion.

Fabrication techniques including joining, surface engineering

Implementation of CI

Implement only the technically and economically feasible strategies with a significant environmental benefit.

Implement simple measures like good housekeeping as soon as possible.

Focus on complex measures, which require a substantial investment. Implementation of these options can require a detailed preparation such as planning the installation and funding requirements.

The installation of equipment requires workforce training in order to ensure the optimal use of the new facilities.

To achieve positive results, CI implementation should be executed by undertaking the following:

Identify a **Champion** with the prime responsibility for the implementation

Develop a **systems and project management methodology** to organize and manage the CI effort to meet the expected date of completion

Monitor progress and Sustain CI

Use agreed measurement criteria to monitor progress and to keep the management as well as other stakeholders frequently informed regarding:

- Resource consumption, including energy,
- Profitability
- Production output
- Product mix
- Waste (and/or emission) quantities

Sustaining CI may require structural changes in the organization and management system of the steel plant such as:

Integration into the technical development effort of the plant

Proper accountability of waste generation

Employee involvement

Integration into the technical development effort could include:

Condition monitoring and Preventive maintenance schedules

Integration of environmental efforts (such as energy and resource management)

Design or selection of new equipment
Integration with long-term research and development plans

Employee involvement can be achieved by:

Workforce training and Staff education

Creation of regular opportunities for two-way internal communication
Employee reward programs

Cost is important

By ensuring the impact of the CI option on throughput, inventory, and operating expense, it is possible to increase net profit, return on investment (ROI), and cash flow.

Collect data regarding investments and operational costs, and benefits. Obtain detailed cost of all changes to equipment, raw material, instrumentation, freight, insurance, energy, maintenance, labor, staff, design engineering, consulting services, installation and start-up, etc.

Develop a balance sheet to determine net savings and payback period.

Demonstrate that the CI effort has benefited the plant by using a cost and benefit analysis as per the following items:

- The investment cost for the option
- Incremental operating cost for in terms of labor, salaried staff, materials, maintenance, utility, admin and depreciation
- Savings in materials, energy, disposal cost, reduction in rejects, labor, higher production, etc.

If the savings, benefits and improvements are less than the expectations then:

Go back and update the CI plan

Identify better options

Implement them

Measure the results

Thank you

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