Based on these results, ISTRC agronomists recommended we develop a program for this season to displace 25 per cent of the putting surface using the aeration tines' outer diameter (OD) in the calculation. By using the ISTRC's surface area calculator, different spacing and tine sizing can be inputted to come up with the best tine to achieve certain goals.

Many golf courses are switching to carbide-tipped aeration tines for longevity, which is probably a good idea. During our most recent aeration, we used a standard side-eject quad tine, and since they were not carbide-tipped, the tines were changed after every 1,858 m_ (20,000 sf) of aeration, or roughly every three greens. Halfway through the aeration of our 12th green, the tines were changed and we noticed the removed core was significantly different.

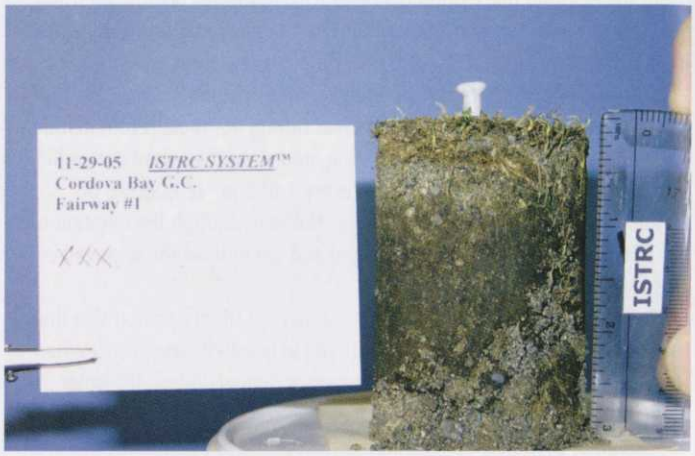
The difference in the core that was pulled out of an aeration tine that has been worn down by 8.3 mm (0.33 in.) in length is significant. When the tine is new, 3.75 per cent of the green is removed using the inner diameter (ID) and 10.04 per cent is removed calculating with the OD dimension of the tine. After 1,858 m_ (20,000 sf), the same tine has worn down by 6.35 mm (0.25 in.), but the ID and OD dimensions of the tine have changed, resulting in 6.24 per cent removal using the ID in the calculation and 9.01 per cent using the OD dimension.

This data suggests when using a standard aeration tine that will wear, it is important they are either changed more frequently or rotated in the order in which the greens are aerated each season. The purpose of this technique is so the amount of material moved from each green during the season is similar. Using soil tests to monitor the changing physical properties of the greens is a useful tool in management programs.

ROOTZONE OXYGEN AND HARMFUL GASES

There are several factors affecting the oxygen levels in your soils, and core aeration is only the first step. Aeration is the venting of soil, which enables gases to move in and out of the soil profile. High water contents in soils cause oxygen deficiency for roots because water-filled pores block the diffusion of oxygen into the soil to replace those used by respiration. In fact, according to Nyle Brady and Ray Weil, authors of The Nature and Properties of Soils, the oxygen diffuses 10,000 times faster through a pore filled with air than a similar pore filled with water. Once soil temperatures warm up and we approach the growing season, oxygen can be rapidly depleted through consumption by actively growing turf roots or by soil microbes that are decomposing readily available supplies of organic matter. If organic matter decomposes under low-oxygen soil conditions, then gases such as methane (CH4), hydrogen sulfide (H2S) and ethylene (C2H4) are produced. Therefore, during the growing season when microbes are very active, it is essential your management programs focus on the constant addition of oxygen in a variety of methods to encourage the decomposition of organic matter and allow for adequate displacement of any harmful gases that may form during these processes. I believe the following tools and procedures are of primary importance for a solid Integrated Pest Management (IPM) program:

- **Hydroject.** During the growing season, when more disruptive methods are unacceptable, this tool may become a superintendent's best friend in terms of managing gas exchange in the soil profile.
- **Planet Aire.** This tool is gaining popularity due to the ease and speed at which aeration can occur. With this machine, a non-disruptive aeration can be performed on greens in as little as four hours.
- **Spiking with a 6.35-mm (0.25-in.) solid tine.** This procedure creates excellent chimneys for gas exchange to take place, and when combined with a light topdressing, minimal surface disruption occurs.



