Intellectual Property Office

BL O/124/16

07 March 2016.

PATENTS ACT 1977

APPLICANT Emerson Process Management Power and Water Solutions Inc.

ISSUE Whether GB 1011185.4 and GB1500021.9 comply with Section 1(2) of the Patents Act 1977

HEARING OFFICER C L Davies

DECISION

Introduction

1 Patent Application GB 1011185.4 was filed in the name of Emerson Process Management Power and Water Solutions Inc. in the UK on 2nd July 2010 claiming priority from US patent application 12/501262 having a priority date of 10th July 2009. It was published as GB 2471758.

2 Patent Application GB 1500021.9 is a divisional application derived from GB 1011185.4. Ante-dating was allowed and accordingly it shares the priority date of 10th July 2009. It was published as GB 2518783.

3 In both instances the examiner has raised an objection that the applications are excluded under Section 1(2)(c) of the Act. There being no agreement with the attorney the matter came before me at a hearing on 25th January 2016. The applicant was represented by Russell Sessford and Stephanie Thomas of Forresters. I was assisted by Nigel Hanley and the hearing was also attended by the Examiner Fraser Stewart and an observer, Examiner Alun Owen.

The Applications

4 Both applications concern a model for use in modelling a process control system. These model a system and can be used to observe the effects changes to the system may have. These changes, amongst others, may be new or replacement equipment or simply allowing for the aging of existing equipment. However, these effects often cannot be modelled correctly without some form of adjustment or compensation factor.

5 To facilitate this the parent application, GB 1011185.4, provides an error model that uses test values from the industrial process system and model test values then applies a number of “prediction equations” to express the relationship between the

two sets of input data. This produces an “error model” that is then used in the model to simulate the effect of changes to the system.

6 GB 1500021.9 is, as one would expect, not dissimilar to the parent application. In this instance a number of prediction equations are used to model the relationship between the inputs and outputs of the system. Optimising these equations allows the production of an error model that can be used to compensate the model and hence allow the effects of changes to inputs, the process or equipment can have on the system to be gauged.

Issues to be Decided

7 The issue before me is whether the two applications comply with Section 1(2)(c) as being a computer program. However I note that in both cases there remain outstanding issues that will require me to remit the applications back to the examiner for continued processing should I find in the applicants favour.

8 I am grateful to Mr Sessford for proposing that the hearings on both cases be held together given the obvious similarity in subject matter and for skeleton arguments filed on 18th January 2016.

Some Preliminary Issues

Compliance Date

9 In the processing of the applications it was recognised by the attorney that they would need to extend the compliance period by filing a Form 52 and the associated fee which they duly filed on 12th November 2015. In normal circumstances this would have extended the compliance date to 11th January 2016. However, due to an administrative error in the office the date was actually extended to 27th January 2016. Such extensions are at the discretion of the IPO and I see no reason in this case to change that date. Therefore the current compliance date is set at 27th January 2016. Given that the hearing was held on the 25th January further extensions may be sought by the applicant to allow them time to amend the case should I find in their favour.

Auxiliary Claims

10 The applicant filed amended main claims and a set of auxiliary claims along with his skeleton argument on 18thJanuary 2016 for consideration at the hearing. Copies of these claims can be found at Annex A (GB1011185.4) and Annex B (GB 1500021.9).

11 It is my understanding that the main request on GB 1011185.4 is correcting a minor error in claim 12 and its associated statement of invention. An error was also corrected in the paragraph numbering. The main request on GB 1500021.9 had deleted omnibus claims, claims 9 and 10. I do not believe anything turns on these amendments so will make no further observations.

12 The auxiliary requests on both applications have amended the independent claims to refer to “determining” rather than “modelling”. This presents a minor problem to resolve. If “determining” and “modelling” have the same meaning then there is really no issue to resolve but if they are different there would appear to be an issue of

added matter to deal with. In this regard Mr Sessford made clear at the hearing that "determining" and "modelling" should be regarded as having the same meaning and it was the applicant's intention to use "determine" to closer link the models to the running of a plant process.

