A Breath of Compressed Air

David Green examines the limited machines available to carry out pneumatic soil fracturing and the specifics of this technique.

Pneumatic or gas pressure fracturing of soil was designed as a process to improve drainage, increase soil oxygen levels, decrease anaerobic bacterial activity, smash compaction pans and so to improve tree and turf health without disturbing the surface. The Pneumatic fracturing process takes air, compresses it to a high pressure, typically between 15 and 20 Bar (200 to 300 PSI), and then releases the built up air through a hollow probe at depth into the soil.

The release of the air is affected by the action of a high speed valve. The resulting shock wave is created as the gas escapes almost explosively into the ground and causes the ground to shake and shudder. This shaking and a slight rise in level together cause the soil profile to crack.

The main charge of air then rushes upwards towards the surface through the newly created cracks and fissures carrying the chosen inoculant material along with the air stream and so distributing the inoculant through the soil.

There have been several machines that have used this principle, many are known and loved by groundsmen and greenkeepers around the country. Sadly at the time of writing none of the machines, except the new Sisis Aer-Aid, are available for sale. A few specialist diehards continue to develop some of the machines for their own use. The machines, in order of age of development, are:

1. The Terralift is the granddaddy of them all, it is the biggest and has a long development history. The Terralift generates and injects large volumes of air at up to 20 bar and at depths of up to 3 metres. The latest developments based on the Terralift injection system are powered by 40 HP diesel engines and have large Atlas Copco piston compressors.

This raw power allows the machines to inject the equivalent of 1200 litres of air at STP per cycle. The latest Terralift derivatives use a massive probe insertion system that is armed with a JCB hydraulic road breaker hammer and hydraulic rams that are capable of up to 4 tonnes of pull. All this power is used to both insert and remove the probe.

2. An off shot of the Terralift is the Aerragreen, which generates its own compressed air and injects large volumes through four probes to a maximum depth of 500mm. Produced in the USA, this machine has seen little use in the UK.

The power comes from a 25 Hp engine driving a 20 Bar Atlas Copco Piston compressor. Probe insertion and removal is achieved by simple pressure from small size pneumatic rams. There is no hammer facility.

3. The Robin Dagger is a small hand held machine that works by injecting air to about 500 mm depth and using a small cam action hammer to insert the probe.

A 50cc 2 stroke engine powers this unit. Such a machine can only inject small volumes of air at modest pressures.

4. The Terravent is a small hand held unit relying on a manual post holer style of sliding hammer to force the probe into the ground to about 1 metre. The Terravent works by injecting nitrogen gas straight from large commercial extra high pressure cylinders. The gas is pulsed as it is released. Calculations from the published nitrogen consumption data suggest only relatively small volumes of gas are released at each cycle.

The Sisis Aer-Aid System in action relieves compaction, improves infiltration rates and combats Black Layer, claim the company

The use of nitrogen gas, not compressed air is, to my mind, one of the Terravent's weaknesses. All turf men know that the turf we strive to grow well requires 'nitrogen' but in the form of soluble nitrates not as the inert and suffocating gas. Only a few plants, such as the legumes, can assimilate nitrogen gas directly and then only because of their symbiotic relations with nitrifying bacteria.

5. The latest to join the market is the Sisis Aer-Aid that injects 88 Litres per minute of low pressure air straight from a Hydrovane compressor through numerous hollow tines into the top 100 to 150mm of the sward. Airflow to each tine is restricted to a small diameter low pressure air pipe and so there is little explosive power in the air that is injected in this manner. This machine was only launched late 2004, so little is yet known of its performance and long term benefits other than the data published from Sisis. While it undoubtedly injects air it is not a true pneumatic fracturing machine.

The first four machines use the stored, almost explosive, energy in the compressed gas or air they release to break up and loosen the soil beneath the turf surface they are treating. Applied with care all of these four systems can be successfully used to treat bowling greens and golf greens where surface disturbance is unacceptable.

The differences between the four machines are found in the depth of penetration into the ground, the ability to inject beneficial substances in granular or liquid form and the degree of ground resistance that can be overcome. The speed of working and the physical input needed from the operator.

There is as always a balance to be struck between the disruptive power of the air blast at the heart of the process and surface disruption. The powerful blast that is so welcome below ground and through the compaction panned layers is most unwelcome if it reaches and destroys the surface. Only the Terralift derivatives guard against accidental surface disruption close to the probe by holding the surface in place with a large steel plate held firmly against the soil by the weight of the machine. This plate also stops the turf lifting as the probe is withdrawn allowing rapid withdrawal.

There are numerous ways of mechanically treating compaction and aerating the soil from the purely agricultural mole plough, through the vertidrain, now an almost generic name for that type of heavy duty reciprocating spiker, and its imitators to corers, slitters and tiners that may or may not shake rattle and roll their way across the turf. All these mechanical operations vary in their ability to treat relatively shallow, up to 300mm deep, compaction pans, as depth of pan increases so the number of capable machines drops away. The deep spikers struggle to penetrate to 500mm in all but the most favourable soil profiles and are really challenged when they are also required to.

MATERIAL INJECTION

Only the Terralift, Aerragreen and Terravent can inject materials with their gas/air blast. The Terralift uses the greater volume of air at the highest pressures and can inject up to a litre of granular material per shot. The Aerragreen and Terravent probes are much smaller in diameter than the Terralift probe and so have lower capacity for injection with each blast of air.

