AN INTRODUCTION TO DUSTCLONE TECHNOLOGY AND THE BENEFITS OFFERED*

Robert Paul Mawer[1]
Richard Harvey[2]

Abstract
In recent times there has been an increase in the demand from Steel plants for a technology that offers the most economical environmentally sustainable solution. In terms of blast furnace off gas cleaning this has seen a drive towards Cyclone technology replacing the older Dustcatchers. Cyclone technology can achieve dust removal efficiencies as high as 95% increasing the dust yield at the primary stage of gas cleaning. The dry dust (rich in Fe and C) can then be recycled to the Sinter Plant or Blast Furnace. Capture of dust at this stage also has the benefit that sludge generation from the secondary stage is also reduced meaning less waste to landfill and / or recovery of some of the by-products for further use. Primetals Technologies already offer a state of the art Tri-Axial Cyclone installed on many sites world-wide, however, this paper focuses on a hybrid of this technology, the DustClone. The DustClone is a low CAPEX unit that is essentially a Cyclone housed inside the Dustcatcher. This unit is aimed at operators who may be carrying out smaller scaled shutdowns / repairs that normally have a reduced CAPEX. This paper describes the technology that Primetals Technologies have developed.
Keywords: DustClone; Dustcatcher; Cyclone; Dust Recycling

[1] *Process and Chemical Engineering, Product Owner – Gas Cleaning Plants, Technical Department, Primetals Technologies ,Stockton- on-Tees, United Kingdom.*
[2] *Metallurgy & Materials Science, Technical Manager – Blast Furnace Ironmaking, Technical Department, Primetals Technologies ,Stockton-on-Tees, United Kingdom.*

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1 INTRODUCTION

The Blast Furnace process generates a dirty dust laden off gas that needs to be treated and conditioned prior to being utilised as an fuel gas that can be used site wide. Typically the off gas will contain 15 – 20 g/Nm3. The off gas is commonly cleaned in two key stages:

- Primary Stage – Dry type, dust removal typically utilising a Dustcatcher or Cyclone

- Secondary Stage – Wet type or Dry Type – Using bag filters, Scrubbers and / or demisting units to condition the gas.

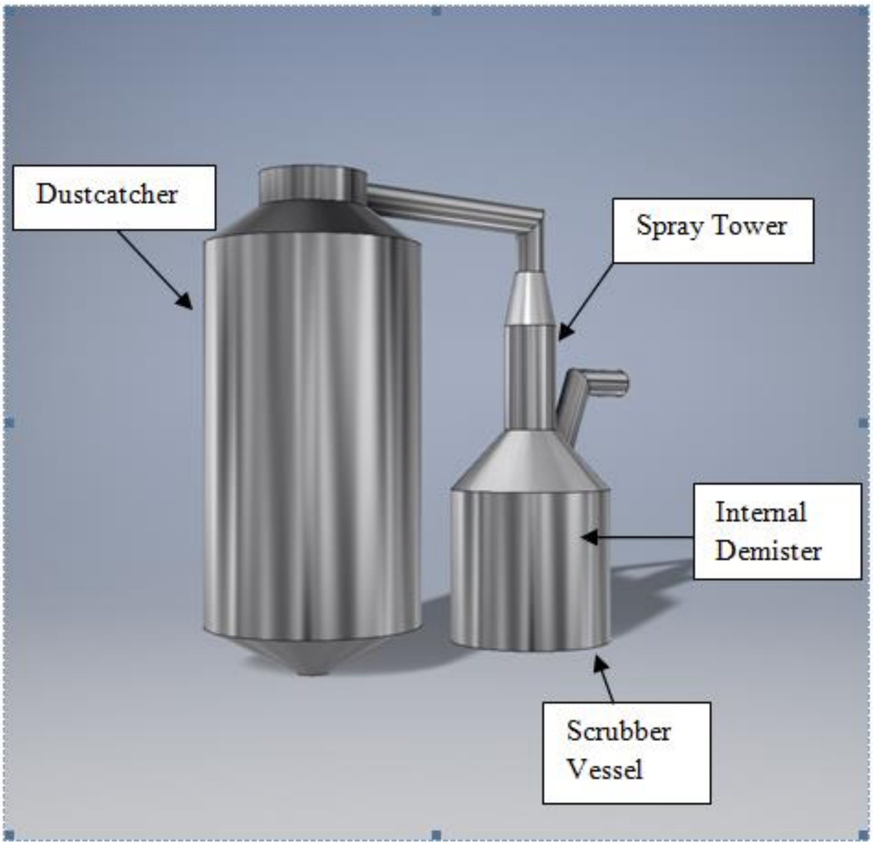

Figure 1:- Example Arrangement of the Primary and Secondary Stages of the Gas Cleaning Plant.