PROPER GREENS DRAINAGE AND VENTING: AN IMPORTANT PIECE OF THE PUZZLE

Once a programme is implemented to monitor and manage the air-pore space in the greens, it is critical to ensure the drainage systems installed in your greens during construction are functioning and properly venting. This will allow oxygen flow into the rootzone as well as the flushing of the harmful gases created by microbial activity and by the plant during respiration that is consuming oxygen and producing carbon dioxide. In order for this to occur, cleanouts or blowouts need to be installed at the upper end of each drain tile loop, and air vents need to be installed where each drain line exits the green. Today, most golf courses are initially being designed with blowouts and vents installed during construction, however, most courses built several years ago did not include this important specification in the construction plans. If certain greens have proven to be a challenge in the past, locating the drains exiting the greens and flushing them to ensure the tiles are open and functioning well may help.

The concept of venting is best described by comparing greens to a basement. Envision a basement with several people living in it with no windows or doors to properly vent the room. It would not take long for uninhabitable conditions to develop and inadequate oxygen levels to exist due to the oxygen consumption by the inhabitants and harmful gases that would build up. If you took this same basement and installed a window at each end to allow proper aeration and venting, the room would become much more habitable and those living in the space would be much healthier as a result. The same holds true with your greens-by installing vents at either end, fresh oxygen can be drawn down into the greens table and the water will flow more freely through the tiles.

TROUBLED GREENS: YOU WILL BE AMAZED BY WHAT YOU WILL FIND

This winter, we just completed the process of venting our greens and exposed several causes to the problems we have been experiencing over the years. Our 8th green has been difficult to manage, even though it is one of the largest on the golf course and is fully exposed to the sun. When we located the drain exiting at the back of the green, we found the tile had been cut during the installation of the irrigation system 16 years ago. On three other greens, we found drains that were plugged with roots from surrounding trees and some of the greens located beside ponds had the drainage tile entering the pond underwater, causing backup of the harmful gases unable to vent out of the end of the tile. Since we encountered various problems during the installation of the vents, we now refer to them as the 'observation ports.' During heavy winter rains, it is reassuring to visually inspect your drains and see the water pouring out of them.

VENTING YOUR GREENS: THE PROCESS

On most of our greens, the venting process took approximately two days per green, three to four cleanouts were installed and two to three exit vents were set up.

WATCHING THE GREENS CHANGE

Since the golf course was built, we have experienced varying degrees of black layer in some of our greens and had attributed this to the sand used during construction. However, after learning our greens' drainage was not functioning to the best of its ability due to the lack of venting, we expected to see improvement in the conditions after the implementation of our venting system.

IRRIGATING WITH OXYGENATED WATER: THE NEXT STEP FOR CORDOVA BAY GOLF COURSE

Water in many soils contain small, but significant quantities of dissolved oxygen. When all the soil pores are filled with water, soil micro-organisms can extract most of the oxygen dissolved in the water for metabolic purposes, but this small amount is used up quickly. I am sure there are many processes that take place in the soil during a nice steady rainfall, and I have always wondered why plants and turf seem to respond so well to rainfall in comparison to the irrigation cycles we implement throughout the season. I believe one of the processes that occurs is an oxygenation of the soil because of a fairly high count of dissolved oxygen in the rainwater. In an effort to promote oxygen in our rootzones at Cordova Bay, we have taken additional measures by installing a Sea Air system. This system has been installed in our pumphouse and it treats the water by injecting dissolved oxygen into the wet well prior to being pumped onto the golf course. During the peak irrigation system from June to September, we have found the dissolved oxygen level in our wet well to be around 6 ppm. With the installation of the Sea Air system, we are now irrigating the golf course with water treated to 15-20 ppm. While it's too early to monitor the results, we do feel this system will bring us one step closer to promoting a healthy aerobic soil profile when managing quality turf.

The intent of this article is to emphasise the important role oxygen plays in managing healthy turf by evaluating all programs that can directly affect the level of oxygen in soil profiles. Hopefully, as a result, greens will become easier to manage and more money will be saved in the process.

Dean Piller is the superintendent at Cordova Bay Golf Course in Victoria, B.C. He can be contacted via e-mail at dpiller@telus.net

References

Brady, Nyle C. and Weil, Ray R., Twelfth Edition 1999, The Nature and Properties of Soils.

Cutlines:

The International Sports Turf Research Center (ISTRC) provides cores that offer useful data for superintendents to work toward.

Hydrojects are very valuable tools in managing gas exchange.

