transferred into heat in the absorbing material/component. Once the material becomes heated, subsequent release of the heat by conduction or radiation is limited. One way in which this may be achieved is by evaporation from the surface of the component to be cooled, using water as a cooling agent. Evaporation of water is well known as a very effective method of cooling. Nevertheless, a supply of fresh water is required. It must also be clean to prevent smell and bacterial growth in the artificial turf system. This is a problem because of the shortage of clean, fresh water, especially in the hottest areas of the world, which are just the areas where artificial turf can offer a solution to gain a consistent green sport surface.

One system that proposes a method of cooling an artificial turf system is described in JP05-132909. The system comprises water collecting and draining air supply tubes buried vertically and horizontally in the ground. Although the system appears to alleviate at least partially some of the problems of overheating of artificial turf, it would be desirable to provide an alternative structure that provided more uniform air distribution. Another system is known from US 2003/0082359 that proposes a method to control the subterranean environment of a variety of media, including artificial and natural turf surfaces in sports stadiums, gardens, botanical displays, roof-top gardens, and lawns. The system uses modular elements that can allow a fluid to circulate beneath the media.

BRIEF SUMMARY OF THE INVENTION

According to the present disclosure there is provided an artificial turf system defining a playing area, the system comprising: an artificial turf layer; an air distribution layer beneath the turf layer, by which air can be distributed throughout the playing area, the air distribution layer being closed at edge regions defining a periphery of the playing area; an air supply in fluid communication with the air distribution layer; and a flow regulating layer between the air distribution layer and the turf layer, the flow regulating layer being provided with a plurality of openings arranged to allow permeation of air through the turf layer within the playing area. The proposed system allows air to be distributed uniformly over the whole of the playing area for cooling of the turf layer. The air distribution layer may take various forms and will be at least partially dependent on the sport to be performed. In one embodiment, this layer comprises a rigid, open construction. In this context, “rigid” is intended to refer to the fact that the

the turf layer, e.g. by weaving or by tufting. When tufting, extra holes could be easily formed or punched for the openings. The flow regulating layer may also comprise a resilient layer, such as a porous foam layer, an in-fill layer or the like.

In another embodiment, the flow regulating layer may be a sheet of, e.g., plastic material provided with holes. In a further embodiment, the flow regulating layer may be a woven layer, either woven separately or together with the turf layer. The openings may be provided between the yarns of the weave, either by use of a suitably open weave or by varying the weave to leave openings.

As indicated above, the size of the openings in the flow regulating layer will be a primary determinant of the flow through the turf layer. Most artificial turfs are made of a backing layer in which fibers are tufted. A secondary backing of a latex, polyurethane or other dispersion coating is used to fix or hold the fibers into the primary backing layer to avoid fibre pull-out. To ensure drainage capacity to release water from the artificial turf layer, drainage holes of 3 to 6 mm diameter are punched into the backing with a typical spacing of 10 to 15 cm from each other. It has been found that this spacing of drainage holes is too large for use in cooling down the artificial turf because the airflow cannot disperse sufficiently through the turf layer. According to one embodiment of the present disclosure, the openings may be between 0.5 mm and 7 mm in size, preferably between 1 mm and 3 mm in size and more preferably between 1 mm and 2 mm in size. The openings may be of any shape, regular or irregular and including round, triangular, square, rectangular or the like. The size of the openings may be defined as the largest dimension of an individual opening.

The number and spacing of the openings in the flow regulating layer will be a further overall determinant of the flow through the turf. In one embodiment, the openings are spaced from each other by less than 50 mm, preferably by less than 30 mm and more preferably by less than 20 mm but more than 10 mm. In some embodiments, flow could be uniform and well distributed with a number of holes fairly evenly distributed. This can automatically spread the airflow equally with a certain pressure drop. For ease of production and installation, the size and spacing of the openings is preferably uniform over the whole of the playing area. Nevertheless, it is not excluded that there may be a variation in the openings e.g. in order to compensate for pressure variations across the playing area.

In order for a flow of air to be created in the air distribution layer, the air supply may comprise a form of closed connection or manifold that allows the air distribution layer to be in fluid communication with a source of air. There may be a single connection for the whole of the playing area or there may be a plurality of connections around the periphery. In one embodiment, the air supply may comprise one or more blowers and ducting to connect the one or more blowers to the air distribution layer.

In many cases, it will be desirable to supply air to the air distribution layer, which then exits the turf system upwards through the turf layer. Nevertheless, there may be situations where flow in the opposite direction is preferable. The one or more blowers may be reversible to allow air flow both downwards through the openings to the air distribution layer and vice versa.