The primary stage predominantly cleans the gas of the larger particles utilising gravity or cyclonic action to separate the dust from the gas phase. Dustcatchers frequently operate at dust removal efficiencies of 45%-60% Whereas Cyclones can achieve up to 95% and are often detuned back to about 85% by the operator to meet site requirements. The dry dust from these devices is captured for further processing (typically recycled to the sinter plant, briquetted or injected back into the Blast Furnace). The remaining dust is captured in the secondary stage - by either a wet scrubber or a dry gas system such as Primetals Technologies' MERIM system. When the gas leaves the secondary stage it is in a useable condition that means other site consumers can utilise it as a fuel and is normally almost free from dust and moisture.

When furnaces are rebuilt, they often have an increased volume and production but the Dustcatcher design is not changed. This can result in the dust removal efficiency being reduced further depending on the size of the Dustcatcher and hence increases the dust loading on the secondary system.

In order to improve on this situation a Cyclone at ≥ 85% efficiency can replace the Dustcatcher. This is easy on a green-field site, but requires greater capital expenditure on a brown-field rebuild project. There are two layout arrangements for installing a cyclone on an existing blast furnace:

- An in-series arrangement, installing the cyclone between the existing Dustcatcher and the existing secondary gas cleaning system. This concept requires additional space for the Cyclone and interconnecting ducts, new foundations and structures, and a new dust discharge system. On the positive side, this allows the new equipment to be installed off-line, with a relatively short furnace shutdown to connect the new equipment.

- Replacing the Dustcatcher with a Cyclone – this requires the downcomer to be supported, possibly with modifications, whilst the Dustcatcher is removed and the cyclone installed - with a longer outage period than for the above in-series concept.

The arrangements above result in high efficiency dust removal solutions – however the installation cost can also be high. Primetals Technologies have developed a new arrangement using their proven Cyclone technology within the Dustcatcher shell – the “DustClone”. Retrofitting a cyclone into an existing Dustcatcher not only increases the efficiency of the system, it also utilises the existing structural and civil works and the existing dust discharge system. It can be installed within a relatively short furnace reline or rebuild outage, with CAPEX approximately 40% of that when compared to the installation of a new cyclone.

2 WHEN TO USE A DustClone

The ideal solution for blast furnace operators would always be the Tri-Axial Cyclone replacing the existing Dustcatcher, the technology is well proven, minimises the overall footprint of the Gas Cleaning plant and most importantly gives maximum dust recovery. This does come at an increased CAPEX and can typically only be achieved during an end of campaign rebuild, these kind of conditions may only come round once every 10 – 15 years.

It was these large lead times and the desire of operators to upgrade the Dustcatcher to a Cyclone based technology that provided the driver to find alternative solutions. The obvious solution was to build a cyclone in series, this is possible on large open plants, however, since the late 80’s gas cleaning plants tend to have been designed with minimised footprints and therefore it is not always possible to install another dust capturing unit on a brown field site.

The above scenario has led to the DustClone concept being developed. The advantages and typical factors around the scenarios can be seen in (Figure. 2)

	OPTION 1 New cyclone in new area	OPTION 2 New cyclone replacing existing dustcatcher	OPTION 3 DustClone
Advantages	• Proven Solution • Short Shutdown (3-10 days) dependent on main route.	• Proven Solution • Reuse existing footprint • Dust handling logistics in place	• Simple solution (30 day) shutdown required. • Low CAPEX (approx 50% less than cyclone) • Reuse footprint
Disadvantages	• High CAPEX • Need land close to furnace • May need to develop dust handling logistics	• High CAPEX • Long shutdown (>72 day)	• No reference plant but it is a well known proven solution.

Figure 2:- Advantages and Disadvantages of the 3 main options when upgrading primary dust collecting technology.

3 DEVELOPMENT OF THE DUSTCLONE

Observation of installations around the world, led to the question ‘Can a Primetals Technologies Tri-Axial Cyclone fit inside an older existing Dustcatcher?’. A survey was carried out on installations world-wide and it was found that in some instances it was straightforward and with a few minor adjustments to the design constraints, then the concept could be applied to most Dustcatchers. Figure. 3, shows a typical Dustcatcher, the well-proven Primetals Technologies Tri-Axial Cyclone as a standalone cyclone unit, and the DustClone incorporating the Tri-Axial Cyclone within the Dustcatcher.

It was decided that the best way to prove the operational functionality of the DustClone and understand the associated challenges, was for it to be modelled using CFD. The unit could then be checked for key performance indicators, such as wear and gas flow through the vessel.