During the installation of a cross piece for a greens' vent, a hole is cut in the bottom of a 22.7-l (5-gal) pail for a 101.6-mm (4-in.) standpipe, forming the base for a 254-mm (10-in.) steel base and grate.

Connecting into existing greens' drainage during installation of drain vents on Cordova Bay's 17th green.

Poor soil conditions and the presence of black layer before ventilation of greens' drainage.

Rootzone soil conditions improved dramatically with greens' drainage ventilation.

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Surface area calculator

Enter your values for Table A

Table A	
Tine ID (inches)	0.289
Tine OD (inches)	0.473
Tine Spacing Width (inches)	1.250
Tine Spacing Length (inches)	1.400
Depth of tines (inches)	3.000

Values for Table B are calculated automatically

Table B	
Number of holes per inch	0.571
Number of holes per foot	82.3
Area removed by one tine (inches)	0.066
Area of hole created by one tine (inches)	0.176
Surface Area Impacted using tine ID	3.75 per cent
Surface Area Impacted using tine OD	10.04 per cent

Infiltration rate:	152.4 to 254 mm/hour (6 to 10 inches/hour)
Subsurface air capacity:	20 per cent
Water porosity:	15 to 20 per cent
Bulk density:	1.35 to 1.45g/cc
Water holding:	10 to 15 per cent
Organic content: 0 to 25.4 mm (0 to 1 in.)	1.5 to 2.5 per cent
Organic content: 25.4 to 50.8 mm (1 to 2 in.)	1 to 2 per cent
Organic content: 50.8 to 76.2 mm (2 to 3 in.)	0.5 to 2 per cent
Organic content: 76.2 to 101.6 mm (3 to 4 in.)	0.5 to 1.5 per cent

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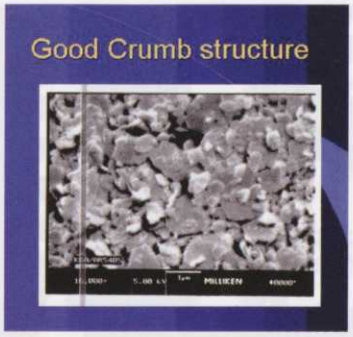

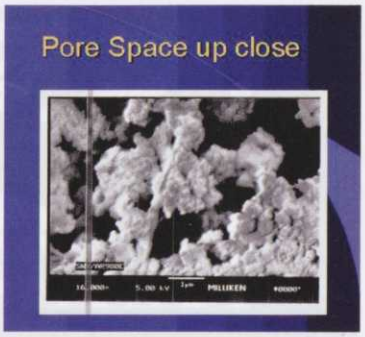

Aeration: Don't let compaction get you down!

"The goal of every turf manager is to produce a healthy, dense sward sustained and supported by a vigorous root system", says Richard Fry...

A good soil should provide the ideal environment for achieving this objective but the forces of compaction, unfavourable climatic conditions and the limits as regards to mechanical 'cultivation' all conspire to impact negatively upon this aim.

The key measure of a good soil structure is its ability to maintain adequate quantities of air, water and nutrients, however, it is the crumb structure and its pore space ratio that holds the key to successful soil management. Soil must have the correct balance of macropores for gravitational water movement and air exchange and enough micropores to hold moisture. At the same time, it is vital that there is an unrestricted capillary action for water to be carried to the plant roots. These pores must be maintained against outside impacts, such as compaction and climate extremes to continue to perform effectively.

IDEAL CRUMB STRUCTURE:

- Open macropores down to the subsurface level - Essential for the rapid removal of gravitational water
- Open macropores to assist root penetration - Roots will 'give-up' when faced with compacted layers
- Closed micropores to hold available moisture 'reservoirs' for plant use - Capillary action delivers water to plant roots and soil surface
- Open pores reduce compaction, perched water table and layering - Aereobic conditions increase microbial activity

Unfortunately, due to the lack of macropores that absorb physical impact, the ideal is rarely achieved as foot and equipment traffic constantly compact the soil. At the same time, due to the build up of fines and lack of effective drainage, saturated soil drives out oxygen and restricts air availability to the roots.

Current techniques for providing a remedy for poor drainage and compaction are well established.

Mechanical aeration is a tried and trusted operation that is very effective over a period of time in that it 'opens' the soil to encourage air and water movement. Nevertheless, this practice does not restore the macropore/micropore ratio in the soil and treats just 5-6% of the surface at any one time.