13 Taking this view into account and my own understanding of the applications I do not see the need to dwell on this issue. As far as I am concerned, as the attorney has confirmed the meaning of "modelling" and "determining" to be interchangeable in these applications, it has no effect on my overall decision in this matter.

The Law

14 The examiner raised objections under section 1(2) of the Patents Act 1977 that both applications are not patentable because they relate inter-alia to one or more categories of excluded matter. The relevant provisions of this section of the Act are shown in bold below:

> *1(2) It is hereby declared that the following (amongst other things) are not inventions for the purpose of the Act, that is to say, anything which consists of –*
>
> *(a) a discovery, scientific theory or mathematical method;*
>
> *(b) a literary, dramatic, musical or artistic work or any other aesthetic creation whatsoever;*
>
> *(c) a scheme, rule, or* method for *performing a mental act, playing a game or doing business, or* ***a program for a computer****;*
>
> *(d) the presentation of information;*
>
> *but the foregoing provisions shall prevent anything from being treated as an invention for the purposes of the Act only to the extent that a patent or application for a patent relates to that thing as such.*

15 As explained in the notice published by the UK Intellectual Property Office on 8th December 2008[1], the starting point for determining whether an invention falls within the exclusions of section 1(2) is the judgment of the Court of Appeal in *Aerotel/Macrossan*[2].

16 The interpretation of section 1(2) has been considered by the Court of Appeal in *Symbian*[3]. *Symbian* arose under the computer program exclusion, but as with its previous decision in *Aerotel/Macrossan*, the Court gave general guidance on section 1(2). Although the Court approached the question of excluded matter primarily on the basis of whether there was a technical contribution, it nevertheless (at paragraph 59) considered its conclusion in the light of the *Aerotel/Macrossan* approach. The Court was quite clear (see paragraphs 8-15) that the structured four-step approach to the question in *Aerotel/Macrossan* was never intended to be a new departure in domestic law; that it remained bound by its previous decisions, particularly *Merrill Lynch*[4] which rested on whether the contribution was technical; and that any

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[1] http://www.ipo.gov.uk/pro-types/pro-patent/p-law/p-pn/p-pn-computer.htm
[2] *Aerotel Ltd v Telco Holdings Ltd and Macrossan's Application* [2006] EWCA Civ 1371; [2007] RPC 7
[3] *Symbian Ltd v Comptroller-General of Patents*, [2009] RPC 1
[4] *Merrill Lynch's Appn*. [1989] RPC 561

differences in the two approaches should affect neither the applicable principles nor the outcome in any particular case.

17 Subject to the clarification provided by *Symbian*, it is therefore appropriate to proceed on the basis of the four-step approach explained at paragraphs 40-48 of *Aerotel/Macrossan* namely:

> *(1) Properly construe the claim.*
>
> *(2) Identify the actual contribution (although at the application stage this might have to be the alleged contribution).*
>
> *(3) Ask whether it falls solely within the excluded matter.*
>
> *(4) If the third step has not covered it, check whether the actual or alleged contribution is actually technical.*

The Claims

18 In GB 1011185.4, claim 1 is directed to a method of modelling or as in the auxiliary request, determining the effects of changes in an industrial process using a first principle simulation model. Claim 12 is an associated apparatus claim. Claim 21 is directed to a computer readable medium comprising instructions and is in effect the computer program that enacts the method of claim 1. The full claims appear at Annex A.

19 In GB 1500021.9 claim 1 is directed to a method of modelling the effects of changes in the inputs, process or equipment of an industrial process system using a first principle model. Claim 8 is a further method claim and refers to optimising a steady state solution of the model. I have some doubts that this is the same invention as that of claim1 and that it may actually be a second invention. However, for the purposes of this decision it shares enough of the common subject matter with the first claim to allow me to consider whether it complies with section 1(2)(c) of the Act. Specifically it involves a model of the process system that is adjusted or optimised to provide a compensation or error factor. The full claims appear at Annex B.

Arguments and Analysis

Construing the Claims

20 The applicant and examiner are both clear on the construction of the claims and I see no reason to delve deeper into these at this point.

