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Method and system of recommending tyres and calculating on site the inflation pressures of said tyres for a vehicle used for civil engineering

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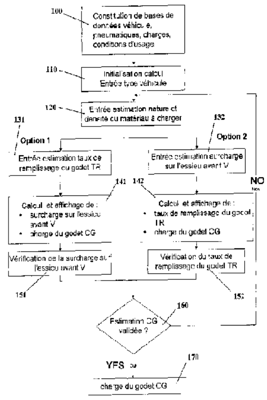
[Suite sur la page suivante]

(54) Title: METHOD AND SYSTEM OF RECOMMENDING TYRES AND CALCULATING ON SITE THE INFLATION PRESSURES OF SAID TYRES FOR A VEHICLE USED FOR CIVIL ENGINEERING

(54) Titre : METHODE ET SYSTEME DE PRECONISATION DE PNEUMATIQUES ET DE CALCUL SUR SITE DES PRESSIONS DE GONFLAGE DESDITS PNEUMATIQUES POUR UN VEHICULE DE GENIE CIVIL



100 ... CREATION OF VEHICLE, TYRE, LOAD, USE CONDITION DATABASE
110 ... CALCULATION INITIALISATION VEHICLE TYPE INPUT
120 ... TYPE AND DENSITY OF MATERIAL TO BE LOADED ESTIMATED INPUT
131 ... BUCKET FILLING RATE ESTIMATED INPUT TR
141 ... CALCULATION AND DISPLAY OF: - EXCESS LOAD ON FRONT AXLE V - BUCKET LOAD CG
151 ... VERIFICATION OF EXCESS LOAD ON FRONT AXLE V
132 ... EXCESS LOAD ON FRONT AXLE ESTIMATED INPUT V
142 ... CALCULATION AND DISPLAY OF: - BUCKET FILLING RATE TR - BUCKET LOAD CG
152 ... VERIFICATION OF BUCKET FILLING RATE TR
160 ... CG ESTIMATE VALIDATED?
170 ... BUCKET LOAD CG

(57) Abstract: The invention relates to a method and system of recommending tyres and calculating on site the inflation pressures of said tyres for a vehicle used for civil engineering purposes. According to the invention, the vehicle, tyre and use condition data are used to calculate an on site estimate of the load of the bucket of the vehicle and to select the suitable type of tyres and the inflation pressures thereof.

(57) Abrégé : Méthode et système de préconisation de pneumatiques et de calcul sur site des pressions de gonflage desdits pneumatiques pour un véhicule de Génie Civil dans lesquels, à partir de données véhicules, pneumatiques et conditions d'usage, on calcule sur site une estimation de la charge du godet du véhicule Génie Civil et on choisit le type du pneumatiques appropriés et leurs pressions de gonflage.

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En ce qui concerne les codes à deux lettres et autres abréviations, se référer aux "Notes explicatives relatives aux codes et abréviations" figurant au début de chaque numéro ordinaire de la Gazette du PCT.

Method and system for advocating tyres and for calculating on site inflation pressures of the said tyres for a construction vehicle

The present invention relates to the technical sector of vehicles known as construction vehicles, such as loaders, dumpers, lorries and similar vehicles which are suitable for loading, unloading and/or transporting materials such as, in particular, ores or similar materials, and which for the sake of simplicity are called "vehicles" hereinbelow.

The technical problem arising is to determine quickly and accurately on site, that is to say at the building site, the optimum values for the internal pressure of tyres which should be set up for the front wheels (AV) and back wheels (AR) of these vehicles as a function of a very large number of parameters relating to the vehicle, the way it is used, the terrain on which it is to travel, the parameters of the available tyres, the characteristics of the load and similar factors well known to those skilled in the art.

Basic methods are currently known, consisting essentially in making a visual assessment of the behaviour of the vehicle under load and deducing the pressures which seem most appropriate therefrom, by manual and empirical calculation. This is highly imprecise.

It is known that the risk associated with such vehicles under load, in particular front-end loaders, is that they may tip forwards under the effect of an excessively large load in the bucket and inappropriate parameters in selecting the tyres and pressure.

