

Batch reactor as a plant engineering essay



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What is a plant unit. All Equipment that make up a plant can be divided into 3 different categories or levels, the highest being the Plant as a whole, then the plant units and the lowest are the plant items.

While the actual plant performs an overall production, the Plant unit refers to the main components of a Plant which perform a major production function of the Plant and without which the Plant can not continue its operations. A Plant unit is made up of items but it can be replaced as a whole (Anthony Kelly...)

In this Plant, the Batch Reactor receives raw materials from the raw material storage, processes them for a certain amount of time then transfers them to the centrifuge feed vessel.

From the above diagram, it is obvious that the Batch Reactor is a major component of the plant and from its function it is seen that the reactor must process the raw material for progress to be made to the next stage of production.

I am therefore concluding this as my explanation as to why the Batch reactor is a plant unit.

Explain Your Reasons For Concluding That This Unit Is Critical For Production.

Several Factors determine how critical a piece of equipment is to production.

They include:

Will the Equipment affect safety in the plant?

Will the Equipment not working cause downtime in the plant?

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How easily can the Equipment be maintained?

What is the cost of this maintenance?

What is the current situation of the Equipment? (Paul Wheelhouse)

Now each of the factors can be used to examine the Batch Reactor and after which an educated decision can be made.

The Batch Reactor affects the safety in the plant because its function involves the heating of chemicals under pressure and its failure might cause the leakage of these chemicals or at the worst lead to an explosion in the Plant.

If the Batch Reactor was to stop working, there would be prolonged downtime until it is fixed; this is due to the fact that the Reactor performs a major function in the Plant without which further production would come to a halt.

The Batch Reactor is made up of a number of different items, some of which can be run-to-failure, but for the most an established schedule of maintenance must be made for. Without such a schedule, maintenance would be most difficult to carry out.

The cost of maintaining the Batch Reactor may vary but if is not properly attended to; one fault might lead to another even bigger one so the cost of maintaining might increase.

The items in the Batch Reactor have a life plan which is currently not being kept to; this means the Equipment requires monitoring to avoid random failure or prolonged breakdown and downtime.

On the account of the above facts, it is my belief that the Batch Reactor needs to be labelled as critical.

Extract Any User Requirements For This Designated Unit From The Plant Description. Are There Any Production Windows?

What are User requirements? This simply refers to the specifications that are inbuilt in a piece of equipment so that it might be able to fulfil the end user's needs according to those tasks which it is used to perform.

In line with the plant description given on this particular Batch Reactor, a number of user requirements can be ascertained and these are listed below:

To receive 18te of raw materials from the raw material storage.

To remain sealed and heat its contents through a preset temperature / time profile by use of a temperature control system consisting of a thermocouple in a temperature pocket, a temperature controller and a control valve.

That the control valve regulates the supply of low pressure steam.

That its temperature alarm signal when the temperature exceeds 1250C.

That all safety relief valves work in event of an increase of temperature past the safety limit of 1250C.

That the bottom run off valve opens when the operation is complete and releases the contents from the Batch reactor to the centrifuge feed vessel by the discharge pump.

That the operation lasts 10 hours only.

What is a production window? This is a period during production in which maintenance procedures can be carried out without causing a halt in production. With emphasis on the Batch reactor it can be seen that there is a production window and this can be explained below.

While the batch reactor makes 18te of product every 10 hours, the centrifuge processes this product at a rate of 1.5te an hour i. e. it would have completely used up the 18te of product in 12 hours. Since it takes 10 hours for the batch reactor to work, this would give a 2 hour production window in which it can be properly maintained.

Also depending on the capacity of the centrifuge storage vessel, it is possible for the batch reactor to work overtime filling this feed vessel up and then be switched off and maintained while the centrifuge is operated using the previously stored produce in the centrifuge feed vessel.

Extract Any Corporate Requirements for This Unit From The Plant Description.