Wetting agents are effective in providing a 'short term fix' as they alter water tension to allow soil particle 'wetting' and assist the movement of water into and through the soil by allowing moisture to 'squeeze' through cracks in the soil. However, they do nothing to cure the compaction problem itself.

COMPLEMENTARY METHODS

Additional methods of providing relief from compaction and poor drainage are the incorporation of soil amendments and the application of polymeric polyelectrolytes.

In the case of soil amendments, the choice is between mined, silica diatoms marketed under a range of brand names or an engineered Profile ceramic granule. Both are highly porous and can be incorporated into the soil surface following hollow, coring or physically 'drilled' into the soil through a technique called 'drill & fill'. The Profile granule is commonly considered as the more stable in the soil and is specially tailored to match USGA particle size distribution.

When incorporated, these amendments physically improve the soil structure by creating artificial macropores that increase water retention, nutrient holding capacity and high CEC ratios.

The use of water soluble, polymeric polyelectrolytes such as Integrate, pioneered in the UK by Rigby Taylor and Greenlink have been very successful in repairing collapsed pore space and restoring aeration and water percolation.

Applied as a conventional high volume spray, the anionically charged polymer ions in Integrate move down through the soil, penetrating compacted layers and solid soil structures.

This action, solubilises clay and organic 'fines' and, together with the catatonically charged, insoluble magnesium and calcium ions, are drawn together into larger particles (agglomerates), repairing and restoring collapsed pore spaces.

This restoration of closed pores and the 'opening up' and creation of new pore spaces will improve crumb structure and the water/air balance in the soil. The available water is now free to move upwards, downwards and across in the repaired pore spaces, pulling in air and transporting nutrients. New root channels are encouraged and a deeper root system developed leading to a more healthy, vigorous turf.

Neither soil amendments or polymeric polyelectrolytes are seen as replacements for mechanical aeration but should be considered as complimentary treatments that can be 'integrated' into the annual maintenance programme.

Ensuring your Contractor Does Not Become a Handicap

There's far more to selecting a golf course irrigation system than meets the eye. Is it any wonder that many clubs opt to engage a consultant from the design stage through to fruition? Jon Jinks explains why it is possible to have the best of both worlds - the right system, at the right price and save potentially many thousands of pounds on consultants fees.

Let me say at the outset that many golf course officers opt to engage a consultant for peace of mind and I for one can fully understand their rationale, having the highest regard for their expertise and professionalism.

At the end of the day, when the job is done and dusted the manager/committee members will - if the project goes "pear-shaped" - be able to say that he or she consulted an expert. "What more could I have done to ensure that the system would be installed smoothly and efficiently," I can almost hear them say.

Well, it is worth putting the pros and cons into perspective. A significant project costed by a contractor of around £150k, would represent a hefty investment by any club's standards. However, with a consultant on board, the costs don't end there - in addition there is his or her fee - adding a further 10% or so to the total bill.

Peace of mind clearly comes at a price, but I would be the first to acknowledge that it is better to employ a good consultant and incur extra costs, than be left flying 'solo' with a contractor who is not up to scratch.

To avoid this pitfall, select a contractor with a real pedigree. Find out some of the projects they have worked on and check out with the respective golf course managers just how they performed. This will give an insight into the commitment and professionalism of the company and whether disruption to the course was kept to an acceptable level. If any snags arose during the project, ascertain how well these were dealt with at the time and, very importantly, whether the costs escalated, or the contractor kept within, or close to budget.

There are a number of key questions that golf course managers should ask of potential contractors looking to quote on the design, supply and installation of an irrigation management system.

First and foremost while seeking design services or professional advice always look to deal with a company that is covered by PI insurance. This is very important and a good guide to the suitability of the company. In order to qualify for PI insurance, a contractor will need to satisfy some very stringent standards and conditions laid down by the insurance company - as a result very few companies are able to get cover.

Secondly, all work should be guaranteed to at least meet the minimum standards as laid down by the British Turf and Landscape Irrigation Association (BTLIA). Website: www.btlia.org.uk

Thirdly, ensure that when a contractor installs a system he is fully aware of all contractual obligations, including health and safety aspects. Also clarify - at the outset - that they will provide full ongoing maintenance support for the system. (Clearly, it is safer to go with a company that has been successfully trading for a number of years).

