

DR Project Proposal

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Project Proposal – Blast Furnace 4 Cyclone semi-auto sequence



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Introduction

The proposed project will be called 'Blast Furnace 4, Cyclone semi-auto sequence', and the research will look into how feasible it is to semi-automate the cyclone to help prevent material clogging and, as a result, prevent multiple episodes of unplanned and unwanted Blast Furnace downtime.

Background

Since BF4 was commissioned in 2013, the cyclone has become problematic with multiple valve issues attributed to material fouling over an extended period of time.

This has then resulted in having to operate the various valves in manual mode with many of the process interlocks bypassed. This manual operation leads to a very time-consuming activity for the operators, with the increased risk of top gas escapes and the requirement for operational staff to force limit switches on the plant to allow the valves to be driven backward and forward to clear material clogging. A team of engineers from Tata Steel UK, Port Talbot site has been tasked to find a solution to this problem.

What is a cyclone and its process?

The cyclone is located at the base of the furnace downcomer and removes almost all of the significant amounts of dust particles from the blast furnace's dirty gas. Gas flows into the cyclone, see Figure 1 (Cyclone Inlet Configuration). A strong vortex, such as that found in a Dyson vacuum cleaner, propels particles in the flow that are heavier than the carrier gas to the Cyclone's walls, see Figure 2.

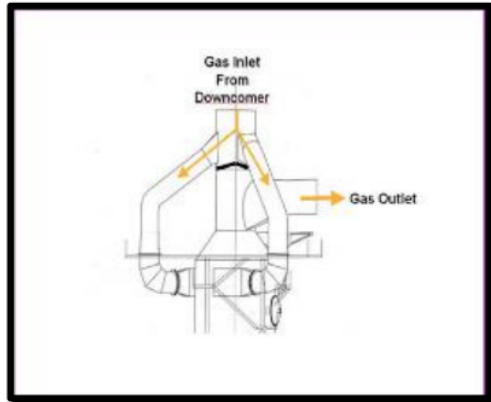


Figure 1 - Gas Inlet from Downcomer

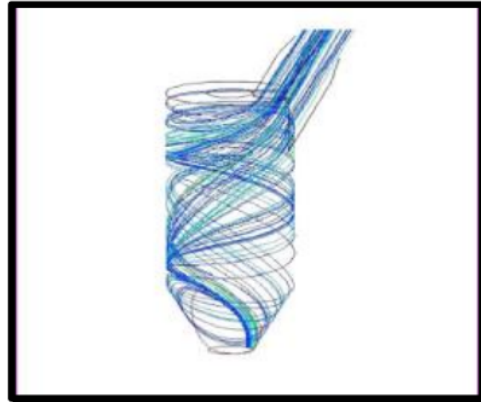


Figure 2 - Vortex created inside the cyclone

Dust then drops under its own weight to the bottom of the cyclone where it can be removed via one of the two lock vessels, the collected dust is then discharged from two separate legs, each improving a lock vessel, isolation valves, dust control valve, and a pug mill, see Figure 3 (Lock vessel and pug mill).

