(12) UK Patent Application (19) GB (11) 2 437 320 (13) A

(43) Date of A Publication 24.10.2007

(21) Application No: 0607702.8

(22) Date of Filing: 19.04.2006

(71) Applicant(s):
Eve Group Limited
(Incorporated in the United Kingdom)
Babcock International Group plc,
2 Cavendish Square, LONDON, S1G 0PX,
United Kingdom

(72) Inventor(s):
David Chesney
Matt Staley

(74) Agent and/or Address for Service:
Harrison Goddard Foote
Fountain Precinct, Balm Green,
SHEFFIELD, S1 2JA, United Kingdom

(51) INT CL:
G06F 17/00 (2006.01) ***G06Q 10/00*** (2006.01)

(52) UK CL (Edition X):
G4A AUB AUXB

(56) Documents Cited:
WO 2001/031494 A2 **US 6195624 B1**

(58) Field of Search:
Other: **Online: EPODOC, INSPEC, NPL, WPI, XPESP**

(54) Abstract Title**: Monitoring corrosion degradation**

(57) A method for monitoring the corrosion degradation of above-ground outdoor situated metal structures comprises the steps of :
calculating an annual corrosion index from environment data pertaining to the asset being monitored; combining said corrosion index with asset data pertaining to the asset being monitored to produce a corrosion degradation rate; using uncertainty modelling e.g. Monte Carlo analysis, and the corrosion degradation rate to calculate the probable degradation of the asset to date and/or in the future. The environmental data may include factors such as temperature, humidity, wind speed and direction, distance or proximity from sea, land, road (chlorides), pollution (e.g.SO_2, NO_x, O_3 data). Asset data may include, year of construction/installation, materials used, galvanising layer thickness, thickness of coating (e.g. paint). The invention can give an indication of lifespan of an outdoor asset or structure which can be used by a maintenance program to prioritise maintenance schedules. The invention may be used for monitoring electricity transmission towers, mobile communication masts.

GB 2 437 320 A

2437320

MONITORING METHOD

This invention relates to the field of methods for monitoring the condition and lifespan of above-ground outdoor-situated metal structures (preferably steel), for example electricity transmission towers, mobile communications masts and the like, which are subjected to weather and other environmental factors which cause corrosion degradation affecting their useful lifespan.

BACKGROUND

The term "asset" is used to designate any outdoor-situated structure containing metal to which the present invention may apply and includes, without limitation, electricity transmission towers, communication towers, masts and flare stacks.

The term "tower" is used as a non-limiting example of a type of asset to which the present invention may apply.

Assets such as electricity transmission towers have a finite lifespan over which the structural condition of the asset degrades until eventually, if left unattended, the asset would fail. To avoid the potentially catastrophic consequences of a tower failure (especially if, for example, if the tower concerned was supporting an electricity supply conductor over a motorway or railway line), a maintenance program of assessing the condition, repairing and replacing towers where necessary is implemented. However, given the extent and number of towers in an electricity supply network, it is difficult to prioritise those towers which need most urgent attention by any means other than simply the age of the tower and the period of time since its last maintenance or thorough inspection. This is often too simplistic an approach, especially given the cost involved in replacing any one tower.

The main threat to the lifespan of a tower is degradation of the materials from which it is constructed caused by the action of a combination of environmental factors. This is a simplistic approach given that the degradation rate is dependent on environmental factors that can change with both time and location (i.e. are not purely age-dependent).

It is therefore desirable to provide a method of monitoring the condition of assets utilising data relating to environmental factors in order to forecast future degradation rates and the lifespan of the asset.

One means of measuring the degradation of a steel transmission tower is by monitoring the condition of the zinc plating thereon. A system is known for monitoring the aged deterioration of zinc plating on steel transmission towers, in which environmental factors for a particular region in which the plated structure is located are taken into account. The deterioration progression of plated structures is managed by observing the deterioration of plated structures and placing these on a map, selecting plated structures that can be considered to have roughly the same corrosion environment, taking into account environmental factors, and then calculating a selected region's deterioration progression speed from the selected plated structures' (actual) deterioration diagnosis results. The results can then be used to identify anticipated repair times for plated structures in the particular regions.

This system has limitations, in that it only considers the degradation of the zinc plating layer (and not the underlying steel structure). The visual condition of the zinc plating may be misleading as to the integrity of the underlying steel structure. If the visual condition of the Zinc shows Zinc that is intact/remaining then the structural integrity of the underlying steel is not compromised. If Zinc has been removed then the structural integrity of steel is compromised, but the degree of compromise is not known. Furthermore, the system's granularity is limited since it categorises all of the plated structures into one of only 5-7 possible types of "regions". Its accuracy is limited since the system is based on statistical extrapolation of site inspection data.

It is therefore desirable to provide an improved monitoring method which seeks to alleviate the above-described problems.

