The Drum Charger® in a Tweet

Drum Charger®, a turbo with no turbine. Perfect for motorcycles, increases torque by up to 20% while reducing fuel consumption, emissions and noise.

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Milan, November 8 - 13
AlterEgo Hardware® is an Italian startup, formally established in 2015 but already active since the end of 2010s. AEH was born as a new industrial concept, in between the well-known engineering firm, aiming to industrialize well-defined projects, and the business incubator, aiming to promote individual creativity in a somewhat looser manner. AEH aims therefore to scout new ideas and patents with relevant technical and commercial potential, to develop them until they reach the necessary maturity and finally to introduce them to the appropriate manufacturing companies in the PTW sector.

AEH has in its portfolio a variety of patents, partly in-house and partly with representation rights, that make up for an interesting asset in terms of innovative, yet down-on-earth technical solutions in any field – engine, chassis, brakes, suspensions, wheels – where the industry can fully draw from. The flagship product is now the Drum Charger®; a technology where AEH decided to heavily invest onto, taking advantage of its many years of experience in the intellectual property field and of its extensive relationships with the industry. The Drum Charger® is a breakthrough technology, which has the potential to set new standards in the OEM parts industry and that AEH will fight to support, alone or through joint-ventures with existing players.

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A TASTER OF DRUM CHARGING®

What is the Drum Charger®?
The Drum Charger® is the first supercharging technology specifically conceived to be low-cost and to fit low displacement engines. Its obvious application are motorcycle and scooter engines.

How does it work?
The system is made of a plastic discoid chamber, with a carbon fiber membrane dividing it into two chambers. One chamber is connected, through a blind alley, to the exhaust line (“hot chamber”); the other is connected to the intake duct (“cold chamber”). The pressure waves that travel through the exhaust pipe, each time the exhaust valve opens, push the membrane, reducing the cold chamber volume and therefore increasing the pressure of the air, that is then sent to the airbox through a series of reed valves. At the end, the membrane travel is reversed through a leaf spring, and the cycle can start again. The Drum Charger® is this way able to transfer some energy of the exhaust gases to the fresh intake air, without mixing the two.

Where can it be applied?
The Drum Charger® is a purely mechanical system, inherently synchronized with the engine and with no need of electronic management. It can in principle be applied to any kind of engine, regardless of the technology it uses: Otto or Diesel cycle, naturally aspirated or supercharged (to get rid of turbo-lag), fuel injected or carburetted, 4 strokes or 2 strokes.

Who does it address?
The Drum Charger® normally raises the power output, requiring to re-homologate the vehicle. For this reason, it addresses mainly the engine manufacturers, be them motorcycle manufacturers or independent OEM suppliers (also for ATVs, small tractors, ultralight aviation, and the like). The retrofit application through an aftermarket kit, technically feasible, is currently under evaluation.

Who are the competitors?
In the automotive sector, competition comes from traditional charging systems: exhaust driven (turbocharger) and power driven (supercharger). Although both types can reach charging pressures two or three times higher than the Drum Charger®, they do so with associated costs and system complexity about ten times higher. There is currently no technology able to boast a benefit/cost ratio anywhere near the Drum Charger®, especially in the motorcycle sector. The only practical alternative can come by completely different technical approaches, such as an increased displacement. Such alternatives do not, anyway, bring along the same benefits in term of fuel economy, noise reduction, smoothening of the power curve and so on. A Drum Charged® engine still has the weight, inertia, friction and pumping losses of the original displacement engine, but is equivalent to a higher displacement one in terms of performance.

The increase in efficiency
In the bench test on real production engines, the Drum Charger® has shown an increase in efficiency in the range of 15-20%. Such enhancement is available to the powertrain engineers, who can then decide whether to use it to increase the low-revs torque, the high-end power, the fuel efficiency or to aim for some combination of different benefits.

The fuel economy
The fuel economy, going from around 10% to 30% in real conditions, is essentially bound to two factors:

- the increased thermodynamic efficiency and the reduced weight of pumping losses;
- the possible “downspeeding”, allowed by the increased low-end torque.

The fuel economy is a cornerstone of the Drum Charger® project, which aims to give the PTW sector the opportunity to match the progresses made by the car sector in the last ten years, thanks to the clever use of turbocharging.