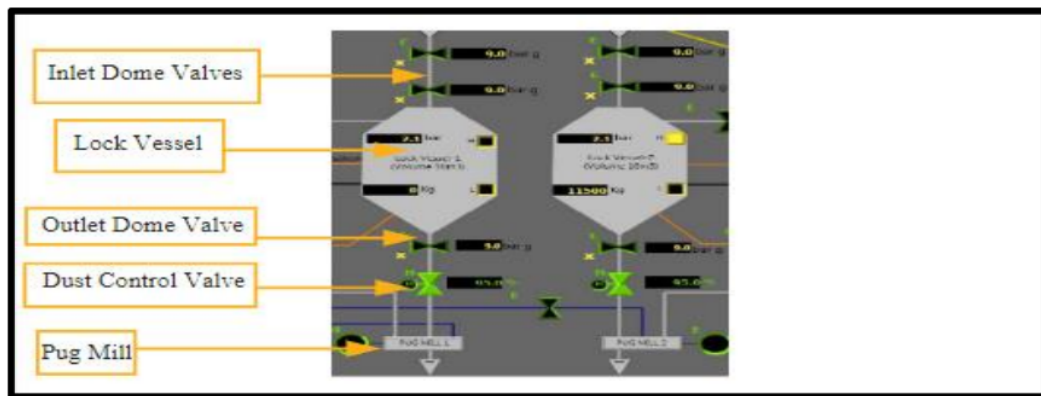


Figure 3 - Lock Vessel and Pug Mill from Tata SCADA Screen

Dust is first discharged from the cyclone to the lock vessel via two in-line series dust isolation valves. Displaced gas is vented from the lock vessel to the cyclone during the discharge. When the discharge is complete, the isolation valves are closed, and a third isolation valve on the outlet of the lock vessel is opened to discharge dust to the pug mill. A lock vessel outlet's dust control valve controls the pug mill's dust flow. The cyclone is very efficient compared to a conventional Blast Furnace dustcatcher, (Blast Furnace 5 at Port Talbot Steel Works operates a conventional dustcatcher) removing 85% of the particles entrapped in the Blast Furnace gas by inertial separation.

At the base of the cyclone. Two discharge legs and two lock vessels are trace heated and fully lagged, this ensures the stainless steel shell remains warm at all times to prevent dust from adhering and blocking the cyclone, see Figure 4 (Cyclone lagged discharge legs)



Figure 4 - Cyclone Discharge Legs (Trouser Legs)

There are six trace heating circuits in situ on the cyclone, the control panel for these is situated local to the cyclone at level 3.

Clean down cycle function

This function is used to aid in clearing a blockage in the cyclone discharge process, normal discharge sequence ensures a differential pressure across the cyclone and lock vessel of less than 0.10bar before progressing the sequence. The cyclone is currently "emptied" once every 24 hours, generally, cyclone drops are scheduled for the night shift (restricted by environmental standards because dust outside is uncontrollable), and the flue dust is "dumped" onto the floor of the pug mill, leaving a huge mound of dust and posing environmental issues, as the dust is prone to be caught up in the wind and therefore exposed to the elements. The OEM recommends that the cyclone is dumped at a maximum of an 8 hour period. The dust is then collected via bob cars and moved to another location on site before being taken to the Sinter plant via lorries for reuse. The bobcats have damaged the pug mill's side walls (sheeting) by scooping up the dust, allowing the flue dust to escape into the walkways around the furnace floor. The new skip system won't require the employment of bob cars and won't cause any side walls to be damaged once more.

The current picture of the pug mill floor can be seen in Figure 5



Figure 5 - Pug Mill Floor



Figure 7 - Pug Mill Floor

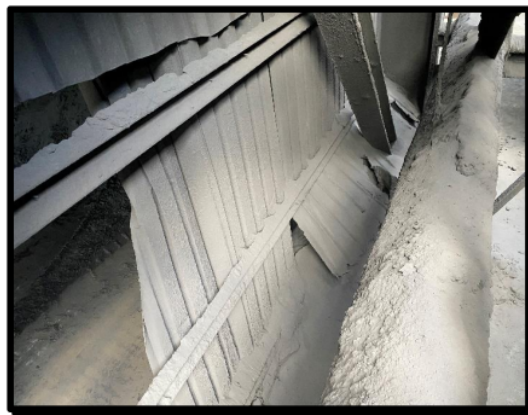


Figure 6 - Pug Mill Floor

Problems being encountered

The main issue encountered at Blast Furnace 4 is that flue dust in the cyclone is hardened during the steel-making operation and therefore clogs the downstream pipelines, putting a stop to the steel-making operations at the heavy end while the issues are investigated and then ultimately rectified.