It has been found that artificial turf systems that are under extreme solar radiation at high outdoor temperatures can be cooled down by flowing air at surrounding temperature through the system to reach acceptable levels under 50 °C. This is because heat transfer is highly dependent on the difference in temperature between the material and the surrounding. If the direct surrounding is constantly refreshed by a forced airflow, the difference in temperature between the hot turf layer and the airflow is constantly at a maximum, leading to higher heat transfer from the surface and a temperature closer to the surrounding air temperature. Furthermore, if the air that is supplied is cooled beneath ambient temperature, it is possible to condensate water on the infill and artificial turf fibres, which can lead to extra cooling and better sliding performance. In many cases, the supply of air to the air distribution layer will itself suffice in providing the necessary cooling to the turf layer. This may at least partially be supplemented by adding moisture to the turf layer to encourage evaporative cooling. Additionally, the air supply may comprise a cooling arrangement to cool the air prior to entry into the air distribution layer. This may be in the form of an air conditioner type unit, an evaporative cooling unit or any other device capable of reducing the air temperature.

In general, the problem described and discussed above is one of keeping a playing area cool under conditions of high solar radiation. According to various embodiments of the present disclosure, the system may also be used for heating of the turf layer should this be required. In regions where the temperature can be below zero for a significant portion of the year, heating system are sometimes installed under the artificial turf structure in

order to prevent the artificial turf structure from freezing. Such heating systems generally consist of conventional water piping systems which may be switched on in October to run to the end of the winter period in order to prevent freezing. During a winter season considerable heat is lost by such a system. Electrical wired systems have also been introduced that are switched on only in periods below zero degrees or even only around the days that the pitch has to be used. These systems are more energy efficient but still use considerable energy. A further problem arises due to the increased use of shock pads beneath the turf that are heat insulating. As a result, heat coming from below the shock pad is hindered from arriving at the turf layer. According to the present disclosure, by providing the air supply with a heating arrangement, the air delivered to the air distribution layer can be heated.

Also, it is found that a frozen artificial turf structure can be heated by flowing heated air through the open construction under the turf structure. For example, air that is heated up to +10 °C can enter the open construction. The heat from below the artificial turf system can flow into the frozen artificial turf system. As the air in the distribution layer is refreshed constantly, the frozen artificial turf structure will melt in time. The water from molten ice and/or snow can be collected in the open construction and transported away from the field for functional usage.

The playing area may be a single region in terms of the air distribution, whereby the air distribution layer extends uninterrupted over the whole playing area. This may be suitable for relatively small playing areas but for larger areas such as for a full sized football pitch, it may be preferable to divide the playing areas into zones or regions that are individually supplied with air. It will be understood that each zone may in itself be considered a playing area. In one embodiment, the air distribution layer is divided into a plurality of separate regions within the playing area and ducting may be provided to connect the separate regions, each, respectively to its own fan, blower or source of air.

According to one embodiment, the air distribution layer may be closed around the periphery of the playing area by a curb. In order to prevent air leaking between the curb and the flow regulating layer, the flow regulating layer may be sealed to the curb by appropriate provisions such as tape or the like.

Temperature and airflow control can be arranged by temperature sensors in the field or by infra-red camera systems that monitors the surface temperature and controls the air volume and temperature thereof which is send to the corresponding zones of the field.

The present disclosure also relates to a method of active cooling of a playing area in an artificial turf system, the method comprising: providing an air distribution layer, by which air can be distributed throughout the playing area, the air distribution layer being closed at edge regions defining a periphery of the playing area; providing a flow regulating layer over the air distribution layer, the flow regulating layer being provided with a plurality of openings arranged to allow passage of air; providing a turf layer over the flow regulating layer; connecting an air supply in fluid communication with the air distribution layer; and operating the air supply to cause air to flow through the air distribution layer and through the openings to cool the playing area.

The amount of air flow may be calculated according to the cooling effect required. In general the air supply may be operated to cause a flow outwards through the openings at an average rate over the playing area of between 0.001 m/s and 0.5 m/s, preferably between 0.05 m/s and 0.25 m/s and more preferably between 0.01 m/s and 0.1 m/s. Alternatively, the air supply may be operated to cause a flow inwards through the openings at an average rate over the playing area of between 0.001 m/s and 0.5 m/s, preferably between 0.05 m/s and 0.25 m/s and more preferably between 0.01 m/s and 0.1 m/s. The above values are average values over the relevant surface and represent cubic metres per second of air flow per square metre of surface area.

The method may also comprise maintaining an overpressure within the air distribution layer, with respect to atmospheric pressure, of between 0.01 and 5 bar, more preferably between 0.05 and 1 bar. By having a relatively large volume within the air distribution layer compared to the volumetric flow through the turf layer, a relatively uniform overpressure throughout the playing area can be maintained.

The present disclosure still further relates to an air distribution arrangement for an air permeable artificial turf layer, the air distribution arrangement comprising an air distribution layer forming a volume delimited at an upper side by the artificial turf layer and an air supply for creating an overpressure within the volume, such that air can escape from the volume through the artificial turf layer to cause cooling thereof.

The air distribution layer may be as described above or hereinafter and may be closed at edge regions to define a periphery of a playing area. Still further the air supply may also be as defined above or hereinafter and may comprise ducting connected to the air distribution layer at edge regions thereof, for connection to appropriate blowers or similar providers of a flow of air.