On the ground, those skilled in the art will of course tend to recommend smaller loads in order to avoid this risk, and hence of course a markedly lower output from the vehicle, but also of course inflation pressures for tyres which are suitable for the maximum load (tipping) and of course a greater sensitivity to cuts in the tyres and hence lower output.

It is also known that too low a pressure must not be advocated, but that too high a pressure must not be advocated either, since in this latter case there then arises a risk of the tyre being cut or torn on certain terrains.

Other factors to take into account are the stability of the vehicle, which those skilled in the art know they can improve by increasing the operating pressure, but those skilled in the art also know that this has a negative effect on the vehicle's flotation, that is to say its capacity to travel on loose or soft terrain or even muddy terrain.

It will therefore be appreciated that the parameters are not merely extremely numerous but in some cases incompatible. There are moreover numerous types and makes of vehicles, tyres available, and so on, which make solving the problem even more complicated.

There is thus a recognised and major need for a method and a system which are simple and accurate and ensure that operations are safe and optimised.

The invention relates to a method and a system of this kind which make use of certain data chosen from the parameters listed above, apply them to "correlated" equations, correct the estimate made from a visual assessment or a more accurate measurement of the behaviour of the vehicle under load, all this being iterated until the calculations of the method and the impression (or measurement) made by the operative as regards the behaviour under load are in reasonable agreement.

The term "in reasonable agreement" is used here to indicate that at the end of one, two or more iterative corrections the operative considers that he has reached a solution calculated using the method and system which corresponds to the actual behaviour of the vehicle with certain approximations and within the tolerance that his knowledge of the field can allow him.

The operative then decides that the solution calculated is satisfactory.

The invention therefore relates to a method of advocating tyres on a method of advocating tyres on a worksite and calculating on the worksite the inflation pressures of said tyres for a construction vehicle having a front axle, a rear axle and a bucket intended to receive a load of material having a density DM, comprising the steps of:

a) making an estimate of a filling level TR of the bucket in conditions of maximum load for use on the worksite;

b) calculating a load CG created by the material filled to the filling level TR in the bucket from the bucket capacity VG and the estimated values for density DM and filling level TR;

c) calculating an overload V on the front axle from a tipping load CB which would produce a tipping of said vehicle;

d) verifying the value obtained for the overload V on the front axle from observations made when the vehicle is loaded to its maximum load for use on the worksite and when empty;

e) if the result of the verification of step D is negative, correcting the estimates of the density DM and/or the filling level TR and performing again the verification of the value obtained for the overload V on the front axle;

f) if the result of the verification of step D is positive, validating the estimate of the maximum load on the bucket CG in the conditions of use on the worksite;

g) using the value for the maximum load CG to calculate total loads ZAV and ZAR on the front axle and the rear axle, respectively;

h) calculating the load on each front tyre by dividing by two the total load ZAV on the front axle calculated in step G, and choosing a load value for each tyre of the rear axle greater than the total load ZAR on the rear axle divided by two;

i) determining the conditions of the terrain on the worksite and the average speed of use of the vehicle;

j) making a search of data from tyre manufacturers for the type or types of tyres and characteristics of tyres, including type, tread pattern and rubber compound quality, which most closely correspond to the loads calculated for the tyres of the front axle and the rear axle, for the conditions of use of the vehicle on the worksite, including the conditions of the terrain, and the average speed of use;

k) making a search of data from tyre manufacturers for the operating pressures of the tyres selected in step J on the front axle and rear axle respectively, corresponding to the loads calculated for the tyres of the front axle and rear axle in step H; and

l) choosing the operating pressures and the tyres for said vehicle.

Preferably the verifying of the overload V on the front axle in steps D and E comprises measuring the sagging of at least one of the tyres of the vehicle, between the sag value with no load and the sag value when the tyre in question is loaded. Preferably the load CG is calculated in step B from the equation

$$CG = VG \times DM \times \frac{\mathrm{TR}}{100}$$

and the overload V is calculated in step C from the equation

$$CG = \frac{V}{100} \times CB$$

where CG=bucket load

VG=capacity of the bucket in m^3,

DM=density of the material to be loaded in kg/m^3,

TR=level of filling of the bucket in %,

V=estimate of the overload on the front axle resulting from the load on the bucket, expressed as % of the tipping load of the vehicle, and

CB=tipping load of the vehicle in kg.

