CONTROLLED ENVIRONMENT HEAT TREATMENT AS A SAFE AND EFFICIENT METHOD OF PEST CONTROL

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Abstract—Environmental and health concerns have caused a radical change in the popular perception of chemical pest control methods. Governmental and environmental agencies seek to further limit the uses of chemicals in areas that have, till now, accepted them as routine treatments.

As an example, the German Dangerous Substances Act requires that 'toxic gases may no longer be employed if a toxin free procedure is effective and reasonable.'

Here in the UK, if we are to be realistic, we must also anticipate a general move in this direction.

These concerns have led to the development of what are essentially two new processes, and a third which uses an amalgamation of the others. Designed to treat insect pests in objects these treatments are thermal with controlled humidity, inert gas "fumigation" and the modified inert atmosphere method.

INTRODUCTION

The treatment and restoration of rare and valuable objects, in a sensitive and non invasive way, is a priority for anyone concerned with conservation. Insect pests account for much loss and damage every year and are partly responsible for the slow erosion of our cultural heritage (Pinniger, 1994). Buildings of architectural value are equally affected both in the country and in the urban environment.

In the field of building preservation a hot air method has been applied successfully for several decades. Using high pressure heated air the temperature of roof timbers and building frames can be raised to over 55°C. At such temperatures animal protein within the insect cell becomes irreversibly denatured resulting in death (Strang, 1992). The main problem encountered in applying this sound biological principle to the treatment of high value works of art, antiques etc. has been the resultant dehydration of the piece. This has caused shrinkage and cracking and leads to irreversible damage (Strang, 1995).

The eradication of insect pests in such a sensitive area requires a method which includes precise control over all the environmental parameters. This is especially true of the relative humidity.

METHODS AND MATERIALS

The development task was to find a treatment which could:

1. Guarantee the destruction of the insect pest at all stages of development.
2. Prove completely harmless to the subject whilst posing no health or environmental risk.
3. Be flexible enough to allow for a treatment tailored to the task as well as the value, importance and condition of the subject.

THE THERMAL TREATMENT METHOD

The thermal solution is the technically refined version of the previously discussed heat treatment. A chamber was designed in which infested objects could be placed and the environment modified precisely by computer. In both the warming up and cooling down phases of the treatment the relative humidity is controlled in such a way as to ensure that the humidity balance is maintained. As a result no dehydration can occur.

The patented Thermo Lignum process is currently being used commercially to treat a variety of organic materials such as furniture, textiles, herbaria, books, manuscripts, silks and leathers. It is suitable for antiques and museum exhibits (Pinniger, 1995) and being used in the treatment of *in-situ* timbers such as roof trusses and timbered buildings.

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THE INERT GAS FUMIGATION METHOD

The use of inert gases was pioneered in the commodities area and has been successfully applied in this sector for a few years (Piening, 1995). First trials to use inert gases in a museum context were undertaken in the USA and in Australia in 1988. The effect of this method lies in its ability to deprive the insects of oxygen by displacing it with other, inert, gases. As a consequence, the metabolism of the insect in all stages of its lifecycle breaks down.

In principle all gases are suitable for displacing oxygen in a closed system. However, only those which have no negative effect on the subject can be used practically and these must be safe to handle. As a result only nitrogen and carbon dioxide along with precious gases such as argon can be considered. For reason of cost, only nitrogen or carbon dioxide, or a combination of both, is viable.

The key disadvantage is, however, that part of the carbon dioxide reacts with water to form carbonic acid. This is regardless of whether the water is present in free form or found within the mass of the object. Depending on the moisture present pigments and binders can be altered due to the acidity of the carbonic acid.

Another very important feature of purely gas treatment is the need to control their initial humidification as from the cylinder gases have a moisture content of almost 0%.

Unmodified application would immediately dehydrate the objects to be treated which, in turn, would lead to drying and shrinkage. By means of controlled humidification it is possible to maintain a climate which conforms to that in which these objects are normally kept.

MODIFIED INERT ATMOSPHERES

The advantage of inert gas fumigation is how gentle it is to sensitive objects. Its disadvantage lies in very long treatment times, generally in excess of a month. During this extended period all relevant values such as that of oxygen reduction, climatic parameters, etc., have to be maintained. In particular airtightness is a decisive factor in the cost of such a treatment as leakage impacts on gas usage. In order to maintain a 1% residual oxygen level, each penetrating m^3 of oxygen has to be displaced again by 100 m^3 of gas. If, as some insist, an even lower residual oxygen level has to be maintained, an economical application of this method is no longer possible.

A 0.2% level in the unit would require a displacement ratio of 1:1000! This could only be done for very small objects or in completely sealed steel chambers. An application to larger objects, particularly *in situ*, would thus be unthinkable.

The total solution to these problems must lie in an amalgamation of both of these methods.

By adding a small quantity of CO_2 to the Nitrogen the reaction time is further reduced because in this concentration, the CO_2 has a stimulating effect on the insects' metabolism and prevents a lapse into a diapause. The amount of CO_2 added is not sufficient, even with high humidity conditions, to affect pigments or binders.

To maximise the desired effect and to shorten the treatment time to an economically viable level the addition of temperature modification comes into play. With every rise in temperature of 1°C the process time decreases. At 38°C total time has reduced to just one week. The combination of warmth and controlled humidity offers a shorter application time to the purely inert gas treatment and, at the same time, a possible reduction of temperature levels for extremely fragile objects.

RESULTS

This technology provides a totally object-focussed and flexible method of pest eradication. The user can decide for himself whether he wants to have the object treated by a purely thermal process, inert fumigation at room temperature, or a combination of both.

Completely new systems were developed to make this concept workable in practice. Suitable measuring and control technologies were selected as well as an intelligent system management unit to control these complex physical, climatological and technical processes in an integrated and largely labour-free way.

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DISCUSSION

Thermal pest treatment with humidity-controlled warm air is currently applied in climatic chambers. It is fast, safe and economically sound. Inert fumigation requires a completely airtight system and relatively long treatment times. This greatly limits its range of applications but makes it a very gentle method for the object.

The use of modified inert atmospheres as an amalgamation of both of the above processes, eliminates any disadvantages.

Because of the careful design of the application technology it is now possible to adapt this method to the individual conditions and requirements (Child, 1994) of both the restorer/ conservator and the object to be treated. It can be used for in-situ applications both in rooms and now for entire buildings.

Further development and feedback has suggested other, more widespread, applications for this process and research continues.

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