What are corporate requirements? These are the requirements which the upper management or Business sector of the company running plant desire from its industrial operations in order to make a suitable return on its investments (ROI).

From the plant description the following corporate requirements can be made below:

That its keeps to its scheduled annual shutdown period of 16 hours during week 40 each year.

That all maintenance pertaining to the batch reactor abides by the “ permit to work” system which controls all maintenance activities.

That the batch reactor achieves a 25 year life and that the gearboxes achieve a 15 year life as well.

That the batch reactor remains well-painted, clean and tidy at all times.

Extract Any Legislative Requirements for This Unit From The Plant Description.

What are legislative requirements? These are Plant requirements made by the Law, rules or regulations or the Country in which the Plant operates.

They must be implemented in order for the plant to avoid sanctions or being shut down.

In this particular plant description they include:

That the Batch Reactor abides by the rules by the FDA and British pharmaceutical Society put in place for their license holders.

All production and maintenance activities involving the Batch reactor comply with the Good Manufacturing practise (GMP).

That the processes involving the Batch Reactor are as okayed by the quality standard ISO 9002.

That the batch reactor conforms to the environmental standard ISO14000.

That if used by the Pharmaceutical inspection team, the batch reactor must pass any risk-based inspections based on a DNV methodology that might be carried out.

Comment On If Some of The tasks Designed For Shutdown Could be Done During Production Windows Or When The Plant Is Online. Could Any Of These Tasks Be Designated For Completion During Production Windows Be Completed Online?

We have previous explained what production windows are and when a Plant is online refers to when the plant is carrying its usual operational procedures. From the work done previously in section 1. 3, we now know that there is a definite 2 hour production window during which the batch reactor can be maintained while the centrifuge is working. In looking at the life plan for the batch reactor unit, there are a certain amount of tasks that could be done in 2 hours and should be moved from shut down to production window, these are:

The replacement of the trim of the CV1 every 2 years.

The pressure testing and inspection of the SV1 every 6 years.

The visual check of the Agitator every 6 years.

The SV2 pressure testing and inspection every 6 years.

There is only one task put to be completed when there is a production window and it can be done while the Plant is online. This is the weekly visual check on the Agitator coupling, because if it is checked while online it might lead to the location of which wouldn't have being seen if the equipment was offline.

Analyse The Recorded Jobs From The Computer Maintenance Management System (CMMS) For This Unit. Is There Any Evidence Which Confirms That The Life Plan Is Being Carried out? Is There Any Evidence To Say If The Life Plan Is Effective Or Not?

What is a Life plan? All plant units or manufacturing stages in production are designed to have a certain life. To fulfil this, maintenance plans are put in place to achieve this expected equipment life and if possible, to exceed it. These maintenance plans are called Life plans. (Wheelhouse, 2008)

On comparing the life plan of the batch reactor to the computer maintenance management system (CMMS) it can be seen that the life plan isn't being carried out. This is due to the factor that there is a remarkable difference between the standard time taken to maintain every single unit item in the reactor and the actual time the job was done in hours, meaning the maintenance done cannot be adequately planned for and could lead to excessive downtime.

It can be seen that for this singular reason the life plan of the batch reactor is not capable of being effective.

Use The Figures, Plant Description And The Data From The CMMS To Analyse The Unit Into Its Maintenance Causing Items.

Using the figure 1 shown previously and the figure 2 shown directly above as well as the Life plan and the CMMS, the maintenance causing items can be broken down as done bel

Batch Chemical Reactor

CV1

Agitator Coupling

Temperature controller

Gearbox

Motor bearing

Oil seal

Agitator

Trim

Agitator gear box

Reactor Vessel

Temperature sensor

Pump

Motor

Pump bearing

SV1

SV2

P1

V1

Vessel

Jacket

Figure 3: The Maintenance Causing Items in a Batch Chemical Reactor

Develop your own life plan for these maintenance causing items using the task selection logic for Reliability Centred Maintenance.

