

DUGLESS 900 AIRBOX UPGRADE

In June 2017 Dugless Machinery Company began development of a new Air Intake system for the Dugless 900 with the aim to improve filter life via reducing the quantity of dust being presented to the final cartridge filter in the Air Filter system. This was to be achieved by reducing the microscopic dust from the airflow and only using the available airflow from the engine.

Stage 1.0: Cyclone Assembly

Over the last 5 years a number of pre-filter arrangements have been infilled tested using different media. In general, these collected the larger dust particles before the standard filter, however;

- they only shifted the change of filter to the prefilter
- less replacement standard filters were required, but the reduction was not sufficient enough that it provided the right solution.

The research showed that the utilisation of a dust cyclone could remove dust particles prior to air going through a dual filter. Using sizing and ratio formulas for Efficient Dust Cyclones we designed, manufactured and tested the first prototype as a single cyclone, with no consideration as to fitment into the machine.

Testing in the field on a mine site over a number of days yielded good results. There were 4 filtering positions where the results were recorded each hour and concluded over an 8-hour shift. These positions being;

- 1) Donaldson pre-Cleaner
- 2) Dust Cyclone
- 3) Outer Filter
- 4) Inner Filter

As can be seen from the results in the table below, of the 207 grams of dust collected during the 8 hours, 61% was collected by the dust cyclone, followed by 29.4% by the Outer Filter, which meant that the inner filter saw less than 0.5% of the dust presented, as the remainder had been collected earlier in the system.

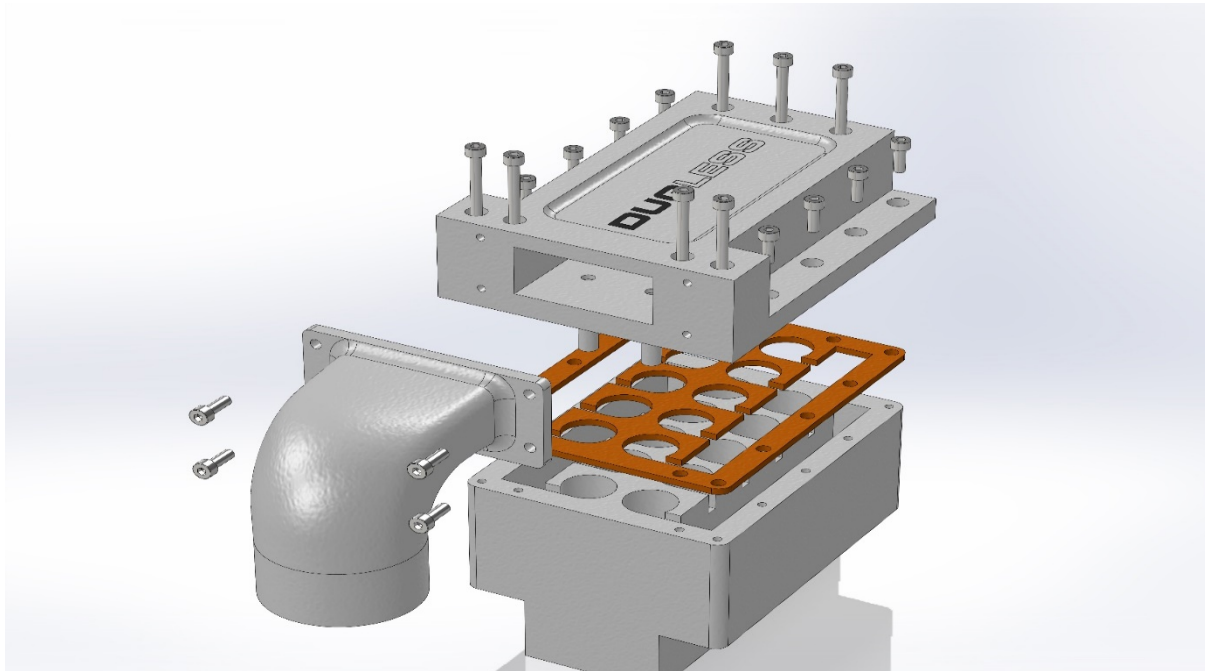
	PRE CLEANER	CYCLONE	OUTER FILTER	INNER FILTER
8hrs	18 grams	127 grams	61 grams	1 grams

Stage 2.0: 10 Single Layer Multi-Cyclone Design

With the single cone cyclone concept proving successful in dust removal, the Dugless's lack of available room inside the main body, the next development stage was to manipulate the design so that that the system could be integrated into the Dugless 900 whilst maintaining the same Cyclone envelope and utilising a maximum of 80% of the exhaust air flow.