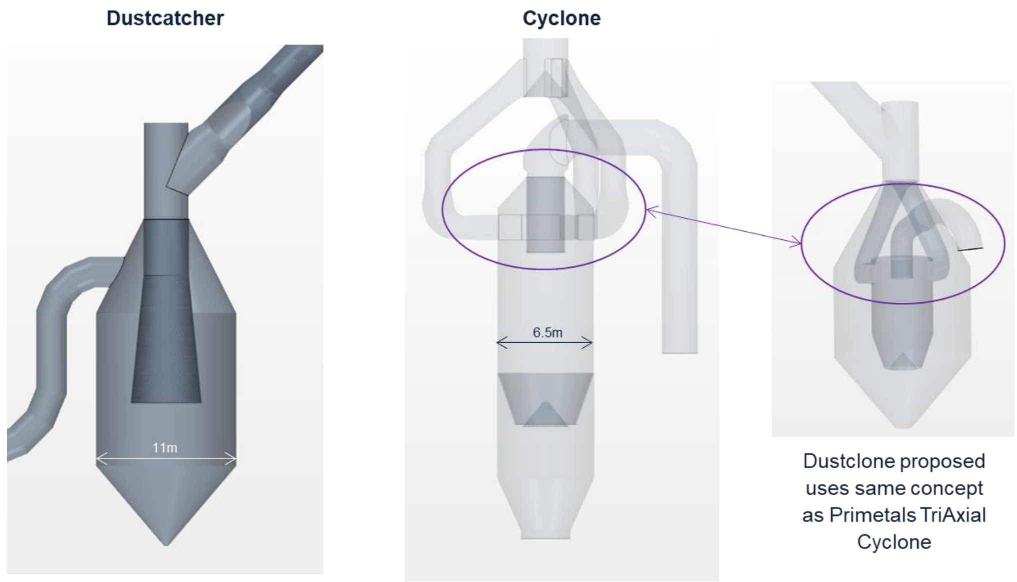

Figure 3:- Examples of a typical Dustcatcher, Tri-Axial Cyclone and DustClone

Primetals Technologies wanted to be confident that the modelled DustClone data reflected actual site conditions if one were to be installed. For this reason it was opted to model both a Dustcatcher and Tri-Axial Cyclone then compare the models to actual conditions witnessed during shutdowns on actual plants. This was carried out on an operating plant that had been in operation for 5 years. Modelling of the Dustcatcher gave results very close to the actual results measured on the plant, and indicated the asymmetrical gas flows inside the Dustcatcher. Modelling of the Tri-Axial Cyclone again demonstrated good agreement with actual operation, however, it was observed during the shutdown that some places had developed slightly more wear than had been expected. This allowed calibration of the model to resemble the actual on-site conditions.

The following graphics show the plots generated using STAR CCM+ software, with the actual dust size distribution input into the model.

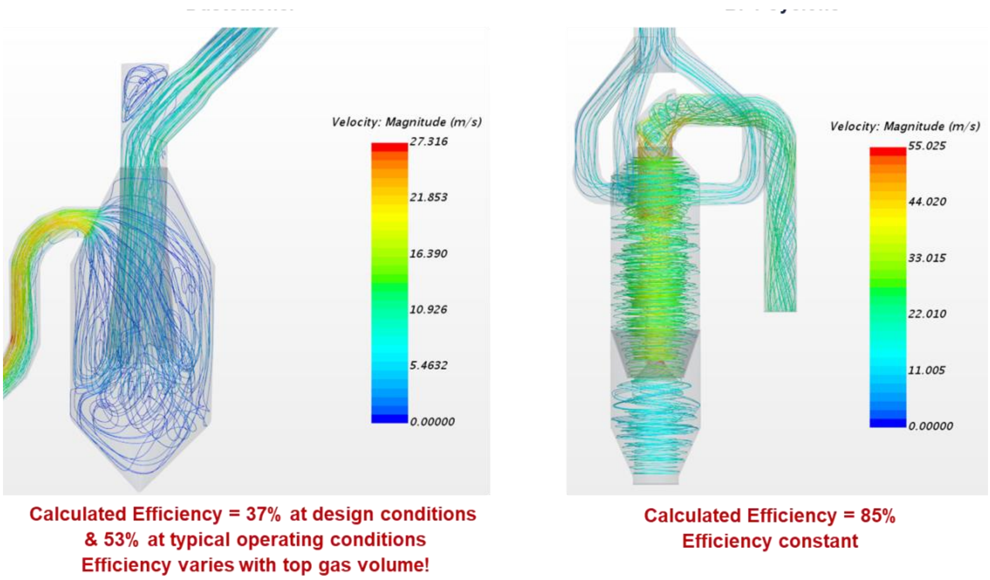

Figure 4:- Modelling of operating Dustcatcher and Tri-Axial Cyclone.