SUMMARY OF THE INVENTION

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

According to a first aspect of the invention there is provided a method of monitoring the corrosion degradation of above-ground outdoor-situated metal structures ("assets"), comprising the steps of:

calculating an annual corrosion index from environmental data pertaining to the asset being monitored ;

combining said corrosion index with asset data pertaining to the asset being monitored to produce a corrosion degradation rate;

using uncertainty modelling and the corrosion degradation rate to calculate the probable degradation of the asset to date and/or in the future.

Preferably, the method further comprises the steps of:

calculating an annual time of wetness index from time of wetness factors pertaining to the asset being monitored;

calculating an annual pollution index from pollution factors pertaining to the asset being monitored;

calculating an annual chloride index from chloride factors pertaining to the asset being monitored;

wherein said time of wetness index, said pollution index and said chloride index comprise the environmental data from which said annual corrosion index is calculated.

In a preferred embodiment, said time of wetness factors comprise one or more of the following: daily average temperature, daily average relative humidity, daily dew point, current weather conditions, wind speed, distance of said asset from the sea, other water or hills.

Preferably, said pollution factors comprise one or more of the following: SO_2 data, NO_x data, O_3 data.

Preferably, said chloride factors comprise one or more of the following: measured chloride data, distance of said asset from the sea, distance of said asset from a trunk road.

In a preferred form, said uncertainty modelling includes Monte Carlo analysis.

Preferably, said asset data pertaining to the asset being monitored comprises one or more of the following: date of construction or installation; material; construction method used; thickness of galvanising layer if any; type, thickness and age of coating, if any.

Preferably, said degradation is displayed graphically and the method may include the step of displaying said probable degradation on a map or other visual representation of the assets being monitored.

Preferably, said probable degradation is displayed in terms of a 90%, a 50% and a 10% likely outcome.

Advantageously, said probable degradation is calculated and displayed for a plurality of assets and may be used to predict the lifespan of the asset and/or to plan a maintenance schedule for a plurality of assets.

Preferably, said probable degradation is compared with degradation data observed at the site of the asset, in order to verify the calculation of the probable degradation.

In a preferred embodiment, said metal structures are steel assets relating to rail, power and/or telecommunications.

According to a second aspect of the invention there is provided a computer program comprising instructions for performing the method of any of the preceding paragraphs.

According to a third aspect of the invention there is provided a computer program product comprising a computer-readable medium storing a computer program as described in the previous paragraph.

In this way, long-standing information records for weather, pollution and other environmental factors can be used to calculate degradation rates and forecast future degradation of assets. This enables the asset owner to plan a long-term maintenance program which prioritises the assets in need of most urgent attention and predicts those which will need attention according to the relevant environmental factors.

DETAILED DESCRIPTION

Corrosion is the destructive disintegration of a metal caused by electrochemical means. For an asset constructed from metal, the corrosion degradation rate is a measure of the loss of metal thickness from the asset per year (measured in microns/year). The factors affecting the corrosion degradation rate for an asset can be divided into two categories, namely "environmental data" and "asset data". A non-exhaustive illustrative list of these factors is given below:

Environmental Data (i.e. pertaining to the geographical location in which the asset is situated):

- Temperature
- Relative humidity
- Pollution (e.g. SO_x, NO_x, Ozone)
- Wind speed and direction (causing drying effects)
- Proximity of asset to water, roads, sea (chlorides)
- Proximity of asset to heavy industry (pollution)
- Location of asset in relation to hills (solar gain)

Asset Data (i.e. pertaining to the individual asset concerned):

- Year of construction/installation
- Material (e.g. whether carbon steel, galvanised etc)
- Construction method used (e.g. type of joints)
- Galvanising layer thickness
- Type and thickness of coating (e.g. paint)
- Age of coating (e.g. paint)
- Number of times that coating (e.g. paint) has been applied.

As expected, there is a correlation between the corrosion condition of an asset and its geography i.e. the environmental factors to which it is subjected, however a simplistic application of this correlation (as described in the prior art method of monitoring plated structures) has significant weaknesses. In particular, a broad application of the correlation to a region containing many towers means that towers showing the greatest level of corrosion damage may not be selected for individual inspection or maintenance. Addition of further factors to the model (e.g. proximity to rivers) would still result in a strongly circumstantial output. Even if it is expected that a particular region has a more corrosive environment than another, this does not mean that a particular individual tower is corroding or will corrode. The risk that individual badly corroded towers are overlooked would remain, with such generalisation.

The present invention seeks to alleviate these problems by using degradation modelling which applies both science and risk engineering to the deterioration of the assets.

For each year and each tower that the model is run, the same process is applied. Initially, the model defines the corrosivity of the local environment of the tower and then it considers the maintenance history of the specific tower of interest. This is detailed in the following procedure.

I: Defining the Corrosivity of the Local Environment

1. A chloride index is determined based upon the distance to sea and distance to major roads.

2. A pollution index is determined based upon the local concentration of pollutants in the atmosphere. This is obtained from the pollutant monitoring station with data that is located closest to the tower of interest.

3. A percentage time of wetness is determined based upon the local humidity and temperature of the atmosphere. This is obtained from the weather monitoring station with data that is located closest to the tower of interest.