Version 2.0 design was a single layer multi-stage cyclone that would be a retrofittable package which bolted onto the existing filter assembly location with minimal changes. The design was a single layer multi-cyclone with 10 cyclone chambers, making up the same volume as the original single cyclone prototype.

Figure 1. Illustration of Single layer multi-cyclone with 10 chambers



The same infield testing was undertaken over an 8-hour shift. The 10 chamber multi-cyclone design did not perform as effectively as the single cyclone with the same volume characteristics, however it was evident that the Outer Filter (which is a standard off-the-shelf filter) was functioning adequately to reduce the dust particles getting to the inner filter, would be suitable for the final product.

	CYCLONE	OUTER FILTER	INNER FILTER
8hrs	10 grams	288 grams	11 grams

Stage 3.0: Finalised 8-Chamber Single Layer Multi-Cyclone Design

Further testing of multi-cyclones was undertaken by reducing the number of chambers drawing a vortex was on 9 port, 8 port & 7 port multi-cyclones. The 8 port multi-cyclone provided the optimum test results for dust particles collected, whilst maintaining a design envelope to be retrofittable to existing and new Dugless 900's. The table below shows that of the 141 grams of dust collected, 56% was via the multi-cyclone, 37.5 % by the Outer filter and 0.5% by the Inner Filter.

	CYCLONE	OUTER FILTER	INNER FILTER
4 hrs	80 grams	53 grams	8 grams

Stage 4.0: Upgraded 8-Chamber Single Layer Multi-Cyclone Design

Now that the multi-cyclone sizing has been confirmed and proven in the field, stage 4.0 was to have the 3D model of 8 multi-cyclone chamber block run through an airflow analysis program to determine whether there were inefficient airflows in the design that can be engineered out. The airflow analysis will be undertaken on the following components of the system as individual items;

- 1) 8-chamber multi-cyclone Block
- 2) Connection Tubing
- 3) Fittings
- 4) Filter Housings

The testing undertaken in the field using a client operated machine showed that there will be a requirement to deal with the machine operators washing down the Dugless 900 whilst the engine is running, which can then introduce moisture to the filtration system, causing caking of the dust to the filters.

Stage 4.1: Final Design, Manufacture and Testing

On completion of the airflow analysis the chamber design was tuned to maximise the vortex effect, ensuring the maximum particle extraction could be achieved. The changes to the cyclone chambers and outlet piping increased the outlet pressure from 80.5 kPa to 100 kPa and increased the Flow Trajectory Velocity by 400%.

The design was provided to 3D printing companies for comment and following their feedback for manufacturing, the final design was completed.

The final assembly is made up of 16 components / assemblies, inclusive of the following main components;

- Airbox frame welded assembly
- Donaldson multi-filter assembly (Outer & Inner cartridges)
- Isolator panel assembly
- Filter to engine hose (3D printed)
- Cyclone to filter hose (3D printed)
- Telemecanique switch box
- Battery charging terminal port
- Single layer 8 chamber multi-cyclone block (3 D printed)
- Removable dust collection tray (3D printed)
- Removable tray for air pressure cleaning of cyclone chambers (3D printed)

Figure 2. Final Airbox Assembly Parts List & Diagram

1	AIRBOX FRAME WELDED ASSY	AIRBOX FRAME ASSY-III	ASSY		1
2	DONALDSON FILTER	DONALDSON FILTER-III	ASSY		1
3	ISOLATOR PANEL ASSY	PANEL ASSY-III	ASSY		1
4	AIRBOX TOP COVER PLATE	AIRBOX PLATE 11-III	PLATE - GRADE 250	3mm	1
5	AIRBOX FRONT COVER PLATE	AIRBOX PLATE 14-III	PLATE - GRADE 250	3mm	1
6	FILTER TO ENGINE HOSE 50mm ID	AIRPIPE 5-III	3D PRINT		1
7	CYCLONE TO FILTER HOSE 50mm ID	INTER AIR HOSE-III	RUBBER		1
8	WASHER M6	102521-III	DIN 985 ZINC PLATED	N/A	7
9	BOLT HEX SOCKET BUTTON HD M6 X 12	102292-III	AS 1110 GR12.9	N/A	7
10	CTSK SCREW M4 X 8	CTSK SCREW M4 X 8-III	DIN7991 / ISO10642		10
11	HOBBS HOUR GUAGE	102348-III	N/A		1
12	TELEMECANIQUE	102328-III	N/A	N/A	1
13	DEUTSCH HDCI6-9	102314-III	N/A		1
14	BATTERY CHARGE TERMINAL	102260-III	N/A		1
15	CYCLONE & TRAY ASSY	Par_30 Cyclone Cluster2	3D PRINT		1
16		WING NUT M4	Material <not specified>		3