RCM WORK SHEET SYSTEM: CHEMICAL PLANT

SUB-SYSTEM: BATCH CHEMICAL REACTOR

SUB-

SYSTEM

FUNCTION

FUNTIONAL

FAILURE

FAILURE

MODE

FAILURE

EFFECT

CRITICALITY

RESPONSE

TIME

FREQUENCY

CV1

Regulates supply of low

Pressure steam

Unable to supply

Steam at all.

Supplies

Inadequate steam

Faulty Trim

Absence or insufficient

Supply of steam

High

Replace trim

3 hrs

2 yearly

(Production window)

Agitator Motor

Gearbox

Transmit motion to the

Agitator

Fails to transmit motion

To the Agitator.

Broken seal

Shortage of lubrication

Damaged bearings

Worn gear teeth

Oil leakage

Damage to gearbox

Medium

Monitor vibrations

and check oil seal

and condition.

2 hrs (vibration

monitoring),

12 mins oil

inspection

Monthly Vibrations,

Daily oil & seal checks

(Online)

Agitator

Coupling

Connects Agitator motor gearbox

to Agitator for motion transmission

Doesn't transmit motion

From gearbox to agitator.

Transmits inadequate

Motion.

Slackness in fitting

Doesn't give agitator

The necessary

Transmitted motion.

Medium

Tighten coupling as

required.

6 mins

Daily (online)

Temperature

Controller

Controls the temperature making

sure it doesn't exceed 1250 C

Unable to read the

correct temperature.

Faulty temperature

sensor .

Increase or reduction

of reactor temperature

on wrong information.

High

Recalibrate

temperature sensor.

2 hrs

2 year (Production

window)

SV1

Releases the pressure steam in the

vessel during times of alert.

Unable to release

excess pressure steam

Blockage at valve

outlet.

Crack in valve

Pressure steam is

not released properly or

in time.

High

Inspect, pressure test

and recondition if

necessary.

3 hrs

6 yearly (Shutdown)

SV2

Releases excess steam in the jacket

in times of alert

Unable to release

excess steam

Blockage at valve

outlet.

Crack in valve

Pressure steam is

not released properly or

in time.

High

Inspect, pressure test

and recondition if

necessary

3 hrs

Yearly (Production

window)

Agitator

Shakes, stirs & mixes the raw

materials in the reactor.

Unable to stir or mix

Raw materials.

Damaged blades

Eroded surface

Raw materials are

not mixed properly.

Medium

Recoat or replace as

necessary.

3 hrs

Re-coat or replace as

necessary.(Shutdown)

Jacket

Maintain its integrity and contain

raw materials during processing.

Leakage of materials

during processing.

Damaged or eroded

Parts.

Contents leak out

causing contamination.

High

Pressure test and

repair as necessary.

5 hrs

Yearly (Shutdown)

V1

Releases processed material to

P1 pump

Processed materials

not released

Leakage of material

during release

Blockage at valve

outlet

Crack in valve

Contents not released

properly.

Contents leak out

causing contamination.

High

Leak test and repair

if necessary.

15 mins

Daily test (Online)

P1

Transfer processed materials from

reactor to centrifuge feed vessel

Leaks material

Unable to pump

materials at all.

Pumps materials at

Wrong rate.

Replace seal if

necessary.

Replace pump if

necessary.

Contents leak.

Contents not pumped

properly

High

Condition

monitoring

Replace seal if

necessary

Replace pump if

necessary.

1. 5 hrs

(Condition

Monitoring)

4 mins (Leak

test)

Monthly condition

Monitoring (Online),

Daily leak checks

(online)

Figure 1. 4: Life Plan using RCM logic.

Compare and contrast between your Life plan with the one described previously, comment on any similarities and differences.

There are a number of ways in which my Life plan differs from the one previously given but there are also ways in which both are similar. Some of them are as listed below:

To begin, the first detail that can be noticed when comparing both life plans is that since I used the RCM selection logic, my life plan carries much more details as I included the functions, functional failures, failure modes, failure effect and criticality of each subsystem or item. This will be particularly useful in settling up priorities as the criticality of each subsystem is set at low, medium or high depending on the considerations of safety, performance and impact of the subsystem or item on the rest of the plant.

