There is a new generation of electric drive systems coming – why are they needed ?

New generation high efficiency motor

Executive Summary

In the first of a series of technical papers, we consider the need for continued electric motor development and explore some of the technologies that can offer solutions.

There is much publicity explaining the contribution made by on-road vehicles to carbon emissions and thus the driver behind the accelerated electrification of the automotive industry. Unless you pick up trade magazines there is less information being published in the consumer domain about the need to reduce emissions from other, every-day, products that traditionally use Internal Combustion Engines (ICE)

Emissions from Outdoor Power Equipment such as lawn mowers and other small ICE powered equipment are a group of products that are less visible in every-day life. According to a study in Sweden [1], published in 2001, a typical four stroke, four-horse power lawn mower produces the same amount of polycyclic aromatic hydrocarbons as driving a modern car for 150 kilometres (93 miles). Studies such as this make it clear that Outdoor Power Equipment is facing similar challenges to the auto industry. One such challenge is delivering the performance of an ICE with a cleaner electric alternative for a similar price.

The challenges

The migration to cordless energy for small power equipment is well established and their market sectors growing. According to one report[2] It is predicted that the cordless lawn mower sector will have a unit CAGR of 6.1% between 2020 and 2025. The medium sized electric drive systems required for these sectors are also highly developed and well established, so at first glance there might seem little opportunity to introduce attractive new technology. Early adopters have identified the advantages of cordless technology but equally voice opinions on the improvements they need to see from the next generation of products. Recognising these opportunities has stimulated the development of a new generation of electric motors; controllers and inverters that will help take the Outdoor Power Equipment (OPE) and Non-Road Mobile Machinery (NRMM) sectors into the next phase of growth.

ICE technology has the advantage of being able to provide circa 1.1Nm/kg [4] but their thermal efficiency is low. Published data states that, dependent on application, spark ignition (SI) engines vary in efficiency from circa 20% [5] to a peak of 35% [6]. In the world of small power products, ICE are often oversized to deliver sufficient torque at lower speeds eliminating the need for mechanical speed reduction and enabling compliance with noise legislation.

In addition, many regions of the world now demand a higher level of emission control. This could eventually burden small ICE's with emission control devices that will make them prohibitively expensive and create further challenges to their physical size.

Another challenge to be considered is that larger outdoor power products often have a longer duty cycle than a hand held product. A professional lawnmower can be used for several hours at a time between charging opportunities. With an ICE its just a matter of pouring in more fuel if more range is required. A cordless equivalent will require time to recharge or fit another battery which is currently more expensive than a tank of fuel. Whilst battery technology is advancing very quickly it is still relatively expensive, large and heavy compared to the power density of liquid fuels. In an ideal world, an electric system will eliminate the Co2 emissions at point of use, be smaller, lighter, cost effective and more efficient whilst continuing to display the favourable characteristics of ICE.

The Opportunities

In a 2019 study, commissioned by an electric power products manufacturer [3], it is stated that 62% of trade users would stop using petrol-powered tools if a suitable alternative was available at the same price. Over 40% of users cited good performance and power as their top two measurements of satisfaction. This paper proposes that some of these critical measurements of satisfaction are not adequately met and that **opportunity exists to fulfil customers unmet needs.**

Many of today's hand held battery operated products are meeting the expectations of the professional user but some larger power products are reaching the limits of the technology that is commercially available and the opportunity is there to improve and refine. Fig 1 shows four of the top measurements of product satisfaction customers refer to when executing a job requiring Outdoor Power Equipment (OPE).

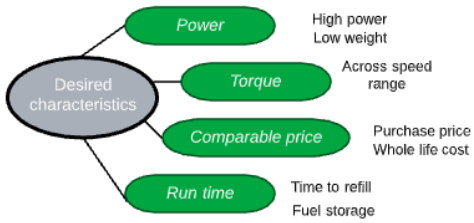

Fig 1:- Four customer measurements of satisfaction

Motor opportunities

With regulatory and market pressures to reduce and remove emissions from OPE, manufacturers find themselves with technical decisions to be made but often based on experience and data from their historic application of ICE solutions.

The purpose of the paper is to support and aid manufacturers in making these decisions and prompt a series of questions.