Unless a customer selects a knowledgeable company - with inherent integrity - he or she will need to ask the right questions in order to obtain a system capable of meeting their requirements. It is vital to make a contractor aware of the club's medium to long-term needs so that the system can be adapted, or expanded accordingly.

The majority of the full system installations undertaken in Northern Europe, will be to irrigate greens, tees and possibly approaches, while it's only the bigger clubs that can stretch to a full fairway system which can cost as much as £750k.

Fourthly, don't opt for a quote just because it is the cheapest - compare like for like specifications. Conversely, a company may over 'spec' a job in order to cover itself. The system will do the job (and do it well), but a contractor that really understands their clubs needs and is technically adept, may recommend a less expensive system, knowing that it is more than equipped to cope with the needs of the course both now and in the future.

What we do as irrigation specialists is a science. On the face of it, applying water to a crop should be child's play. However, if not applied correctly, grass will not grow properly. Water needs to be distributed evenly and at the correct pressure to ensure that it permeates the ground optimally and reaches the root in the desired quantities.

There are some excellent companies in our industry. Unfortunately there are a substantial number that don't fully appreciate the required science. Yes, they can install pipes, correctly and at the desired depths, but this is an engineering job and everyone in our sector should be able to do that. If they can't, a good analogy would be rather like a house builder unable to lay bricks.

Therefore, my advice to any golf course manager or club official is to do your homework before selecting a contractor, including checking out the satisfaction levels of a number of their customers. By doing this, you will be helping to safeguard your investment and be in a position to select a company that will be capable of meeting your needs.

For further information please contact Jon Jinks, Managing Director of Osprey Irrigation Tel: 01939 236677.

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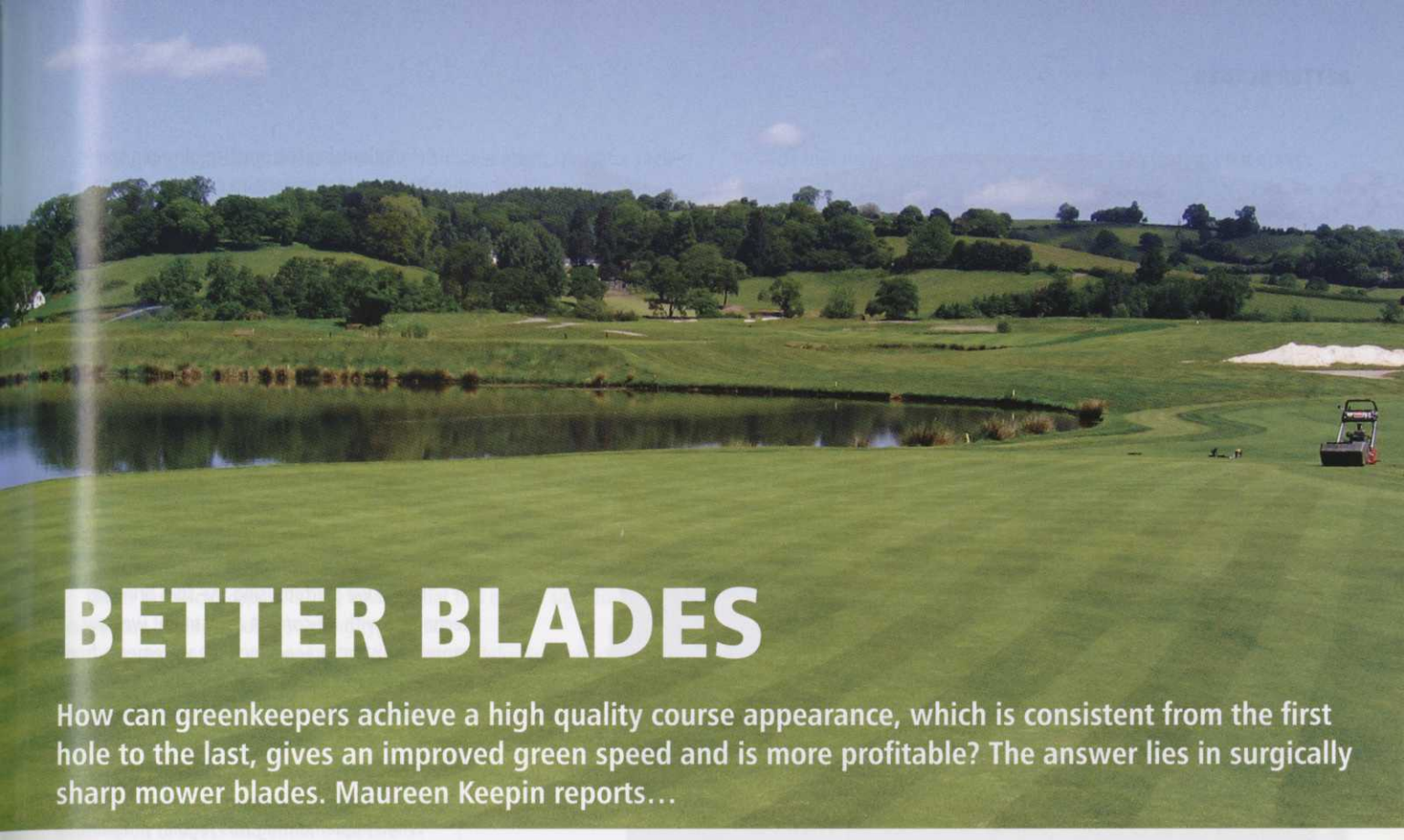