The total loads ZAV and AZR maybe calculated in step 6 from the equations:

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG$$

where ZAV=load on the front axle;

ZAR=load on the rear axle;

VAV=load on the front axle when empty;

VAR=load on the rear axle when empty;

CG=bucket load;

CB=tipping load of the vehicle in kg.

Preferably the average speed is determined in step I from the equation

speed=LxNb

where:

L=length of the cycle for loading/unloading in km;

Nb=number of cycles per hour.

In accordance with a further aspect of this invention there is provided a method of advocating tyres on a worksite and calculating on the worksite the inflation pressures of said tyres for a construction vehicle having a front axle, a rear axle and a bucket intended to receive a load of material having a density DM, comprising the following steps:

a) making an estimate of an overload V on the front axle in conditions of maximum use of the bucket from observations made when the vehicle is at maximum load for use on the worksite and when empty;

b) calculating and displaying a load CG in the bucket from a tipping load CB which would produce a tipping of the vehicle, from the equation:

$$CG = \frac{V}{100} \times CB$$

c) calculating a filling level TR of the bucket under said conditions of maximum load for use from the capacity VG of the bucket of said vehicle and estimating the values above DM and V from the equation:

$$\mathrm{TR} = \frac{CG}{VG \times DM} \times 100$$

d) verifying the value obtained for the filling level TR of the bucket from observations made when the vehicle is loaded to its maximum load for use on the worksite;

e) if the result of the verification of step D is negative, correcting the estimates of the density DM and/or the overload V on the front axle and performing again the verification of the value obtained for the filling level TR of the bucket;

f) if the result of the verification of step D is positive, validating the estimate of the maximum load CG on the bucket in the conditions of use on the worksite;

g) using the value for the maximum load CG on the bucket validated in step F, to calculate total loads ZAV and ZAR on the front axle and the rear axle, respectively, from the equations

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG$$

where ZAV=load on the front axle,

ZAR=load on the rear axle,

VAV=load on the front axle when empty,

VAR=load on the rear axle when empty

h) calculating the load on each front tyre by dividing by two the total load ZAV on the front axle calculated in step G, and choosing a load value for each tyre of the rear axle greater than the total load ZAR on the rear axle divided by two;

i) determining the conditions of the terrain on the worksite and the average speed of use of the vehicle;

j) making a search of data from tyre manufacturers for the type or types of tyres and characteristics of tyres, including type, tread pattern and the rubber compound quality, which best correspond to the loads calculated for the tyres of the front axle and the rear axle, for the conditions of use of the vehicle on the worksite, including the conditions of the terrain, and the average speed of use;

k) making a search of data from tyre manufacturers for the operating pressures of the tyres selected in step J on the front axle and rear axle respectively, corresponding to the loads calculated for the tyres of the front axle and rear axle in step H; and

l) choosing the operating pressures and the tyres for said vehicle.

Preferably, estimating and/or verifying the value of the overload on the front axle V is carried out on the basis of measuring the distance using the sagging of at least one of the tyres of the vehicle, between the sag value with no load and the sag value when the tyre in question is loaded. A relative value is thus used, which greatly improves the accuracy of measurement and hence the estimate or verification of the variable V is very reliable.

Most preferably, this variation in the level of sagging will be measured by an optical method, for example with a laser pen (or accurate measuring instrument of this type) which is positioned at a stable point on the wheel, with heights read off from a calibrated rule positioned opposite the laser beam. Conversely, a card could be placed on the wheel with the laser pen opposite this card. Those skilled in the art will have an understanding of these simple devices, and will have others at their disposal.

Preferably the load CG is calculated in step B from the equation

$$CG = VGxDMxCB$$

and the overload V is calculated in step A from the equation

$$CG = \frac{V}{100} x \frac{TR}{100}$$

where CG=bucket load

VG=capacity of the bucket m^3,

DM=density of the material to be loaded in kg/m^3,

TR=level of filling of the bucket in %,

V=estimate of the overload on the front axle resulting from the load on the bucket, expressed as % of the tipping load of the vehicle, and

CB=tipping load of the vehicle in kg.