Three key factors have been considered when assessing the viability of the DustClone:

Size

The key to the Dustclone is the optimised design of the cyclonic adaptor and its ability to fit inside an existing Dustcatcher

When sizing the Cyclonic adaptor the gas inlet velocity sets the diameter, which in turn dictates the geometry of the rest of the vessel. Therefore a higher gas velocity can be used allowing a reduction in the size of the DustClone. Velocity, however, has an impact on the wear rate experienced by the vessel, with higher velocities leading to higher wear. Other factors such as dust loading can affect the extent of the wear but usually in the case of Blast furnaces the gas make and loading is relatively stable and therefore can be negated in terms of comparison.

A number of CFD models were made using Discrete Element Modelling (DEM) to assess the wear rate potential; - this confirmed the concern that if the velocity at the cyclone inlet is increased, then greater wear can be expected. Primetals Technologies' experience is that wear at the cyclone inlet can be seen and therefore either lower velocities should be maintained or a longer life wear tile should be purchased at the inlet region from the start.

Another impact that was observed during the modelling of the DustClone was that if the size of the inlets were reduced to increase the inlet velocity, then as the velocity increased, instability in the lower cone region started to develop. It was feared that this turbulence would increase the wear in the lower cone region and for this reason the inlet velocity was reduced to give the final design shown in (Figure. 5).

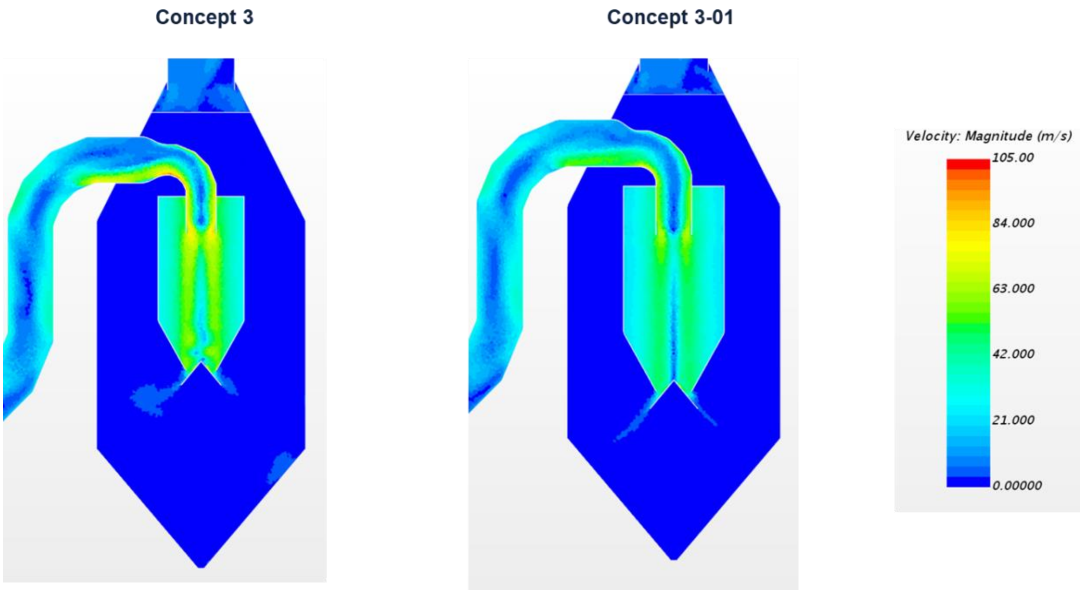

Figure 5:- An Example of development modelling for the DustClone

Maintenance and Mechanical design for safe isolation:

Maintenance requirements around the DustClone and Cyclone technology is infrequent but internal inspections are a requirement. Primetals Technologies considers positive isolation via a plate i.e. slip plate or goggle valve to be the most effective way of achieving this.

After discussion with several customers and learning from their experiences it was decided that an isolation valve at the inlet of the DustClone with adequate purging and venting facilities downstream was the preferred method of isolation for the entire GCP. Figure. 6 below gives an indication of the Primetals Technologies recommended configuration to be adopted.

Figure 6:- Modelled DustClone with goggle type Isolation

Dust Handling

Due to the higher efficiencies of the DustClone a lot more dust will be captured from the process gas therefore the emptying regime of a DustClone may be more frequent than that of the Dustcatcher or require greater discharge at each emptying cycle. It is important this emptying regime is maintained since high dust levels, i.e. up to the vortex stabilizer, may lead to failure of the support mechanism. To avoid this a level detection system is in place that comprises of a series of switches and radars.