At a high level, some key advantages of electric drive systems over an ICE can be, but not limited to, the following:-

- The ability to deliver peak perofrmance for short periods of time
- Eliminate power consumption when not in use (unlike an idling ICE)
- Scale an electric drive system for demand; 4 smaller motors instead of 1 larger motor.
- Offer an opportunity to harvest kinetic energy by utilising regenerative braking thus extending battery autonomy
- Utilising regenerative braking in support or instead of mechanical brakes which not only add cost but waste energy in the form of heat
- Electric motors can usually be orientated in any plane
- Multiple orientation also offers a reduction in stock-keeping units (SKU's)

There is potential to:-

- Minimise noise levels
- Minimise Hand Arm Vibration (HAV) levels
- Minimise Whole Body Vibration (WBV) when used in a ride-on machine

Data to compare one ICE against another is often based on power, torque, cubic capacity, weight and perhaps fuel consumption. The reader needs to become aquaited with units of measurement that are more appropriate when comparing ICE against electic motors. Power and torque compared to weight and volume give immedate snap-shots for comparison although there are other factors to be considered such as noise and vibration.

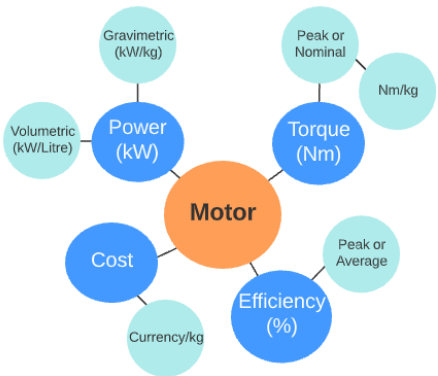

Fig 2:- Comparative units of measurement

With these units of measurement in mind it is easier to compare all the options. It becomes apparent that there is a motor gap to be filled as a truly competitive alternative to ICE.

Product Comparison	Typical ICE	Typical electric motor 1	Typical electric motor 2	New Generation electric motor
*Cost/kW	110	102	75 (est)	Circa 10
kW/l	0.016	1.22	2.45	6 plus
kW/kg	0.22	0.63	1.14	2 plus
**Ave effcy.	20-35%	50-60%	40-50%	Circa 93%
Nominal Torque (Nm)	9.6	5-10	1.25	Circa 5
Base on data measured by ETA Green Power during 2020 *Costs are based on indicative, high volume $US list prices*				

Table 1

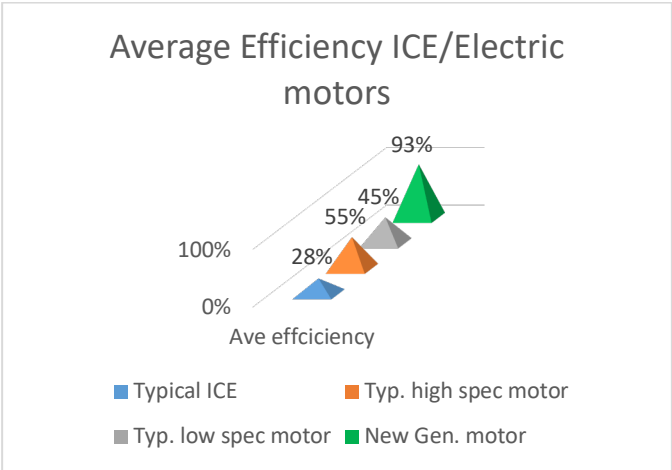

Fig 3:- typical efficiency comparisons

Table 1 & Fig 3:- highlight the comparisons of efficiency between current small ICE and electric motor offerings against what will be possible with a new generatioin of electric motor and controller

With the additional effeciency on offer from new technology comes the opportunity to reduce battery size and therefore cost or to extend range. Two of the meaurements of satisfaction expressed by end users.

It is important that OEM's understand the duty cycle typically seen by there products as this may also offer an opportunity to size the electric drive system more effectively

The next edition in this white paper series will address system architectures, take a more in depth view concerning duty cycles and introduce a new generation of motor that will address the issues highlighted in this paper.

References

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March 2021

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About ETA Green Power Ltd
An Innovator in Magnetics and power efficiency

Our patented technology delivers advanced electric motors, power controllers and inverters to the Off-highway sector.

Developed from over 15 years of research and expertise, our technology answers the unmet need for a market leading, efficient and inexpensive electric drive system alternative to traditional internal combustion engines and some existing electric motors.

Our game-changing electric motor topology offers advanced efficiency, high performance and a cost effective solution removing reliance on hydrocarbon fuel sources and rare-earth magnets whilst minimising manufacturing processes.