BETTER BLADES

How can greenkeepers achieve a high quality course appearance, which is consistent from the first hole to the last, gives an improved green speed and is more profitable? The answer lies in surgically sharp mower blades. Maureen Keepin reports...

Dramatic changes have taken place within the turf industry in the last decade. With golfers watching tournaments played around the world on lush, striped fairways and smooth, consistent greens, they have come to expect these conditions for every round of golf they play. Is it possible to achieve these playing conditions without having a massive budget and a staff of 50? Yes, it certainly is. Greenkeepers can deliver better course conditions by cutting the grass with surgically sharp, properly adjusted mowing equipment.

It is no surprise that mowers cut best when they are properly set and sharp. However, there are many cultural practices, which take place on the golf course today that are beneficial to turf, but can be harmful to mower blades, such as top dressing and aeration. These impact on the quality of cut.

Grinders operating with speed, simplicity and accuracy have a significant role to play in achieving consistent playing conditions, improving turf health and course appearance.

"The difference sharp blades make to the course is astronomical," says Steven Byrne Course Manager at The Wisley.

"Our grasses on closely mown areas are predominantly creeping bent and annual meadow grass, growing on a very silty soil, with a very low infiltration rate," he says.

"We have very heavy thatch areas, because of the flood plains, so need to apply lots of top dressing and that produces plenty of blunt blades.

"One week we use greens mowers with top dressing units attached and the second week just the greens units.

"We use Express Dual 5000 to sharpen blades and find units can be ground really quickly and soon be back in operation.

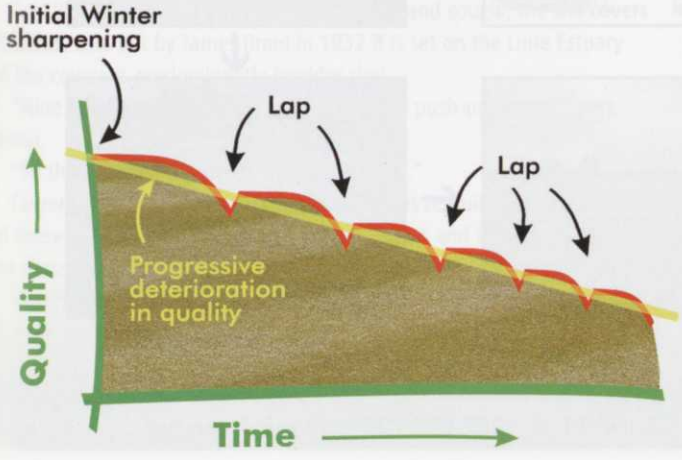
"At this time of year, with heavy dew levels, there is much more possibility of disease so sharp blades become even more vital.

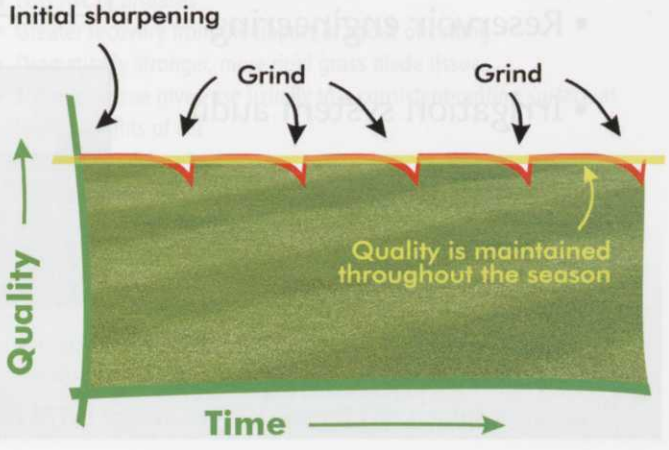
"Members always expect to see lush green Axminster-type turf."