4. CONSTRUCTION PHILOSOPHY

Primetals Technologies construction experts have assessed the constructability of the DustClone, with a target to ensure the installation can be made within a 30 day blast furnace outage. Key actions, such as the pre-fabrication of the DustClone unit and preparation of the Dustcatcher shell, can be made in advance of the blast furnace shutdown.

A schematic (Figure.7) on how the Dustcatcher will be opened with addition of an access platform to allow removal of the existing Dustcatcher "trumpet" and allow installation of the cyclonic adaptor piece.

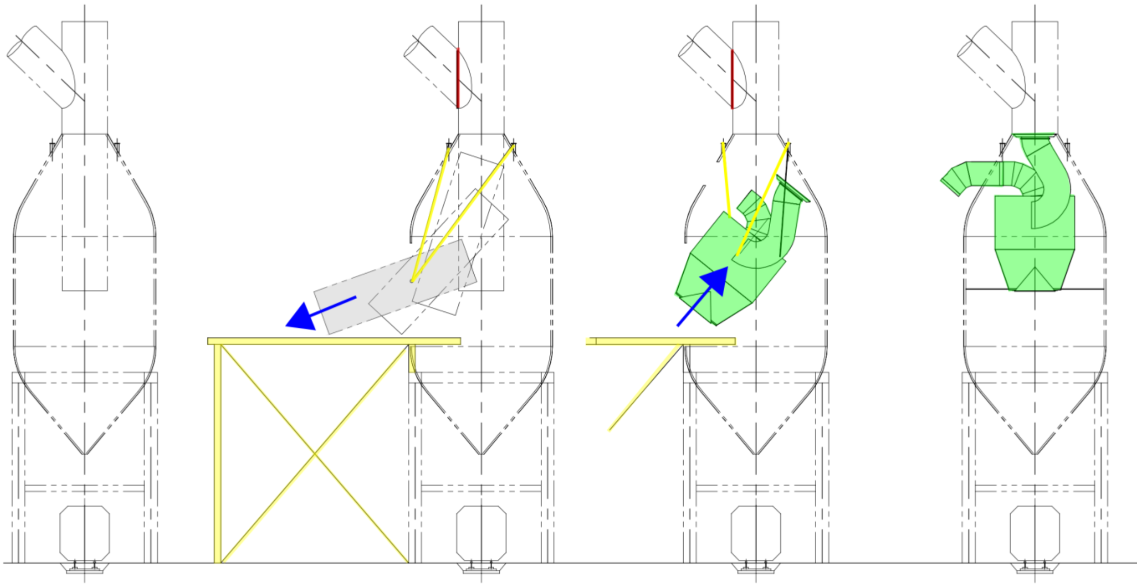

Figure 7:- Basic erection scheme for the DustClone

5. COST COMPARISON – CAPEX, OPEX and PAYBACK

Since the installation of a DustClone maintains the foundations and structure of the Dustcatcher it means that the CAPEX for the unit is driven right down; (Figure. 8) shows typical CAPEX savings that can be made by using a DustClone over a conventional Cyclone.

	Outage	CAPEX
“in-series / in parallel” cyclone	5 days	100%
DustClone	30 days	40%

Figure 8:- Table indicating typical CAPEX savings that can be made.

The greatest financial driver for switching to Cyclone technology for the blast furnace operator is predominantly around coke recovery, combined with a reduction in amount of waste sent to landfill. A furnace of 10,000THM/d if switching to Cyclone Technology will recover approximately 22T/d more Iron and 22T/d more Carbon than a furnace with a Dustcatcher (assuming a 30% Carbon and 30% Iron content in the Blast Furnace Off Gas).

The low CAPEX of the DustClone combined with the large savings made during operation mean that payback periods under 20 months have been seen during studies carried out to date.

6. CONCLUSION

Cyclone technology offers higher recoveries of dust from Blast Furnace off Gas and offers significant environmental and financial advantages over more traditional technology such as the Dustcatcher. Cyclones are a well proven technology now with reference plants functioning for over 9 years.

Due to the continuing success of Primetals Technologies Cyclones and the drive for reducing waste there are more and more enquiries for this type of technology. However, not all operators have the capability to install a cyclone, whether it be due to lack of initial CAPEX, lack of available space or not having shutdown time available to install a new Cyclone.

The DustClone offers a cost effective solution that isn’t restricted by the needs of additional space or long shutdowns and the fast payback periods are incentive enough for a blast furnace operator to consider this technology.

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