How does it fit on the vehicle
Integrating a Drum Charger® on a vehicle (motorcycle or scooter) represents its only criticality. Being a volumetric machine, the Drum Charger® needs to move a certain air volume, and because of the intrinsically limited travel of the membrane, it is necessary to have relatively wide system diameters to move enough air. Systems in the current range start from a 220 mm diameter and up to 270 mm, single or double (two Drum Chargers side by side, with a single exhaust pipe to feed pressure to the membranes, or a single cold duct with two exhaust pipes pumping) and the positioning of the inlets can vary according to the engine manufacturer’s needs. The external casing is 37 mm thick. The Drum Charger® has to be at 60 to 80 cm distance from the engine head, in order for the “thermal barrier” to effectively arise, keeping the operating temperature of the system below 50 °C. The actual position of the Drum Charger® on the vehicle depends on its technical features, but also on the designer creativity.
The side benefits
While placing the Drum Charger® aboard the vehicle can be some more hassle, it has to be said that it is light (less than 1 kg, plus the inlets on the hot side and cold side) and that it can allow for reducing – or even eliminating completely – the airbox. Also the muffler can be smaller and lighter (thus offsetting the weight of the Drum Charger®), thanks to the reduced energy content of the exhaust gases.

High-tech, low-price
There are currently no systems on the market able to offer the same benefits of the Drum Charger®: higher torque, improved smoothness, better efficiency, better fuel economy, lower exhaust noise – and with a system easy to integrate, requiring a modest or no engine tuning at all and coming at an unprecedented low cost.

The Drum Charger® won’t let you down
The Drum Charger® is a purely mechanical system, inherently synchronized with the engine, maintenance free. The vapour normally contained in the exhaust gases tends to condense on the “hot” side of the vibrating membrane, and the water droplets wash the combustion by-products away: the membrane is therefore “self-cleaning”. Only in the unlikely case of damage, a sensor alerts the engine management system, but the engine keeps running normally, only with no charging effect. The whole Drum Charger® can in this case be replaced, a simple operation that any mechanic can perform. And the cost of the spare part is affordable for everybody – unlike with a turbo.

A “Turbo 2.0”
Although being 100% mechanical, and far away from the IT world, the Drum Charger® is the real “Turbo 2.0”, getting rid of all its downsides while keeping the advantages. It cannot match its absolute charging performances, but brings along a series of benefits: it allows for injecting more life into the low and medium displacement engines, making them more bright and interesting. It can lower the fuel consumption, and with it the running costs; it improves the combustion quality and reduces noise, helping comply with the present-day and future homologation rules (Euro4, Euro5). It is a perfect fit on the newest scooter and light motorcycles, along with a new generation of vehicles that have still to be imagined: motorcycles and scooters 2.0, endowed with a 2.0 charging system.
THE LOST OPPORTUNITY

The “breathing” of an engine is a fundamental characteristic, so much that the most fundamental parameter used to classify engines is the displacement, that is, their “lung capacity”. The reciprocating movement of the piston, combined with the timing, the port shape and dimension, and so on, defines the air volume that can be sucked into the combustion chamber. All the engine performances are a result of the available air: power output, combustion efficiency, polluting emissions, and so on.

Because of the fundamental importance of the air volume available to the engine and of its characteristics (air pressure, speed, …), supercharging systems arose soon after the internal combustion engine was born, already in the second half of the XIX century. The idea was to “artificially” increase the engine ability to draw air. On road vehicles, this helped boast more torque, in an era when engine efficiency was extremely low; in airplanes, instead, it could compensate for the drop in air density at high altitudes. If working with less dense air is equivalent to have a lower displacement engine, then supercharging could lift up again – quite literally – the performances of engines in the air.

Just as early, the use of rotating machines – compact and highly effective – to compress air became the most popular way to increase the air flow into a given engine. Two kind of systems were to confront themselves on the market: compressors mechanically driven by the engine through belts, chain or gears (supercharging) and compressors driven by exhaust gases through a turbine, a different kind of rotating machine (turbocharging).

Following the fleeting boom of turbocharged sports cars in the Eighties, the present-day drive for more efficient engines in order to reduce polluting emissions, fuel consumption and noise has revived charging – especially turbocharging. This solution inherently allows for achieving efficiency increases, since the power needed to compress the intake air is not taken from the engine – as in mechanical supercharging – but from the exhaust gases, instead of throwing their energy away entirely. In the meantime, reducing the energy content of the exhaust gases makes them slower and colder, making the life easier for the exhaust and substantially reducing the associated noise.