Identifying the Actual or Alleged Contribution

21 The key issue that I need to resolve is what is the actual or alleged contribution made by the applications? The Examiner has identified the contribution in both applications as:

"The problem to be solved is the tuning/adjustment of a process system model. The invention works by compensating model output data generated by a first principle based simulation model of a process system, where an optimisation function is

solved within given constraints to determine one or more model parameters for an error model. Its advantage is the creation of a more accurate model. Therefore the contribution is a more accurate model of the effects of the changes to the process system".

22 Mr Sessford for the applicant disagrees with this assessment of the contribution. His argument is that a "*better model*" allows you to more accurately tune the industrial process system. In his view it is not just about the model and how it works as you have to take into account the use of the model in "*completing the circle of determining the effects of the changes to a process control system*".

23 The issue of "*how you use the model*" goes to the core of the arguments made by Mr Sessford on the contribution made by the applications. In neither case is it suggested in the applications that the model is used to control the process control system being modelled either directly or indirectly.

24 This is an issue that Mr Sessford raised at the hearing where he felt such a link was implied. In supporting his view he made the point that process control systems have become more complex and now are distributed with some portions of the system being held on individual devices rather than centrally. Consequently, it is more difficult to observe the effects each component has on one another. Furthermore, this increased complexity makes it more difficult to control operational routines within a process control system and has led to complex models being used to observe the effects of changes to the system. Mr Sessford rather helpfully gave the example of modelling an oil refinery and observing the effect a different type of oil would have when it was processed. I would add at this point that the specification itself refers to a coal fired power station at paragraph 62 of the specification.

25 He went on to argue that any system that provided a better model which more accurately reflected the system would clearly aid the operational system. In fact, whilst he acknowledged that the link between the model and the system was not clearly made in the specification he did suggest that it was implied. He further acknowledged that the final clause of the claims was an effort to provide this link. To use his word, such an effect was implied as "*what else would you do with the model?*"

26 To illustrate his point he gave the example of a motorcycle frame. There was no doubt that this was intended for use in the construction of a motorcycle. However, he pointed out that such things could be considered by some to be an aesthetic creation who may hang it on a wall as a work of art. His point though was to illustrate that you have to take a pragmatic view of the purpose of the model and that would, in these applications, be their use in helping to control the process control system.

27 At the hearing I asked Mr Sessford how he saw the model being used. He made the point that the user of the system would see the results of the model and use these to tune the process control system under their command. In doing so he also acknowledged that there was no direct control of the system by the model.

28 Mr Sessford then took me through the decision of Birss J in *Halliburton [2011] EWHC 2508 (Pat)*[5] and a number of office decision with the aim of showing me that the use of the model was part of the contribution.

29 I think it germane to point out at this juncture that whilst I am bound by *Halliburton* in arriving at my decision, Office decisions are not binding on me but are considered to be persuasive. In these instances, I think it is fair to say that I will need to pay close attention to the exact details considering carefully whether they are on all fours with the applications in suit.

30 Mr Sessford also took exception to the view of the Examiner that any comment in *Halliburton* with regards to the computer program exception was obiter. His view was that as the original objection was that *Halliburton* was excluded as a mental act and a computer program then any comments cannot be obiter. As such, it is binding precedent on the Office. I cannot disagree with this view though I do not believe that whether the comments were obiter or not alters how I should consider these applications.

31 The *Halliburton* case was first raised by Mr Sessford during the substantive examination who argued that it showed that a model, even though it was not used, could still be allowable. Specifically, the process in *Halliburton* was the method of designing a drill bit which, even though the drill bit was not made, was still found to be patentable. In his view this has parallels with the current application in that the substance of *Halliburton* as a real and tangible method of modifying a model is used to determine effects within a design, is no different to that of modifying the model of the process control system which can determine the effects changes will have to the real process control system. He puts it more succinctly as "*our model is an inevitable consequence that would be understood by the skilled man*".