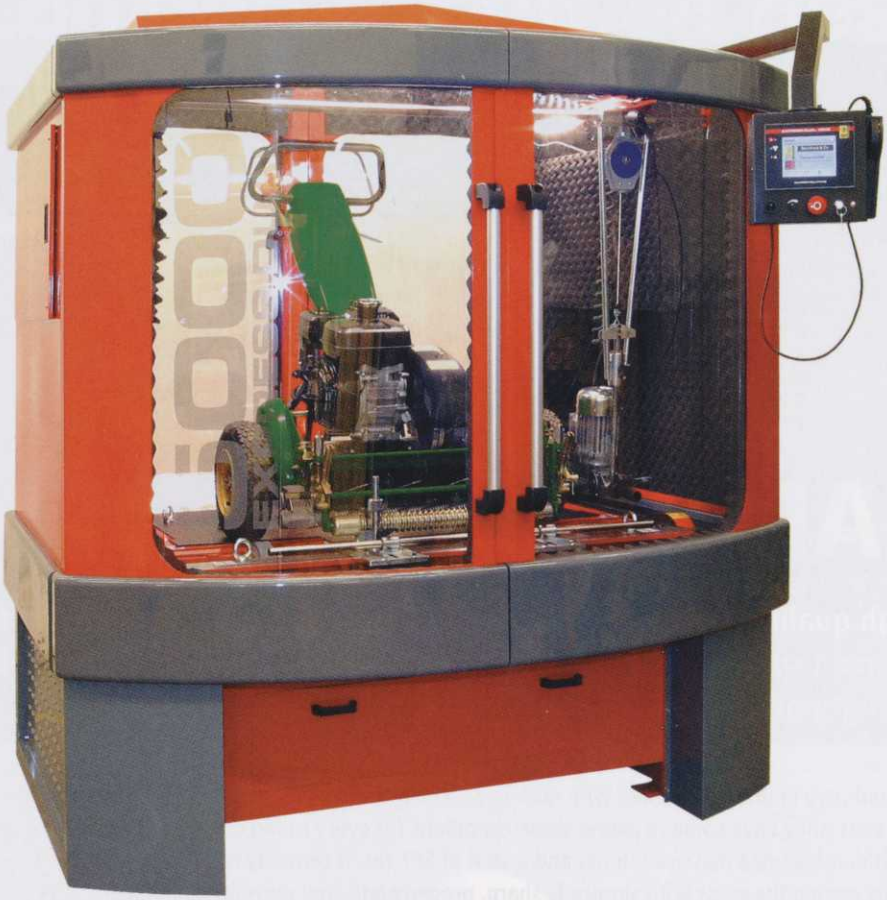
SHARP CUT FOR GREEN SPEED

Greenkeepers adopting a regular grinding programme can achieve consistency from one hole to the next and improve green speed. This is backed-up by extensive research carried out in America.

Mike Morris, Superintendent at Crystal Downs Country Club - one of the US Top 100 golf courses - is quickly becoming known for his green speed research. Mike and Thom Nikolai, PhD at Michigan State University, have been sharing their knowledge with greenkeepers around the world on this complicated subject.







Revolutionising the practice of green speed, they help superintendents to communicate these issues to golfers.

Mike says: "Grinding programmes impact on consistency and playability at several levels.

"First there is the daily cylinder to bottom blade inspection and adjustment, to ensure they are perfectly matched. Then there is the height of cut inspection and adjustment.

"All of these checks are crucial for a consistent, predictable performance from your mowers.

"If the mowers are not set correctly how can you expect the putting surface to exhibit any sort of consistency?

"When we started using the spin grinding technique with no-contact adjustment we saw more consistent green speed measurements from green to green and from day to day," he says.

"Mower sharpening and adjustment was the single factor that we could directly attribute to improved playing conditions when our study began.

"When implementing this regular programme we also discovered an even more rewarding surprise.

"The quality of cut we achieved on our course every day.