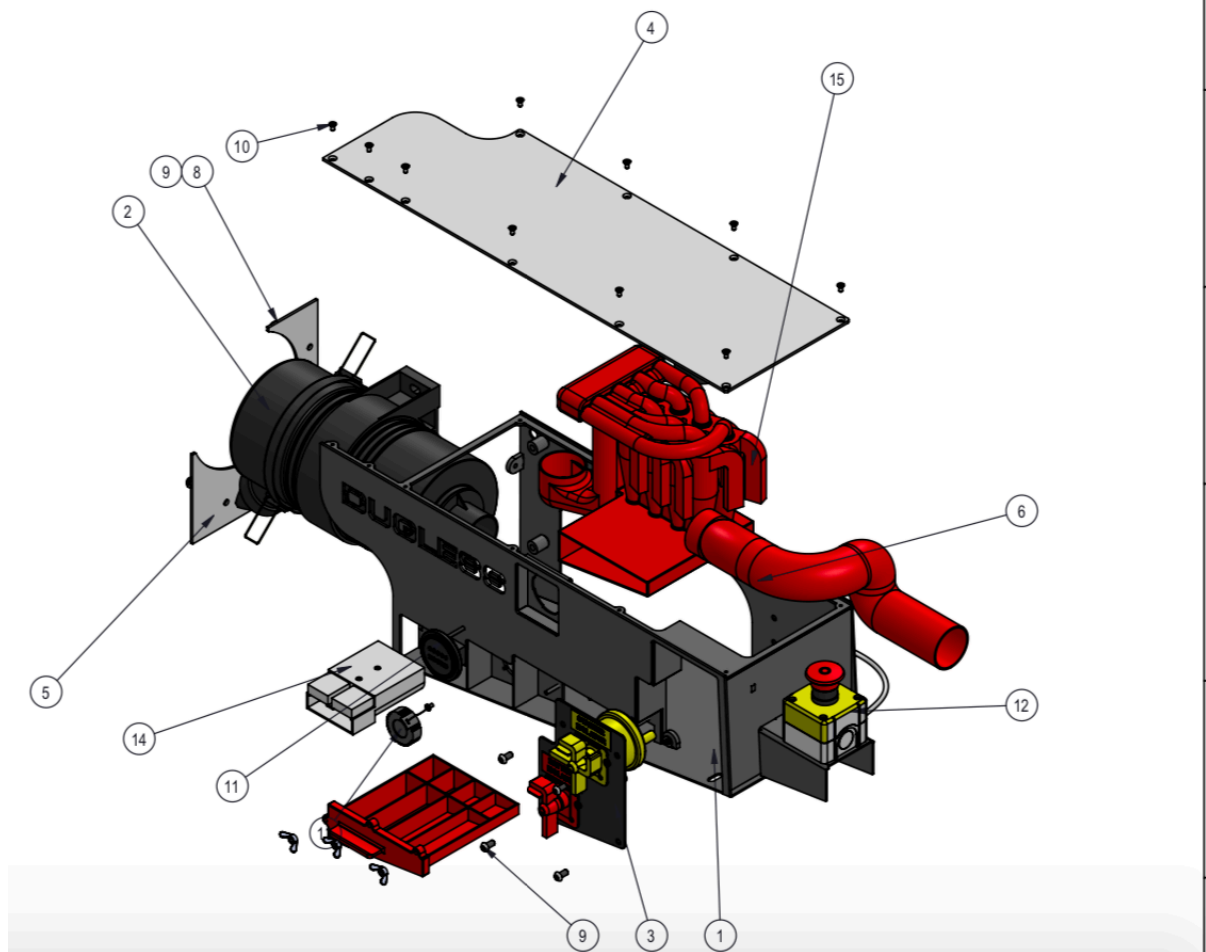


Figure 3. Illustration of Cyclone & Tray Assembly

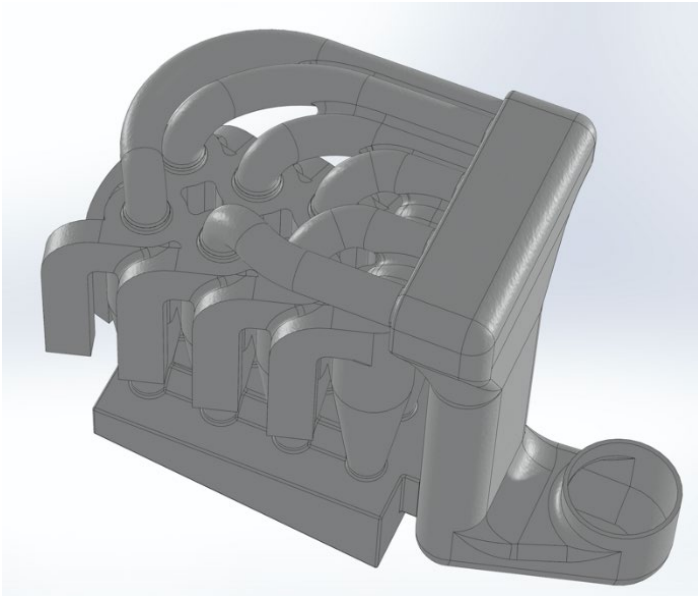


Figure 4. Illustration of 8-Chamber Multi-Cyclone Block (part of Cyclone & Tray Assembly)