I brainstormed and added more failure modes and their activities than had being previously discovered or had activities planned for in the previous life plan so as to further prepare maintenance personnel to be able to tackle these failures if and when they do occur.

I changed the time frame for certain activities to take into consideration the new 2 hour production window that was discovered earlier. This will help reduce the amount tasks that are done during a shutdown and therefore cut down the downtime which the plant undergoes.

I increased the amount of time to be used to accomplish most tasks due to the fact that in the previous life plan, insufficient time was allocated to these

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tasks so therefore they couldn't be planned or executed properly within the targets set for them.

Now in terms of similarities, I observed that the preventive maintenance and condition monitoring carried out on the Batch Reactor had ensured breakdowns were kept to a minimum so bearing this in mind, I retained all the activities from the old life plan and continued using them for the various items.

I also continued to carry out maintenance activities at the same frequency that was mapped out in the old life plan as I believe that the punctuality with which activities were carried out improved the reliability of the equipment.

CHAPTER 2

Describe The Philosophy of Total Productive Maintenance.

What is TPM? Total Productive Maintenance (TPM) refers to a management system for optimizing the productivity of manufacturing equipment through systematic equipment maintenance involving employees at all levels. Under TPM, everyone is involved in keeping the equipment in good working order to minimize production losses from equipment repairs, assists, set-ups, and the like. (<http://www.siliconfareast.com/tpm.htm>).

The goal of TPM is to increase production while at the same time boosting employee morale and job satisfaction. (Venkatesh. J) This is possible because there would be less downtime as TPM is carried out by the Operators on the items or machinery which they use as they, the maintainers and Designers work as a team towards the total elimination of equipment defects in the Plant (Paul Wheelhouse).

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History of TPM

TPM is a Japanese idea that can be traced back to 1951 when preventive maintenance was introduced into Japan from the USA. Nippondenso, part of Toyota, was the first company in Japan to introduce plant wide preventive maintenance in 1960. In preventive maintenance operators produced goods using machines and the maintenance group was dedicated to the work of maintaining those machines. However with the high level of automation of Nippondenso, maintenance became a problem as so many more maintenance personnel were now required. So the management decided that the routine maintenance of equipment would now be carried out by the operators themselves. This is known as Autonomous maintenance, one of the features of TPM. The maintenance group then focussed only on “maintenance” works for upgrades. For pioneering TPM, Nippondenso became the 1st company to receive TPM certification (wikipedia).

Why Use TPM?

For TPM to be used in an Organisation, everyone from senior management to the operators on the floor must be carried along and made to understand why this particular system is being used. For this to happen effectively, the Motives, Objectives and benefits must be fully stated out and properly absorbed. The table below gives a generic illustration:

Motives of TPM

Adoption of life cycle approach for improving the overall performance of production equipment.

Improving productivity by highly motivated workers which is achieved by job enlargement.

The use of voluntary small group activities for identifying the cause of failure, possible plant and equipment modifications.

Uniqueness of TPM

The major difference between TPM and other concepts is that the operators are also made to involve in the maintenance process. The concept of “ I (Production operators) Operate, You (Maintenance department) fix” is not followed.

TPM Objectives

Achieve Zero Defects, Zero Breakdown and Zero accidents in all functional areas of the organization.

Involve people in all levels of organization.

Form different teams to reduce defects and Self Maintenance.

Direct benefits of TPM

Increase productivity and OPE (Overall Plant Efficiency) by 1.5 or 2 times.

Rectify customer complaints.

Reduce the manufacturing cost by 30%.

Satisfy the customers' needs by 100 % (Delivering the right quantity at the right time, in the required quality.)

Reduce accidents.

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Follow pollution control measures.