4. The time of wetness is increased by a factor based upon the proximity of the tower to various water sources. This is used to determine a time of wetness index.

5. A corrosivity index is assigned based upon the indices defined above. This index will be used to determine the corrosion rate and hence the metal loss for the specified year.

However, next the model considers the maintenance history of the tower of interest.

II: Defining the Effect of the Maintenance History for Each Tower

6. If the surface of the tower has been painted in the year of interest, the compatibility of the paint type is cross-referenced against previous coating layers and the estimated paint life is altered accordingly.

7. If there is no painting activity in the year of interest, the model determines the surface that is exposed in the year previous to that of interest. This is achieved by considering a) if the exposed surface was painted in the previous year, b) the remaining coating life and c) the number of years for which bare metal has been exposed.

8. If the exposed surface is either carbon steel or zinc the appropriate loss of section is applied to the existing surface. However, if the exposed surface is paint, its life is output by the probability model of paint durability and the metal loss assigned to this, and each year for which the paint remains, is zero.

9. The model considers the elevation of the tower and applies the corresponding multiplication factor to the metal loss in each year.

10. For each year, an inverted S-curve is developed which is indicative of the probability of cumulative metal loss resulting from the previous year's activity.

11. The cumulative metal loss for which there is a 10%, 50% and 90% chance of occurrence is output as the cumulative probability P(10), P(50) and P(90), for each year.

12. The S-curves are combined year on year, for each tower, to produce a single plot for the cumulative metal loss against probability.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A method of monitoring the corrosion degradation of above-ground outdoor-situated metal structures ("assets"), comprising the steps of:

calculating an annual corrosion index from environmental data pertaining to the asset being monitored ;

combining said corrosion index with asset data pertaining to the asset being monitored to produce a corrosion degradation rate;

using uncertainty modelling and the corrosion degradation rate to calculate the probable degradation of the asset to date and/or in the future.

2. A method as claimed in claim 1 further comprising the steps of:

calculating an annual time of wetness index from time of wetness factors pertaining to the asset being monitored;

calculating an annual pollution index from pollution factors pertaining to the asset being monitored;

calculating an annual chloride index from chloride factors pertaining to the asset being monitored;

wherein said time of wetness index, said pollution index and said chloride index comprise the environmental data from which said annual corrosion index is calculated.

3. A method as claimed in claim 2 wherein said time of wetness factors comprise one or more of the following: daily average temperature, daily average relative humidity, daily dew point, current weather conditions, wind speed, distance of said asset from the sea, other water or hills.

4. A method as claimed in claim 2 or claim 3 wherein said pollution factors comprise one or more of the following: SO_2 data, NO_x data, O_3 data.

5. A method as claimed in any of claims 2-4 wherein said chloride factors comprise one or more of the following: measured chloride data, distance of said asset from the sea, distance of said asset from a trunk road.

6. A method as claimed in any of the preceding claims wherein said uncertainty modelling includes Monte Carlo analysis.

7. A method as claimed in any of the preceding claims wherein said asset data pertaining to the asset being monitored comprises one or more of the following: date of construction or installation; material; construction method used; thickness of galvanising layer if any; type, thickness and age of coating, if any.

8. A method as claimed in any of the preceding claims further comprising the step of displaying said probable degradation on a map or other visual representation of the assets being monitored.

9. A method as claimed in any of the preceding claims wherein said probable degradation is displayed graphically.

10. A method as claimed in any of the preceding claims wherein said probable degradation is displayed in terms of a 90%, a 50% and a 10% likely outcome.

11. A method as claimed in any of the preceding claims wherein said probable degradation is calculated and displayed for a plurality of assets.

12. A method as claimed in any of the preceding claims wherein said probable degradation is used to predict the lifespan of the asset.

13. A method as claimed in any of the preceding claims wherein said probable degradation is used to plan a maintenance schedule for a plurality of assets.

14. A method as claimed in any of the preceding claims wherein said probable degradation is compared with degradation data observed at the site of the asset, in order to verify the calculation of the probable degradation.

15. A method as claimed in any of the preceding claims wherein said metal structures are steel assets relating to rail, power and/or telecommunications.

16. A method of monitoring the corrosion degradation of outdoor-situated metal structures ("assets") substantially as described herein.

17. A computer program comprising instructions for performing the method of any of claims 1-9.

18. A computer program product comprising a computer-readable medium storing a computer program as claimed in claim 17.

12

Application No: GB0607702.8 | Examiner: Kalim Yasseen
Claims searched: 1-18 | Date of search: 4 July 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	at least 1, 6	WO01/31494 A2 (3M INNOVATIVE) see whole document especially page 9 line 3 to page 10 line 16, page 20 line 8 to page 21 line 22
Y	at least 1, 6	US6195624 B1 (COMBUSTION ENGINEERING) see whole document especially col. 1 lines 8-26, col. 2 lines 27-67

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

Online: EPODOC, INSPEC, NPL, WPI, XPESP