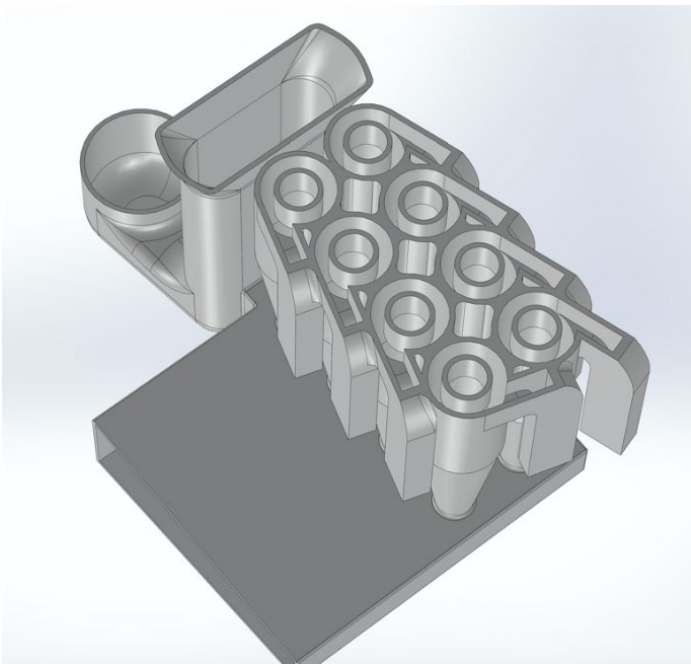
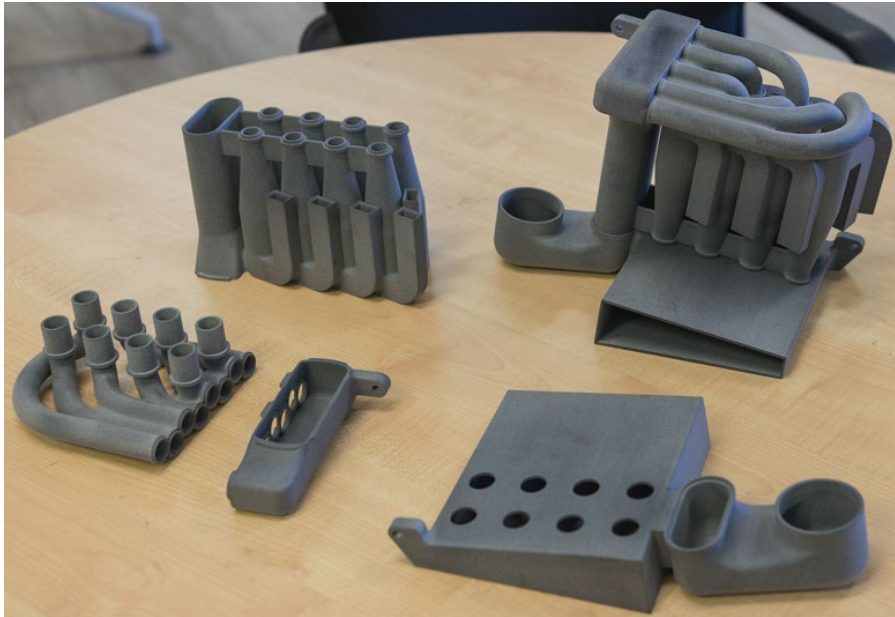


Figure 5. 3-D Printed Parts for Cyclone & Tray Assembly



Notes:

- It is expected that the operator will empty the dust collection tray and check the filter condition only once a day at prestart
- Where the infield trials have been undertaken (2 x 8hr shifts per 24 hour period), the client is using;
 - 1 Outer Filters @ \$40.30 per filter (7 day period)
 - 1 inner Filter @ \$36.50 per filter (7 day period)
 - Previously had been using 14 of the Standard Filters @\$115.94 per filter (7 day period)
- It has been evident that there has been significantly less dust ingress into the engine with the new Airbox system
- The 3D printed base material has been chosen to maximise the wear characteristics and sufficient durability to handle the vibration of the Dugless 900 during operation

For any enquiries, please contact Sales@minprovis.com.au or cal 08 9359 6800.