Supercharging allows for having engines able to suck air just as they were of bigger displacement, but keeping low friction and low pumping losses – both proportional to the effective displacement. Upon this very principle (“downsizing”) rests a large part of the technical choices made by engineers in this decade, to comply with the demanding targets set up by the EU for 2020 (average fleet CO2 emissions of 95 g/km, or a gasoline consumption of 24.4 km/l, compared to the current average of 130 g/km or 17.8 km/l, enforced since 2012). Downsizing via supercharging is one of the three pillars of the latest engine technology, together with hybridization and intelligent transmissions.

To realize the extent to what downsizing has caught on, suffice to look at the car manufacturers range. Let us take three very popular cars, of different origin and class: an Italian city car (Fiat Panda), a French family or touring car (Renault Espace) and a German sports car (Porsche Boxster). All have been on the market for more than 15 years and allow for studying the engine offer in time. In the following diagrams we have plotted the average displacement of gasoline engines (excluding the Diesel engines to make a coherent comparison with the motorcycle engines).
The onset of downsizing is evident, not to speak of the reduction in the number of cylinders (the Panda boasts a twin after 15 years of four cylinders, the Espace leaves the V6 in favour of inline fours and the Boxster drops its historical flat-6 to host a flat-4). Such reduction is the basis for the reduction of fuel consumption – especially in the homologation cycle: smaller engines can normally be lighter and more efficient, and charging provides the expected performances.

In the motorcycle sector, still, none of this has happened; the displacement trend, rather, is upwards. Let us take as an example three more representative vehicles: a large selling mid-size scooter (Piaggio Beverly), a race replica (Ducati SBK series) and the best seller of the last decade, the BMW R GS on-off. These also have been on the market for many years, and allow for studying the evolution in the engine offer. We are plotting for the Beverly the averaged engine displacement, for the other two the higher displacement version, which has always been the most sold; the lower displacement models follow anyway the same trend.

We see no sign of downsizing, but this is no way the fault of motorcycle engineers. They simply do not have any option suitable for two wheelers.

The reason is that matching a reciprocating machine as the engine with a rotating machine is, to put it mildly, difficult. Especially if we are talking a turbocharger, made up of two rotating machines itself (the turbine and the compressor). The turbine, immersed in the scorching exhaust gases (800 °C and more) requires specific, extremely expensive materials, having additionally to withstand the huge centrifugal forces it undergoes: to work properly, turbines must turn even faster than 100,000 rpm – which makes moreover for a difficult lubrication. Also, their operating range is quite narrow, making it necessary to cut the turbocharger out when the engine is revving either too low or too high, through additional systems such as the waste-gate or the pop-off valve.

Furthermore, because of the high compression ratios of rotating machines it is necessary to cool the air after it has been compressed, not to waste compression work (hot air is less dense, therefore the air flow decreases when temperature raises) or run into engine knocking because of the high temperature in the combustion chamber. For these reasons the air has to be cooled before entering the combustion chamber, via another additional element, the intercooler. Also, the management of the rotating group entails a sophisticated control unit, which monitors the connection between the reciprocating and the rotating machines, trying to limit classical problems such as turbo-lag or exponential power rise, which on a car can be bothersome, but on a motorcycle or scooter become dangerous. It does not come as a surprise, at the end, that the motorcycle engineers have let turbocharging go quite soon; even the use of supercharging – although less affected by such problems – has been occasional and basically limited to two examples in the last 20 years (Peugeot Jet Force, Kawasaki H2). It is in any case impossible to get rid of the high costs for the additional elements (mechanical and electronic parts) and for their arrangement on the engine (system costs); not to speak about the maintenance or replacement costs.
THE MISSING OPPORTUNITY | THE HISTORY

No leading manufacturer or supplier has shown a clear commitment in closing the technical gap in charging for engines of low displacement and low number of cylinders. **Nor any existing technology seemed able to deal** with all the issues in terms of cost, complexity, working temperatures of conventional charging systems: no practical way seemed to exist to obtain a technical solution that could be also economically feasible.

At the onset of 2010s, AlterEgo was already working in the field of **bottom-up innovation**, looking for ideas and patents technically promising, but needing to be further developed and promoted to the companies of the PTW sector. In 2015, AEH came in contact with an interesting patent for a low cost charging system, and was able to acquire the **exclusive rights** for producing and selling it in the PTW sector.