Indirect benefits of TPM

Higher confidence level among the employees.

Keep the work place clean, neat and attractive.

Favourable change in the attitude of the operators.

Achieve goals by working as team.

Horizontal deployment of a new concept in all areas of the organization.

Share knowledge and experience.

The workers get a feeling of owning the machine.

Figure 4 . TPM table

Source: An Introduction to Total Productive Maintenance (Venkatesh. J)

For TPM to start properly, the OEE (Overall Equipment Effectiveness) should be calculated and a loss analysis performed to give both a baseline for continuous upgrading and ascertain the improvement priorities.

This will allow the operator/core maintenance team to prioritize and then tackle the 6 classic losses of:

Breakdowns

Set-ups and changeovers

Running at reduced speeds

Minor stops and idling

Quality defects, scrap, yield and rework

Starting up losses

The above losses add to the direct costs. Implementation of TPM attacks these and other direct (visible) costs as well as indirect (hidden) costs and follows each step in the production and supply chain from Management to the human resources to the Machine to the process, then to suppliers and finally to the customers (Willmott and McCarthy).

Components of TPM

Figure 4: Pillars of TPM

Source: An Introduction to Total Productive Maintenance (Venkatesh. J)

As shown above, TPM is made up of 8 main aspects which when combined present the full TPM package. They are:

The 5 S which are primarily the foundation of TPM and involve organising the workplace. These are sorting, systematising, sweeping, standardising and self-discipline.

Autonomous maintenance which refers to the operators handling most or in cases all of the maintenance concerning the machines which they operate.

Kobetsu Kaizen means small improvements or changes for the better of the organisation.

Planned maintenance entails scheduled maintenance which is done to ensure trouble free machines and equipments producing defect free products for total customer satisfaction.

Quality maintenance is aimed at providing customer satisfaction by providing the highest quality through defect free manufacturing.

Training to give employees a multi skilled edge.

Office TPM to ensure administrative efficiency as well.

Safety, health and environmental awareness to ensure zero accidents, zero health damages and zero fires (Venkatesh. J).

Describe a Case Study Where TPM has been successfully applied

The case study which I wish to use is that of RHP Bearings. This RHP Bearings branch which is in Blackburn, manufactures cast iron bearing housings for a variety of uses from agricultural machinery to fairground rides, and is one of seven RHP manufacturing sites in Europe owned by Japanese group NSK, the world's second largest bearings manufacturer.

How TPM was carried out.

NSK acquired RHP in 1990, when the Blackburn site was under the imminent threat of closure because of high costs and the subsequent lack of competitiveness. Employing a staff of 93, TPM was then introduced to the site in 1993 but it didn't see much success till 1996 due to the fact that the earlier efforts to drive TPM had been largely theoretical and the workforce faded to see its relevance to the everyday running of the plant. In 1996 a

maintenance company was brought in to do a scoping study of the plant, conduct a workshop and support two pilot TPM projects.

The Plant Manager and the TPM facilitator then began to implement measures to ensure TPM was made directly relevant to the jobs of the staff. Operators were sent off to climb over their machines and log problems through a detailed condition appraisal, to establish a foundation for future TPM improvements.

TPM was piloted on two key machines, the PGM core making machine in the foundry and the Shiftnal sphering machine in the machine shop, using a detailed seven-step TPM implementation programme:

Collection and calculation of Overall Equipment Effectiveness (OEE) Data

Assessing the six losses

Criticality assessment and condition appraisal

Risk assessment

Refurbishment plan

Asset care and best practice routines

Regular review for problem solving

TPM is applied to machines of all ages – from new to 30 years old, ensuring that older machinery is brought up to modern specification and newer machinery is kept in ‘as-new’ condition. The TPM was applied at the site by 9 different equipment teams focusing on specific machinery and involving

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60% of the workforce. These teams included operators, maintainers, quality technicians and group leaders also drawing on help from personnel with specialist skills when necessary.