Unplanned plant outages put a huge burden on the business which tries to achieve a target of making ***a minimum of 300,000 tonnes of steel every month.***

As the trace heating system is currently not operational, (it is thought this has ceased working as the current trace heating cabling is only rated for exposure to 250 degrees Celsius, whereas the cyclone has been known to reach operating temperatures in excess of 1000 degrees Celsius) and this is considered to be at least part of the root cause for the material clogging issues, the trace heating system is responsible for keeping the cyclone hot enough that the flue dust does not harden and clog the cyclone.

Other alternatives to a Cyclone

A gravity dust-catcher is a high-tonnage device that is widely used to separate a mixture of dust from blast furnace (BF) top gas flow. Dust includes limestone, iron ore, and coke/coal. The gravity dust catcher has been the equipment of choice for decades to clean blast furnace top gas generated from the energy-intensive iron-making process. However, in recent years there has been an increase in demand for gas separation cyclones in place of the gravity dust-catcher due to the substantially higher particle separation efficiencies that can be achieved. Yet, reliability still remains an issue due to higher maintenance costs associated with the regular repair of the refractory lining within the cyclone. [1]

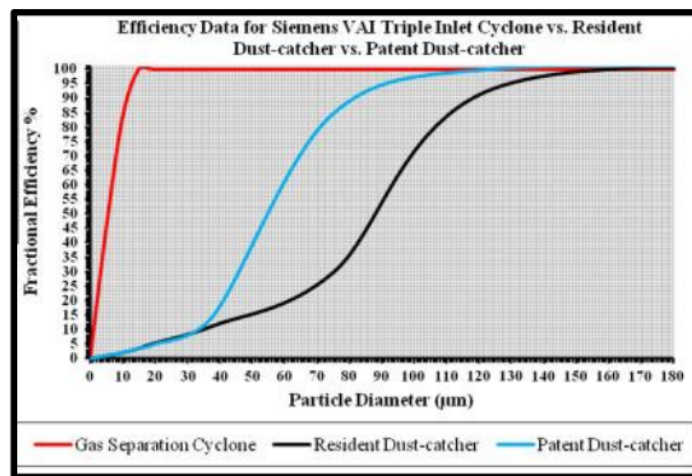


Figure 8 - Cyclone v Dust Catcher

Graph showing particle separation performance for a triple inlet cyclone and patented dust catcher considered for BF4 rebuild. [1]

The primary conclusion is that a dust catcher is an alternative option to a cyclone for the Blast Furnace dust-catching operation; however, this is considered old technology and there is no benefit to Tata Steel in exploring this option; this option is already in place on Blast Furnace 5.

Solutions

For the rectification of the cyclone clogging with flue dust, the following 3 solutions have been proposed, they are outlined in Table 1 below:

Cyclone Proposed Solutions								
	Proposal	Overview of Proposal	Estimated Timeline	Estimated Cost	Risks	External Impact	Business Impact	Suitability
Option 1	Do Nothing	In this option, existing dust extraction system will be kept as it is.	N/A	£0	Potential Intervention from the Competent Authority regarding dust pollution.	Port Talbot Steelworks is located in the middle of Port Talbot and has received several complaints from the community as a result of process dust getting into surrounding homes, schools, and	Tata Steel's reputation will suffer as a result of being perceived as doing nothing to address this issue.	Low
Option 2	Upgrade existing trace heating system	In this option, the present trace heating system will be updated to a steam system in this option, which will allow for the intense heat that the cyclone dissipates while also keeping the cyclone warm at all times.	6-9 Months	A budget price was received from Randall and Daniels Electrical Ltd of £500,000, who specialise in trace heating systems.	Despite the fact that the trace heating system was part of the original plan for BF4's major upgrade in 2013, there is no guarantee that it will work, as it is presently failing.	If the project is undertaken and successful, then the dumping of flue dust still needs to be addressed, with skips to be placed under the pug mill. Once in place, there will be no environmental impact.	Tata Steel's reputation in the surrounding community will increase tenfold since less process dust will be released into the environment.	High
Option 3	Install Laser Measurement Device	In this option, a laser measurement device will be installed at a set point on the cyclone, which will be incorporated into the local network, allowing the automated dumping of dust once levels have reached a set point won't be a chance for the flue dust to harden, and in turn, allowing manual "jogging" of the valves could also be implemented from the safe haven (BF Offices) without the need to send operation staff to the plant to force limit switches, and also be exposed to harmful CO within the blast furnace gas.	3-6 Months	Estimated Cost of £30,000	For the proposed cost, the only risk foreseen is that of not trying to implement this option. The cost is relatively low to the business, and the idea can be easily implemented with the experience and plant knowledge of Tata Steel staff.	If the project is completed and successful, all flue dust will be collected in skips from under the pug mill and sent directly to the Sinter Plant for re-use, posing no problems to the surrounding estate.	Because less process dust will be emitted into the environment, Tata Steel's reputation in the neighbouring community will improve exponentially.	High