32 *Halliburton* is clearly a relevant decision and I need to consider how it comes into play. On precedent, its main finding is that a "mental act" has to be considered narrowly and put simply, the use of an apparatus is enough to overcome that objection. Mr Sessford made clear it also referred to the computer program exclusion, though in the circumstances, I have some difficulty in seeing how it assists him in these applications.

33 In considering this point I am also cognisant that at paragraph 32 of the *Halliburton* decision, the judge makes it clear that key to interpreting the program exclusion is "by considering what task it is the program actually performs". Furthermore, in paragraph 33 of the decision he goes on to point out that if the task the program undertakes is excluded there is no further need to continue. He summarises these points in paragraph 38 when he states:

> *"Put in other language, when the task carried out by the computer program is not itself something within the excluded categories then it is likely that the technical contribution has been revealed and thus the invention is patentable. I emphasise the word likely rather than necessarily because there are no doubt cases in which the task carried out is not within the excluded areas but nevertheless there is no technical contribution at all"*

[5] http://www.bailii.org/ew/cases/EWHC/Patents/2011/2508.html

34 The Judge then went on to consider whether the invention in *Halliburton* was a mental act or not. In paragraph 70 and 71 he found that it was not a mental act and having done so he considered the technical contribution to be revealed and unaffected by the computer program exclusion. Of specific interest is the lack of discussion about the program exclusion and its effects which, in my opinion, place a limitation on how relevant it can be to the canon of precedent on that exclusion. It may be this that led the Examiner to consider the remarks on the program exclusion to be obiter.

35 The claim in *Halliburton* involved simulation as part of an iterative design method in taking an initial design of a drill bit to produce a final design fully equipped to deal with the different types of rock strata the drill was required to operate in. As the Judge said in paragraph 74:

> *"Designing drill bits is obviously a highly technical process, capable of being applied industrially. Drill bit designers are, I am sure, highly skilled engineers. The detailed problems to be solved with wear and ability to cut rock and on are technical problems with technical solutions. Accordingly, finding a better way for designing drilling bits is itself a technical problem. The invention is a better way of carrying that out. Moreover the detailed way in which this method works – the use of finite element analysis – is also highly technical"*

36 As such, whilst I can see the initial attraction to Mr Sessford as it involves a model, I believe it is qualitatively different in substance to the current application resulting as it does in a new and specifically designed drill bit. In *Halliburton* the actual process of designing the drill bits involves much more than just the modelling of the drill bit. Taking an initial design, it involves simulating the operation of the design and through a number of iterations arriving at a design. Importantly it involves multiple technical elements that all feed into the design such as the earth formation, the operation of each cutting element as well as the wellbore itself.

37 This is in contrast to the existing model which, whilst it uses some initial inputs reflective of the system being modelled, it has no other links to the system being modelled. Unlike *Halliburton*, where I would end up with a new drill bit, I do not end up with a new process control system but rather a somewhat detached and abstracted model. Specifically, the application is about improving a model and not the process control system. I think this degree of detachment is an important point and as such I am not swayed by this line of argument. If anything it points to the applications being excluded as they resulted in abstract models.

38 It has become established law that constructing a generalised category of allowable inventions which may or may not include the claimed invention, from decisions where the claims were allowable, does not always help. Whilst it is true that in some instances it does show that some things are patentable it is also true that it shows that some are not. With that in mind I will consider the hearing decisions referred to by Mr Sessford at the hearing.

39 Mr Sessford also drew my attention to the Office decision in *Senergy* (BL 0/057/15)[6]. Claim 1 of this application was directed to a modelling production from a

[6] https://www.ipo.gov.uk/p-challenge-decision-results/p-challenge-decision-results-bl?BL_Number=O/057/15

subterranean region comprising a wellbore and a surrounding formation. Ultimately the case was granted with a claim directed to optimising the design of a wellbore. Mr Sessford suggested this was perhaps a triumph of form over substance as he saw little difference between the claims granted and those of the hearing. Mr Sessford went on to make the point that the modelling element is the technical component of the invention and also follows the kernel of the *Halliburton* decision. As to helping him make the case for allowance in this application, he points out that to the skilled person what has made the application allowable is the use to which the model is put i.e. optimising a wellbore.