Each Team developed a standard routine for their respective machines using:

Autonomous Maintenance System (AMS) boards which show a schematic of the machine then tags with labels to show losses affecting availability, performance and quality. These labels are then used to generate TPM agendas for team meetings.

TPM step notices which illustrate the machine's progress in TPM seven step programme.

Mainpac database which is used to gather machine performance details and calculate the OEE.

Key performance indicators which the teams use to access their improvement and progress in areas of waste sand, Gas emissions, Kaizen, Customer returns, lost time incidents, injurious accidents, Audit and product conformance.

Each team then has an activity board covering subjects such as milestone activities and previous day's conformance result among others. To ensure TPM succeeded, Teams had to dedicate substantial time to carrying out laid down activities and held meetings as needed.

Benefits of TPM

Implementing TPM had both direct and indirect effect on the production system a combination of which generated major savings at RHP, Blackburn.

Major Site-wide benefits were scored in the following areas:

€400, 000 running costs saved

Unit cost reduced by 21%

Scrap reduced by 8%

Attracting increased capital investment currently at 15% of turnover and

Customer returns reduced by 11%

Increased customer satisfaction

Improved safety record

Environmental and quality awards

Improvement in staff morale

The two key machines (The Shiftnal sphering and the PGM core making machine) also had major total cost saving OEE improvements as well as other time saving and cost reduction achievements making the TPM well worth it (Willmott and McCarthy).

Reliability Centred Maintenance (RCM) As Applied in a Section of a Plant

What is RCM? RCM is a method for developing and selecting maintenance alternatives based on safety, operational and economical criteria. RCM

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employs a system perspective in its analyses of system functions, failures of functions and prevention of these functions (Jones, R. B).

So RCM requires in-depth of the machinery, detailing all logic problems and their maintenance solutions and as such can be quite time consuming, for this reason it is usually used only on the critical equipment. The use of RCM methodology requires that 7 questions be answered:

What are the functions of the Asset?

What are the functional failures?

What causes the functional failures?

What happens when the failure occurs?

How much does each failure matter?

Can we predict or prevent failure and should we be doing so?

How should we manage the failure if prediction or prevention is not an option?(Paul Wheelhouse)

Now in order to answer the above questions, a System analysis process is used to begin RCM on any section of the plant. This System process will implement several steps, all of which define and characterize RCM and will methodically delineate the information required for the maintenance:

Step 1. System selection and Information collection: Taking decisions as to what level of the plant at which to do the RCM and also choosing this system

or section based on criticality i. e. based on function and impact on plant and environment.

Step 2. System Boundary Definition: This involves creating an accurate list of what is or is not part of the section so an accurate list of components can be identified and to establish what comes in and what leaves the System (IN and OUT interfaces). This is necessary to ensure the accuracy of the Systems analysis process.

Step 3. System description and functional Block diagram: This is used to identify and document the essential details of a system that are needed to perform the remaining steps in a thorough and technical fashion. The five separate items are developed in this step:

System Description

Functional Block Diagram

IN/OUT interfaces

System Component list

Equipment history

Step 4. System Functions and Functional failures: involves classifying each OUT interface of the system into its functions and identifying the failures which might hinder these functions.

Step 5. Failure Mode and Effect analysis (FMEA): involves analyzing each component failure to discover which have the potential to disrupt their

function and then detailing what exactly these effects could be. This is done using functional failure-equipment matrix.

Step 6. Logic (Decision) Tree Analysis (LTA): the failure modes which pass through effects analysis will now go through this process. The purpose of this step is to further prioritize the emphasis and resources that should be devoted to each failure mode on the basis that all Authority (TVA). TVA is a power production plant wholly owned by the US government and equipment, functions and failures are not the same. The LTA identifies the failure modes in 3 aspects:

Safety

Downtime

Economics (Finance)

Step 7. Task selection: In this step, applicable maintenance tasks which are most effective to combat the detailed failure modes are listed, at the same time decisions on whether to run-to-failure or design out