Figure 9 - Solutions Table

Consequently, following many discussions with Engineers within the Blast Furnace, option 3 has been given the green light to go ahead, with the justifications outlined in the table above and also, another crucial factor is, currently, Tata Steel UK is experiencing a drive-to-save scheme following poor performance by the Heavy End in Port Talbot, so every effort is being made to reduce all non-essential spending where possible.

Therefore, to overcome the cyclone's lack of a functional trace heating system, a new proposal is for a laser measurement device to be installed to measure the dust levels inside the cyclone, this will allow the levels to be accurately measured, once the levels reach the required level, the cyclone is then emptied into a skip located on the pug mill floor (directly under the cyclone), and then taken straight to the Sinter Plant via lorries. The estimated cost of this project is £30,000.

This suggestion is based on the rationale that by emptying the cyclone more recurrently there will not be a chance for the flue dust to harden, and for the expense involved, it's worth investigating before committing to a future upgrading project that could cost half a million pounds.

Project Design

For the design, a level measurement device will be positioned on the cyclone, the level measurement device will then be incorporated into the existing PLC network, allowing the cyclone to be emptied once flue dust levels reach a set point. All level sensors will be required to meet current ATEX standards BS60079 as Blast Furnace gas is considered to be designated in gas group IIB with a temperature classification of T1 (6500C).

Typical composition of Blast Furnace Gas	
Gas component	Composition (%v/v Dry)
Carbon Monoxide	20-25
Carbon Dioxide	15-30
Hydrogen	1-8
Nitrogen	40-60

Table 2 shows the typical composition of Blast Furnace Gas at Port Talbot.

Proposed Positions of Laser's



Figure 11 - Position of Sensor 2



Figure 10 - Position of Sensor 1

Aims and Objectives

The aim of this project is to determine if an alternative solution can be found to installing a new trace heating system.

OBJECTIVES	
Investigation	Is there another solution to prevent Tata Steel from spending money on a trace heating system which will cost in the region of £500,000. Following a brainstorming session, the idea of a laser measurement device has been proposed. This will give a accurate reading of the dust levels, as opposed to the level switches currently in place.
Planning	Work with Gareth Symons (works package leader) to confirm roles and responsibilities for the project. Complete a Management of Change that identifies pre-modification risk assessments for the project related to all safety-related plant and equipment within the Blast Furnace.
Design	Identify a suitable laser measurement device for the project that meets BS-60079 DSEAR standards and design the electrical circuit. Identify how to incorporate the new design of level transmitters into the existing software available across the Blast Furnace. The installation of visible indicators on-site (local control panels existing) and within the control room is required to allow Blast Furnace staff to know when the
Implementation	When all of the above has been accomplished, and the system has been tested and commissioned, the project's implementation will be complete.
Analysis	Perform an analysis of the project, what was learned, if the project was successful, and what new skills were acquired by myself and the team.

Figure 12 - Objectives Table

Objective 1: Confirm semi-auto Team

Work with Gareth Symons (works package leader) to confirm roles and responsibilities for the project.

Objective 2: Management of Change

Complete a Management of Change that identifies pre-modification risk assessments for the project related to all safety-related plant and equipment within the Blast Furnace.