40 To my mind, this last point is the important feature that is missing from these applications. Following my understanding of *Halliburton* where the process started with a drill and finished with an improved drill, *Senergy*, as granted, starts with a wellbore and finishes with an improved wellbore. The current applications have no such link where the start and finish and all points in between are nothing more than a model that is not connected to the process control system.

41 Mr Sessford asked me to consider *Western GeCo* (0/135/07). *Western GeCo* was a method of processing geophysical data and was in this form found to be unallowable as a mathematical method. However, in paragraph 14 of that decision the Hearing Officer found that when tied to a specific use of "determining one or more parameters relating to physical properties of the earth's interior from the processed geophysical data" the contribution shifted to producing an improved "seismic image". Following the principles set out in *Vicom (T208/84)* the Hearing Officer allowed this claim as he believed this contribution did not fall entirely within excluded matter.

42 Mr Sessford would have me believe that this is the same situation for his applications. I, on the other hand, do not believe it is. Firstly, the method of *Western GeCo* dealt with improving a seismic image which is somewhat removed from modelling a process control system. Even if I go beyond that, the improvements were internal to the seismic data whereas in the current applications they are to the model rather than the process system.

43 The next decision Mr Sessford referred to was *Logined* (0/408/12)[7]. In this application a computer was used to generate a field development plan for an oil or gas field. This is an interesting case and although in a different field, it shares some similarities with the current applications. It concerns taking of values from existing data and using them as inputs to a model which is then optimised to produce a development plan that specifies the location of a drilling platform, borehole trajectories and well completions.

44 I do not disagree with Mr Sessford when he says it is a better model. However, I also agree with the Hearing Officer who pointed out that this is an abstract plan and is not connected to the physical process of extracting oil. In terms of the current applications I believe the same applies – what is produced is an abstract model and not an improved process control system.

45 *Marathon Oil* (0/174/10) is a decision I am familiar with. The invention in this case was a method of determining a value of a designated rock or fluid property in a

[7] https://www.ipo.gov.uk/p-challenge-decision-results/o40812.pdf

subterranean geological volume by comparing a predicted value from a model against actual seismic data and adjusting the predicted value according to the differences.

46 In *Marathon Oil* I found the case to be excluded as a computer program as the method was clearly meant to be run on a computer. I also found that the application was not saved by using real seismic data. I think the same facts apply here in that a series of predictions are being made in either application in order to arrive at a compromise or compensation value. As such, I am not convinced that *Marathon Oil* provides me with any reason to find the current applications allowable since they too, receive real data which is then used as part of a method of arriving at a compensation or error factor albeit for a process control system rather than a subterranean geological volume.

47 The final two decisions referred to by Mr Sessford where *Toshiba* (0/453/14) and *GE* (0/018/12). Of these *GE* is perhaps the more interesting as it concerns using values from a sensor as inputs to a model for making predictions about characteristics. Both the Hearing Officer and the attorney for *GE* agreed that a computer model making a prediction does not have a technical effect on either the process or the computer used to make the prediction. What was key to this application ultimately being allowed was that this prediction was then used to control the process. Unfortunately, for Mr Sessford this is the one clear thing that is missing from his current applications.

48 *Toshiba* concerns the training of a speech recognition system using a corpus of specific subject matter expressed as file vectors and using these to search the database of subject matter. The Hearing Officer found that this was allowable principally because the underlying concept was about an improved speech recognition system rather than the computer processing underlying it. In this regard the method was a better speech recognition system.

49 It appears to me from the existing Court and Office decisions that several factors need to be present when I consider whether the use of the model of the applications forms part of the contribution or not:-

a) Does the model feed back or actively control the system being modelled?

b) Is the modelling an intrinsic part of the method of producing something such as was the case in Halliburton?

c) Is the model anything more than an abstraction of the process being modelled?