The three main “ingredients” making this solution so interesting are the following:

- it achieves the charging effect through a volumetric machine (essentially a pump), not a rotating one, to avoid the matching problems and get possibly rid of any electronic management;
- it works away from the cylinder head, in order to keep the working temperature low, thus enabling the use of low-cost materials (such as plastic) and avoiding the need for an intercooler;
- it uses “**disposable energy**”, free of charge: the energy of the exhaust gases, exactly like a turbocharger.

This technology is conceived from the onset to be the simplest and the most reliable charging system ever seen: a membrane set to vibrate by the pulsating pressure waves in the exhaust pipes – which produce each time the exhaust valve opens – and that on the opposite side pumps air in the intake line. The first system prototype, applied to a small CHP plant based on an internal combustion engine of 200 cm³, achieves **an improvement in fuel economy of nearly 20%**.

The application to the motorcycle field becomes obvious, especially for low displacement engines. Calculations show that the system could work without major problems up to at least 10,000 rpms. Another prototype is then built as a proof of concept, and applied to a (carburetted!) MZ 125 motorcycle. The result is a torque curve much stronger, which in turn allows for a wider transmission final ratio (downspeeding) leading to an improvement in fuel consumption of 25%, in spite of the engine being more torquey, smooth and swift.
Once the worldwide license for the PTW sector acquired, AlterEgo Hardware immediately started an extensive range of test activities (bench tests, road tests, numerical models). A series of prototype versions, with performances and reliability improved at each step, has lead to the current range of this system, dubbed “Impulse Drum Charger” or more simply Drum Charger. Its cylindrical chamber and the vibrating membrane in it resemble indeed a drum, where the pressure impulse in the exhaust pipe make for the drum sticks. Its special constructions allow however the membrane to travel for a much wider distance than in a drum, so to displace a bigger air volume to be delivered to the airbox, increasing the air pressure in it until the intake valve in the cylinder head starts to open.

The amazing thing in the Drum Charger is how naturally it fits existing engines. Designed not to require changes in the powertrain, the Drum Charger has shown the ability to immediately improve the engine characteristics. Some tuning of the valve and fuel injection timing can lead to optimal results, but generally when installed (properly), it works from the first engine stroke bringing along all its benefits. Even in single cylinder engines, where the wide pressure fluctuation in the exhaust pipe make for a puzzling adoption of a turbo, the Drum Charger is at its best, smoothening the engine character and broadening its usable power range.

This is possible because the Drum Charger itself is a reciprocating machine, spontaneously synchronizing on the same frequency of the cylinder it assists, and because it acts on the breathing function, which as we saw before is at the very heart of the functioning of any combustion engine. The increase in the air volume (combustive agent) available to the engine, and of its pressure, allows for automatically improve the engine performances. This is particularly true in fuel injected engines, where the lambda sensor automatically matches the fuel delivery to the air flow rate.

The secret of the Drum Charger lays therefore in its ability to raise the air pressure entering the combustion chamber, without taking energy from the engine (as a mechanically driven supercharger would do), but using instead part of the exhaust gases energy content, that the engine would otherwise dispose of.

The exhaust gases reach the Drum Charger through a specially made branch in the header tube, with the branching point just downstream the cylinder head. They do not pass through the Drum, as they would do in a turbocharger, but stay in the pipe and transfer energy to the membrane, just as they were “knocking at the door”. The branch leading to the membrane is a dead end, and the exhaust gases keep flowing through the exhaust pipe just as ever; they simple do so after having transferred part of their energy to the membrane (and therefore to the intake air on the other side of the membrane, which is compressed) in the form of pressure waves. The pressure pulses press against the membrane, and a coil takes the membrane back to its starting position. The phase of the pressure waves is crucial for the proper functioning of the system; for this reason, the geometry of the piping has to differ to match the different engines, much as it happens with the exhausts of 2 stroke engines.

The system temperature is also crucial: therefore the distance has to be carefully determined, where the exhaust gases in the pipe have become cold enough to be dealt with by conventional materials. Once the branching pipe is filled up with gases, they stay there and provide themselves the thermal insulation.

After having partly transferred their energy to the Drum Charger, exhaust gases reach the muffler having a lower temperature and speed, much like in a turbo. The drum charged engine can therefore be quieter (1 dB less, on average) and the exhaust system can treat the gases more easily. From the polluting emissions standpoint, the availability of a higher air volume, at a higher pressure, can be used to obtain a more complete and cleaner combustion, for example increasing the tumble level in the combustion chamber.