BACKFILLING

The probe holes produced by these machines form valuable drainage and aeration pathways from the surface to the subsoil and if they can be made to remain open they provide a long term improvement to local surface water drainage. The large probe holes of the Terralift derivatives at nearly 40mm diameter are of a size that can be filled with an inert aggregate. Any coarse aggregate will do but the aggregate of choice is Lytag. This man made lightweight aggregate is sterile, inert and nutrient free.

Lytag's most important property is the honeycomb internal structure that allows this material to pass through greens mowers without damaging the finely set blades. The probes of all the other machines that measure less than 25mmn in diameter leave probe holes that are too small to backfill.

SOIL CONDITIONS

Regardless of sales blurb there are strict limits to the type and condition of soils that benefit from pneumatic or gas fracturing. The first requirement is a sufficient depth of soil and subsoil so immediately strike out. In particular chalk and limestone soils of most types do this because the bedrock is generally too close to the surface. The same is true wherever igneous or hard sandstone rocks form the country rock and lie close to the surface.

The second requirement is a capacity to drain water away, however limited into the subsoil. Where heavy clay overlies a free draining chalk stratum the results of pneumatic fracturing can be almost magical in the speed with which the turf improves. The soil has to be moist enough to treat but not so wet that the injected air is effectively being pumped into liquid mud that has no ability to form fissures. Dry Sand does not work because the air blast dissipates through the coarse pore structure without disturbing the soil. Moist sand works well. Wet sand rarely exists. Dry clays are simply too hard to penetrate and if it moves at all when blasted with air then it tends to form large hard plates that crack and split at the surface. Moist clays generally work well, wet clays are less successful.

Frozen soils are untreatable and while they remain frozen leave the surface free of plucking. The Aerragreen has 4 x 500mm long probes but in UK conditions 300mm is about the limit of its penetration. The Aerragreen also lacks any form of hammer to drive the probes through heavily compacted layers and resistant layers such as Iron pan.

Terralift machines, L-R, Airforce Tracher, Airforce Scamper and Airforce.

WORKING DEPTH

Below 500mm depth the field is therefore left clear for the Robin Dagger, Terravent and Terralift and its derivatives. Both the Robin Dagger and the Terravent are, at the time of compiling this article, unavailable for sale and any already in use are unsupported by its manufacturers and the Terralift derivatives are not available except for contract hire.

WORKING PATTERN

As the depth the probe goes so the air pressure increases and so the area around each probe hole that is treated increases. The shallow 500mm depth of the Robin Dagger and the Aerragreen mean that the probe holes need to be spaced no more than a metre apart to fully treat the area.

The 1 metre depth and higher working pressures that are used by the Terravent and the Terralift derivatives allow the area to be fully treated with probe holes 2 metres apart in lines that are themselves 2 metres apart.

WORK RATE

Penetrating between 500mm and 1 metre into the soil can never be done rapidly, particularly when there is a solid compaction pan to be broken through on the way down. Here raw power and machine weight are vital to force the injection probe through any obstruction in the profile at an economically viable time of between 45 and 60 seconds per cycle. Such a work rate will severely tax the human part of any human powered machine and so limit its use to a short period for each operator.

Even the biggest and most powerful machines developed from the original Terralift struggle to treat more than 3000 square metres a day. This is simply due to the time taken to get the probe into and out of the ground. A 45 second cycle time, of which probe insertion takes 20 seconds, probe withdrawal is 10 seconds and the rest is movement and blasting time. This 45 second cycle gives 80 cycles per hour that covers just 320 square metres. This is less than the area of an average golf green.

The Aerragreen with its four probes and 300mm penetration can just equal this daily total despite its manufacturers claims for 3728 square metres per day. Treating 3000 square metres per day every day with either the Robin Dagger or the Terravent appears to require the stamina of marathon runners and the strength of an Olympic Weightlifter. The Sisis Aer-Aid can easily beat this 3000 square metre per day target but because the Aer-Aid operates to such a shallow depth and has around 40 tines it is more of a surface spiker than a true deep soil aerator and decompaction machine.

The soil moisture requirements mean that there is a definite seasonality to the use of the Pneumatic Fracturing technique with work being most effective in the wider spring and autumn periods.

David Green is Managing Director of Terrain Aeration and can be contacted on 01449 673783.

AIDING AIR

The Sisis Aer-Aid system is the latest piece of machinery to come on to the market in this area. While not a true pneumatic fracturing machine this is one of the only pieces of kit of its kind that can be purchased rather that contracted out.

Most compaction is found in the top 100mm of the soil. In compacted ground air passage is restricted and more water is held also hindering the passage of air. Grasses starved of air at their roots cannot grow properly. Ultimately Black Layer can form, particularly in poorer quality sand based rootzones and in areas growing in shady conditions.

The Sisis Aer-Aid System enables turf professionals to give their turf a blast of air, directly into the rootzone, every time they aerate. The cam trigger system ensures that the air is always expelled at the bottom of the tine penetration, ensuring a targeted, precise and constant working depth to a maximum of 127mm. Working at 150mm spacing, air is introduced at a rate of 88l per minute. Trials have shown significant improvements to infiltration rates after use of the Aer-Aid and hardness is reduced.

The Aer-Aid System has received two major industry awards and, in addition to the many now working around the UK, there are also machines in South Africa, Japan, Sweden, Hong Kong and Canada.