50. In these applications before me there is no direct control, the process remains unaltered by the model and it would appear to be nothing more than an abstraction. As such and based on the arguments presented during the hearing I am of the opinion that the Examiner's assessment of the contribution in both cases is the more appropriate one to take. In coming to this view, I do not believe that the "use of the model" is part of the contribution. To allow the view that "*what else would you do with it?*" alters the contribution would, I think, undermine the intentions of the Act as it

could allow any modelling technique to be patentable provided it was put to a use. To avoid any doubt I see the contribution as:

"*A more accurate model of the effects of the changes to a process system."*

Does the Contribution lie solely within an Excluded Area?

50 The third step of the *Aerotel* test is to decide whether an application lies wholly within excluded matter. Having decided that the use of the model is not part of the contribution, I believe both applications are excluded as a computer program.

51 However, following the decision in *Symbian,* a computer program can be allowable provided it makes a technical contribution. To assist this decision Lewison J, as he then was, set out five signposts in *AT&T/CVON [2009] EWHC 343 (Pat)* and which he modified in *HTC v Apple [2013] EWCA Civ 451*, which are as follows:

> *i) whether the claimed technical effect has a technical effect on a process which is carried on outside the computer;*
>
> *ii) whether the claimed technical effect operates at the level of the architecture of the computer; that is to say whether the effect is produced irrespective of the data being processed or the applications being run;*
>
> *iii) whether the claimed technical effect results in the computer being made to operate in a new way;*
>
> *iv) whether the program make the computer a better computer in the sense of running more efficiently and effectively as a computer;*
>
> *v) whether the perceived problem is overcome by the claimed invention as opposed to merely being circumvented.*

52 Mr Sessford conceded that the only relevant signpost is the first one and I am happy to adopt that approach here.

53 This is a point, I have in reality already discussed, and I see no need to expand any further on it here. Given that the model of the applications has no connection to the process control system and does not affect any changes in it, then it cannot be said to present any relevant technical effect outside the computer. Put simply, any effects are seen only within the model on the computer.

Is the Actual or Alleged Contribution Technical?

54 As the applications have failed to show a technical contribution I do not need to consider this any further.

Conclusion

55 Having considered the issue before me, I conclude that the inventions defined by the independent claims (main and auxiliary) in both GB 1011185.4 and GB 1500021.9 are excluded under Section 1(2)(c) of the Act as computer programs.

56 I have carefully considered each application and cannot see any changes or amendments that could be made to the claims to alter this viewpoint. I therefore refuse both applications under Section 18(3) of the Act.

Appeal

57 Any appeal must be lodged within 28 days after the date of this decision.

C L Davies

Deputy Director acting for the Comptroller

Annex A – GB 1011185.4

Main Request – Bold
Auxilliary Request – Italics

Claim 1

A method of **modelling** *(determining)* the effects of changes in one or more inputs to **an industrial process system, changes to a process of the industrial process system,** and/or changes to one of more pieces of equipment of the industrial process system by compensating model output data generated by a first-principle simulation model of the industrial process system, the method comprising:

Applying one or more first test inputs to the industrial process system to generate first output data;

Applying one of more second test inputs to a first-principle model to generate second output data;

Determining a first prediction equation to express a relationship between the first test inputs and the first output data;

Determining an initial condition of the first prediction equation for one of more model parameters based on the first test inputs and the first output data;

Determining a second prediction equation for a first time based on at least one of a third prediction equation for a second time prior to the first time or the initial condition;

Generating an error model based on the first and second output data and based on at least one of the second or third prediction equations;

Applying model input data to the first principle model to generate simulation model output data;

Compensating the simulation model output data via the error model to generate compensated model output data; and

Using the compensated model output data to determine the effects of

Changes in one or more inputs to the industrial process system;
Changes to the process of the industrial process system and/or
Changes to one or more pieces of equipment of the industrial process system.