Objective 3: Identify Material Requirement

Identify a suitable level measurement device for the project that meets BS-60079 DSEAR standards and design the electrical circuit.

Objective 4: System Design

Identify how to incorporate the new design of level transmitters into the existing software available across the Blast Furnace.

Objective 5: Visible Indicators

The installation of visible indicators on-site (local control panels existing) and within the control room is required to allow Blast Furnace staff to know when the cyclone empties.

Objective 6: Pug Mill Floor

Installation of sheeting on the pug mill floor and skips arranged to be placed directly under the pug mill.

Objective 7: Review the Project

Perform an analysis of the project, what was learned, if the project was successful, and what new skills were acquired by myself and the team.

Project Plan

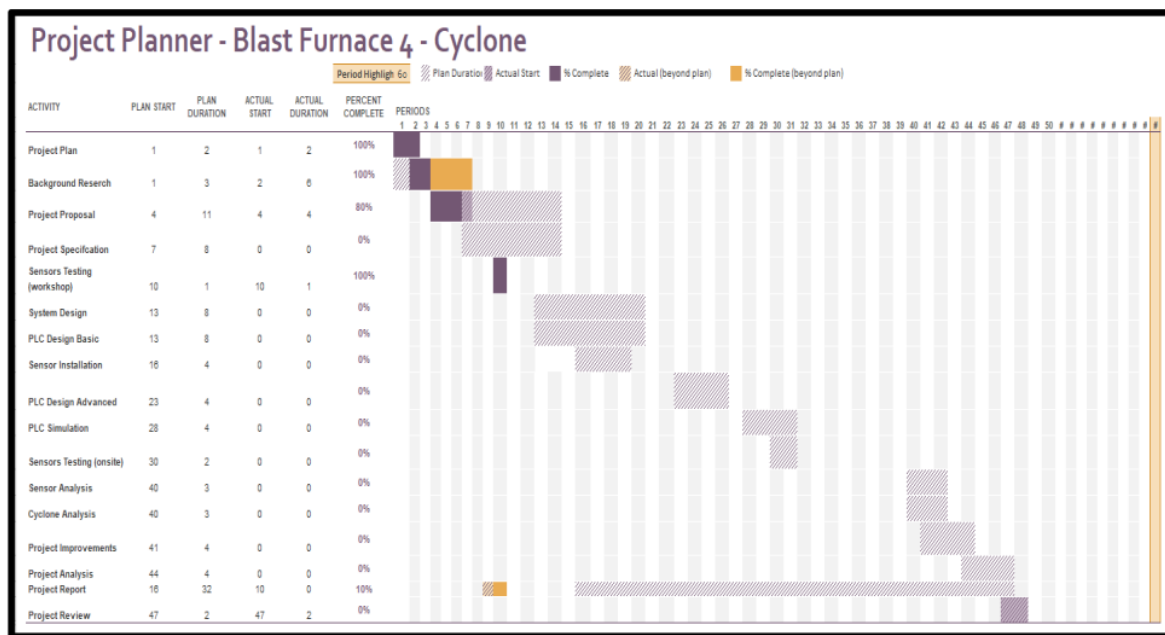


Figure 13 - Gantt Chart

Landmarks from the project planner

Period 1 - 30/04/2023 is the proposed start date of the project, this is when contact was made with the University to suggest looking at a potential project ideas.

Period 4 – 22/05/2023, is the start of the project proposal.

Period 16 – 20/08/2023 is the start of the project's design phase.

Period 16 – 20/08/2023 is the start of the main project write-up, this was actually started during period 9, ahead of target.

Period 30 – 26/11/2023 is the start of the project's commissioning phase.

Period 47 – 24/03/2023 is the proposed completion date for the project write-up.

Bibliography

- [1] D. W. D. P. M. C. N. C. I. Craig, "ww.sciencedirect.com," 22 05 23. [Online]. Available: <https://www.sciencedirect.com/journal/separation-and-purification-technology>.

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FINAL GRADE

GENERAL COMMENTS

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