The Drum Charger can moreover be used as a support to a conventional turbocharger, to enhance its low end behaviour, where the turbo is usually disabled, and mitigate the turbo-lag, which is still evident especially in the lower displacement car engines, gasoline or Diesel.
The Drum Charger®: A Turbo with No Turbine

In its current configuration, the Drum Charger can reach about 0.3 bar of net charging effect: a lower charging level than that of a turbo, yet sufficient to obtain improvements on three sides.

1. Higher performances in terms of torque and power output, especially at low revs where many low and medium displacement engines are unsatisfying.

2. Higher engine efficiency (thanks to the energy recovered from the exhaust gases and to the improved combustion), and therefore lower fuel consumption.

3. Easier complying with the present and future homologation parameters, once more thanks to the cleaner combustion (implying less polluting emissions) and the exhaust noise reduction.

The turbo has been long considered for its many merits, above all the ability to transfer energy from the exhaust gases to the intake air; the turbine, as we have seen, is unfortunately also its main flaw. The Drum Charger has the same positive characteristics of a turbo, but with no need for a turbine. This fundamental point entails huge differences not only on the technical side, but also on the practical side: unlike a turbo, the Drum Charger is inherently “synchronized” with the cylinder it assists. The drum charged engine behaves therefore exactly as if it had a bigger displacement. There is no need of the typical systems used to manage the pressure level in the pipes (pop-off valve, waste-gate), nor of the related management electronics. The power delivery is smooth, and in any case smoother than that of the original engine. The torque increment is in the 15%-25% range, depending on the engine characteristics, based on the first prototypes – but this technology still has not reached its full maturity, and further improvements are expected.

All this is realized by a system designed to be conceivably the simplest charging system: it can be fully made in plastic, it does not require modification to the engine other than the exhaust and intake pipes, it does not need ancillary element such as an intercooler and it neither calls for a management electronics (only a sensor is present, to notice the ECU about possible damage events). Its cost is therefore about ten times lower than the cost of a turbo, which completely overturns the parameters of the technical and economical equation to make supercharging attractive in cases where it had never been considered to date, such as in motorcycles and scooters.

Moreover, the Drum Charger is maintenance free. It is supplied as a sealed component, and can in the case be replaced with a new one at the end of its life, thanks to the low cost and installation ease.

The weak point of this technology are mainly its dimensions. Being a volumetric machine instead of rotating, the Drum Charger needs to physically displace air: and given the limited travel that can be achieved by the membrane, its diameter has to be quite wide. Current models do produce about 400 cm³ of pumping volume, with a discoid system of about 220 by 70 mm. Such a system can be applied to engines of up to 125-150 cm³. Larger displacement cylinders require bigger systems or twin systems, which already are in the range. The expected range of application is for engines of 125 to 800 cm³.

The Drum Charger dimensions are in principle larger than those of a supercharger or a turbocharger, but one must keep in mind that the Drum Charger is “self-sufficient” and does not need any belts, rotating parts, control valves, dedicated ECU and the like. In many applications it is moreover possible to integrate a filter into the system and remove the airbox, accommodating the Drum in its place.
THE DEVELOPMENT

After having acquired the worldwide license for producing and marketing this technology, AlterEgo Hardware pulled the trigger on a long development process involving many aspects, namely:

- the scouting of the best materials and suppliers for the different parts of the system (carter, vibrating membrane);
- the system design, required to improve its flow efficiency, reducing in the meantime its weight and dimensions;
- the study of its life span, to reach the high reliability and durability standards of the automotive sector;
- the deep analysis of the behaviour of the Drum Charger when coupled to the engine, including the design of numerical tools;
- an extensive bench testing to assess the performances and the potential of the system, with or without major changes in the engine;
- road tests to assess the real improvements in the “rideability” area;
- introducing this technology to the most important manufacturers of the PTW sector in Europe, and collecting their feedbacks about it;
- the potential for future improvements and novel applications.
One of the prototype bikes used in the development of the Drum Charger can be seen at the AlterEgo Hardware booth in Eicma, Milan. It is a KTM RC 390, with two IDC270S.16 installed (see section 4 for details on the IDC range), able to achieve with little or no engine calibration a 15% increase in the torque and power output on the whole range, and a simultaneous efficiency increase. The power curve is clearly smoother and stronger, especially at low revs; the engine can withstand braking at lower rpms, while it can reach higher rpms at the top end. Overall, the engine is more powerful, yet more smooth and usable.