In view of the above, according to an aspect of the present disclosure, there is provided an artificial turf system defining a playing area. The system comprises: an artificial turf layer; an air distribution layer beneath the turf layer, by which air can be distributed throughout the playing area, the air distribution layer being closed at edge regions defining a periphery of the playing area; an air supply in fluid communication with the air distribution layer; and a flow regulating layer between the air distribution layer and the turf layer, wherein the flow regulating layer is a backing layer having artificial grass fibres directly attached thereto by weaving or tufting to form the turf layer and a plurality of openings being arranged through the backing layer to allow permeation of air through the turf layer within the playing area wherein the openings in the backing layer are between 0.5 mm and 7 mm in size and are spaced from each other by less than 50 mm but more than 5 mm.

According to another aspect of the present disclosure, there is provided a method of active cooling of a playing area in an artificial turf system as described herein. The method comprises: providing an air distribution layer, by which air can be distributed throughout the playing area, the air distribution layer being closed at edge regions defining a periphery of the playing area; providing a flow regulating layer over the air distribution layer, the flow regulating layer being provided with a plurality of openings arranged to allow passage of air and having artificial grass fibres directly attached thereto by weaving or tufting to form an artificial turf layer; connecting an air supply in fluid communication with the air distribution layer; and operating the air supply to cause air to flow through the air distribution layer and through the openings to cool the playing area.

CLAIMS:

1. An artificial turf system defining a playing area, the system comprising:

an artificial turf layer;

an air distribution layer beneath the turf layer, by which air can be distributed throughout the playing area, the air distribution layer being closed at edge regions defining a periphery of the playing area;

an air supply in fluid communication with the air distribution layer; and

a flow regulating layer between the air distribution layer and the turf layer, wherein the flow regulating layer is a backing layer having artificial grass fibres directly attached thereto by weaving or tufting to form the turf layer and a plurality of openings being arranged through the backing layer to allow permeation of air through the turf layer within the playing area wherein the openings in the backing layer are between 0.5 mm and 7 mm in size and are spaced from each other by less than 50 mm but more than 5 mm.

2. The system according to claim 1, wherein the air distribution layer comprises a rigid, open construction.

3. The system according to claim 1, wherein the air distribution layer comprises a plastic crate type structure.

4. The system according to claim 1, wherein the air distribution layer comprises an open, resilient layer.

5. The system according to claim 1, wherein the air distribution layer has a height of between 0.5 cm and 50 cm, preferably between 4 cm and 20 cm.

6. The system according to claim 1, wherein the flow regulating layer is a backing layer in which the artificial grass fibres are woven to form the turf layer.

7. The system according to claim 1, wherein the openings in the flow regulating layer are between 1 mm and 3 mm in size and more preferably between 1 mm and 2 mm in size.

8. The system according to claim 1, wherein the openings in the flow regulating layer are spaced from each other by less than 30 mm and more preferably by less than 20 mm.

9. The system according to claim 1, wherein the flow regulating layer is a woven layer.

10. The system according to claim 1, wherein the flow regulating layer is a non-woven into which the artificial grass fibres are tufted.

11. The system according to claim 1, wherein the air supply comprises one or more blowers and ducting to connect the one or more blowers to the air distribution layer.

12. The system according to claim 11, wherein the one or more blowers is reversible to allow air flow both through the openings to the air distribution layer and vice versa.

13. The system according to claim 11, wherein the air distribution layer is divided into a plurality of separate regions within the playing area and the ducting connects to the separate regions.

14. The system according to claim 1, wherein the air supply comprises a heating arrangement.

15. The system according to claim 1, wherein the air supply comprises a cooling arrangement.

16. The system according to claim 1, wherein the air distribution layer is closed at its edge regions by a curb.

17. A method of active cooling of a playing area in an artificial turf system according to claim 1, the method comprising:

providing an air distribution layer, by which air can be distributed throughout the playing area, the air distribution layer being closed at edge regions defining a periphery of the playing area;

providing a flow regulating layer over the air distribution layer, the flow regulating layer being provided with a plurality of openings arranged to allow passage of air and having artificial grass fibres directly attached thereto by weaving or tufting to form an artificial turf layer;

connecting an air supply in fluid communication with the air distribution layer; and

operating the air supply to cause air to flow through the air distribution layer and through the openings to cool the playing area.

18. The method of claim 17, comprising operating the air supply to cause a flow outwards through the openings at an average rate over the playing area of between 0.001 m/s and 0.5 m/s, preferably between 0.05 m/s and 0.25 m/s and more preferably between 0.01 m/s and 0.1 m/s.

19. The method of claim 17, comprising operating the air supply to cause a flow inwards through the openings at an average rate over the playing area of between 0.001 m/s and 0.5 m/s, preferably between 0.05 m/s and 0.25 m/s and more preferably between 0.01 m/s and 0.1 m/s.

20. The method of claim 17, comprising maintaining an overpressure within the air distribution layer, with respect to atmospheric pressure, of between 0.01 and 5 bar, more preferably between 0.05 and 1 bar.