Claim 12

An apparatus to **model** *(determine)* the effects of changes in one or more inputs to **an industrial process system, changes to a process of the industrial process system,** and/or changes to one of more pieces of equipment of the industrial process system by compensating model output data generated by a first-principle simulation model of the industrial process system, the apparatus comprising:

A first principle model implemented in a memory to generate first output data based on one or more first inputs;

An error model implemented in memory to compensate the first output data during an operational phase to generate a compensated first principle-based model output based on the first output data;

An error model generator to

Determine a first prediction equation to express a relationship between the first test inputs and the first output data;

Determine an initial condition of the first prediction equation for one of more model parameters based on one or more test inputs and one or more test outputs;

Determine a second prediction equation for a first time based on at least one of a third prediction equation at a second time prior to the first time or the initial condition;

And

Generate the error model based on the first output data, based on process data during a training phase, and based on at least the second or third prediction equation, wherein the error model generator is to generate error model data received from the industrial process system;

The apparatus being configured to use the compensated first principle-based model output data to determine the effects of:

Changes in one or more inputs to the industrial process system;
Changes to the process of the industrial process system and/or
Changes to one or more pieces of equipment of the industrial process system.

Claim 21

A computer readable medium for **modelling** *(determining)* the effects of changes in one or more inputs to an industrial process system, changes to a process of the industrial process system**,** and/or changes to one of more pieces of equipment of the industrial process system by compensating model output data which when executed by a computer , cause the computer to generated by a first-principle simulation model of the industrial process system, the method comprising:

Apply one or more first test inputs to the industrial process system to generate first output data;

Apply one of more second test inputs to a first-principle model to generate second output data;

Determine a first prediction equation to express a relationship between the first test inputs and the first output data;

Determine an initial condition of the first prediction equation for one of more model parameters based on the first test inputs and the first output data;

Determine a second prediction equation for a first time based on at least one of a third prediction equation for a second time prior to the first time or the initial condition;

Generate an error model based on the first and second output data and based on at least one of the second or third prediction equations;

Applying input data to the first principle model to generate simulation model output data;

Compensate the simulation model output data via the error model to generate compensated model output data; and

Using the compensated model output data to determine the effects of

Changes in one or more inputs to the industrial process system;
Changes to the process of the industrial process system and/or
Changes to one or more pieces of equipment of the industrial process system.

Annex B – GB 1500021.9

Main Request – Bold
Auxilliary Request – Italics

Claim 1

A method of **modelling** (*determining*) the effects of changes in one or more inputs to an industrial process system, changes to a process of the industrial process system, and/or changed to one or more pieces of equipment of the industrial process system using a dynamic error model to compensate a first principle-based model of the industrial process system, the method comprising:

Determining a plurality of prediction equations to express a relationship between one or more process system inputs and one or more process system outputs;

Determining an initial condition based on the prediction equations for one or more model parameters based on one or more test inputs and on or more test outputs;

Determining a second prediction equation t a first time based on at least one of a third prediction equation at a second time prior to the first time of the initial condition;

Determining an optimization function to optimize a difference in outputs between a first principle-based model and the industrial process system in response to one or more substantially equivalent inputs;

Solving the optimization function within the constraints to determine the one or more model parameters based on at least one of hte second prediction or third prediction equations;

Generating a dynamic error model based on one or more model parameters and using the dynamic error model to compensate the first principle-based model of the industrial process system and determining the effects of

Changes in one or more inputs to the industrial process system;

Changes to the process of the industrial process system;

Changes to one or more pieces of equipment of the industrial process system;

Claim 8

A method of **modelling** (*determining*) the effects of changes in one or more inputs to an industrial process system, changes to a process of the industrial process system, and/or changed to one or more pieces of equipment of the industrial process system using a dynamic error model to compensate a first principle-based model of the industrial process system, the method comprising:

Applying test input data to a process to generate test output data;

Generating a steady state solution based on the test input and output data;

Generating one or more prediction equations based on the steady state solution wherein a prediction equation at a first time is based on at least one of:

Test output data at one or more previous times;

Test input data at one or more previous times; or

One or more prediction equations at previous times;

Applying one or more constraints to an optimization function;

Solving the optimization function to optimize the one or or more prediction equations within the one or more constraints to generate a dynamic error model and

Using the dynamic error to compensate the first principle-based model of the industrial process system and determining the effects of:

Changes in one or more inputs to the industrial process system;

Changes to the process of the industrial process system;

Changes to one or more pieces of equipment of the industrial process system;