The work on this engine has however just started: further improvements in terms of performances are expected, possibly using smaller diameter Drum Chargers.

The Drum Charger is today a technical reality, with different versions to match the engine displacement, number of cylinders, and revving limit, and the development targets (more torque, less fuel consumption, less pollutant emissions and so on).

AlterEgo Hardware is working to bring this technology into production as soon as possible. The benefits of drum charging are tangible, and many manufacturers have already shown real interest in it. The year 2017 will be devoted to complete the system development and to map out the manufacturing process, and the first drum charged production models could follow as early as in 2018. Until then… stay charged!
### COMPARISON TABLES – CHARGING TECHNOLOGIES

**Competitor technologies – overview**

<table>
<thead>
<tr>
<th>TECHNOLOGY (supplier)</th>
<th>PROS</th>
<th>CONS</th>
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<tbody>
<tr>
<td><strong>Turbocharger</strong> (Bosch, Borg Warner, KKK, IHI Mitsubishi, Honeywell)</td>
<td>Increase in efficiency, High performances, Established technology, Compact package, Noise reduction, Ideally covers any displacement</td>
<td>High temperature, Heating of intake air, High-tech materials, Electronics needed, Lubrication required, Turbo-lag, Additional components (intercooler, waste-gate, pop-off,...), Not convenient for displacements under 600 cc, No single cylinder</td>
</tr>
<tr>
<td><strong>Supercharger</strong> (Eaton, Paxton, Rotrex, Powerdyne, ATI, Vortech, Lysholm)</td>
<td>High performances, Established technology, Ideally covers any displacement, No turbo-lag</td>
<td>Reduced efficiency (it takes some power of the engine), Complex installation (belts, chains, clutches), Heats intake air, Additional components (intercooler, waste-gate, pop-off), Intake noise</td>
</tr>
<tr>
<td><strong>Drum Charger®</strong> (AEH)</td>
<td>Increase in efficiency, No turbo-lag, Constant mild torque, Power increase over the entire range, Separation exhaust-intake, No electronics (passive system, self-triggering), Extremely low cost, Fits low displacements, Suitable for single cylinder engines, Maintenance free</td>
<td>Package requirements, Unfit for high displacements, Limited increase in pressure, Limitation in revs (10,000)</td>
</tr>
</tbody>
</table>
## THE ENGINEER’S STANPOINT: A WISH LIST

<table>
<thead>
<tr>
<th>TECHNICAL BENEFIT</th>
<th>TURBOCHARGER</th>
<th>SUPERCHARGER</th>
<th>DRUM CHARGER®</th>
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<tbody>
<tr>
<td>High charging pressures</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Compact layout</td>
<td>✔ (possible)</td>
<td>✔ (possible)</td>
<td></td>
</tr>
<tr>
<td>Increase in efficiency</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Low temperature operation</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Separation exhaust gases – intake air</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Negligible heating of intake air</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Responsiveness at low speeds (no turbo-lag)</td>
<td>✔ (modest)</td>
<td>✔ (no turbo-lag)</td>
<td>✔ (modest)</td>
</tr>
<tr>
<td>No need for electronic management</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common-use materials</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Low installation cost</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Maintenance free</td>
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## THE RANGE

<table>
<thead>
<tr>
<th>VERSIONE</th>
<th>CARATTERISTICHE</th>
<th>APPLICAZIONE</th>
</tr>
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<tbody>
<tr>
<td>IDC220S.16</td>
<td>Single membrane, 220 mm diameter</td>
<td>Unit cylinder capacity up to 150 cc</td>
</tr>
<tr>
<td>IDC220D.16</td>
<td>Double membrane, 220 mm diameter</td>
<td>Unit cylinder capacity up to 250 cc</td>
</tr>
<tr>
<td>IDC270S.16</td>
<td>Single membrane, 270 mm diameter</td>
<td>Unit cylinder capacity up to 300 cc</td>
</tr>
<tr>
<td>IDC270D.16</td>
<td>Double membrane, 270 mm diameter</td>
<td>Unit cylinder capacity up to 400 cc</td>
</tr>
</tbody>
</table>

Every model in the range can be supplied with different configurations regarding the position of the fresh air ports (in and out of the Drum Charger). The “D” models can additionally be chosen with central exhaust gas port (single pipe) or external gas port (double pipe).