Preferably the total loads ZAV and ZAR are calculated in step G from the equations:

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG$$

where ZAV=load on the front axle;

ZAR=load on the rear axle;

VAV=load on the front axle when empty;

VAR=load on the rear axle when empty;

CG=bucket load;

CB=tipping load of the vehicle in kg.

Preferably the average speed is determined in step I from the equation

speed=LxNb

where:

L=length of the cycle for loading/unloading in km;

Nb=number of cycles per hour.

Preferably, the method according to the invention is such that it also includes a step of correcting and/or determining the limits for use of the inflation pressures proposed, this step being chosen from the following operations:

- correction of the speed of the vehicle; and/or
- correction of the stability factor and the flotation factor; and/or
- correction of the type of terrain;

(these three corrections giving rise to a correction of the pressures from databases from the tyre manufacturers); and/or

- choice of a final correction of the pressure.

In fact, once the parameters from the vehicle manufacturer and the conditions of use have been entered and the advocated pressure values for certain types of tyres have been obtained by the method above, it is in general important to determine the limits for use of the vehicle for safety reasons.

If desired, the influence of a higher or lower speed on the vehicle than that provided will therefore be explored successively (and independently); it will therefore be advisable to select from the list advocated for the vehicle a different type of tyre, rubber compound or tread pattern or even different pressures.

Similarly, the parameters for the stability (which may be improved by increasing the internal pressure of the tyres) and for the flotation of the vehicle (that is to say its suitability for travelling safely on terrain which is loose, soft, muddy, etc.) will be explored. Since these two factors are not compatible, it is important to verify that an improvement in the flotation made necessary for example by the type of terrain encountered, or the risk of bad weather, etc., will not compromise stability or vice versa. In this case, too, the operative will advocate a different combination of tyre parameters with a larger tolerance.

The type of terrain may also bring about serious problems with safety and damage to the tyres by cuts or tears if the pressure is too high. Here too, correcting the initial terrain factor will allow the behaviour of the vehicle to be explored within certain limits of the conditions, in order to verify that the implementation is still sound. In the opposite case a different advocated result will be selected.

It goes without saying that in all cases where this "exploration" reaches a risk zone an alarm is triggered, matched to an appropriate message on the system screen.

According to a particular embodiment, a database **A** is created with all the known data from the manufacturers of the vehicles, and this database **A** includes at least the following elements:

- a list of vehicle references with, for each one:
  - weight on front axle when empty, VAV;
  - weight on rear axle when empty, VAR;
  - in-line tipping load, CB;
  - dimension of authorised tyre(s);
  - capacity of the bucket VG, in m^3; and
  - capacity of the bucket in kg.

As known by those skilled in the art, the concept of in-line wheels (or in-line tipping load) corresponds to a configuration of the vehicle in which the axes of the wheels are perpendicular to the longitudinal axis of the vehicle, in particular the front axle. This is the case, for example, when the vehicle is moving towards the lorry and begins to back under load. The tipping load is highest in a case of this kind.

The configuration with "out-of-line wheels" corresponds to the situation when the vehicle manoeuvres by pivoting at least two wheels, in particular the two front wheels. In this case, those skilled in the art know that the resulting variation in the centre of gravity gives rise to a lower tipping load. This tipping load with out-of-line wheels may optionally be used to give a maximum limit which should not be exceeded for the bucket load value.

This data is necessarily known (vehicle manufacturer data) in the case of the in-line wheel configuration (compulsory vehicle manufacturer data – tipping load) and very generally known as regards the configuration with out-of-line wheels (again, vehicle manufacturer data).

According to a particular embodiment, a database **B** is created with the known material data, and this database **B** includes at least the following elements:

- data relating to the usual materials involved, with their densities DM.

In the best current embodiment, this database includes 24 types of materials with their usual density in kg/m^3, with the proportions of ore and deads, and/or the densities DM of the materials to be loaded in kg/m^3. This database thus allows work to be carried out using the densities of the ores associated with the content of these ores at the site in question, and can also directly give the density DM of the materials to be loaded at the site; this last value includes the content and density of complementary or dead rocks which will have to be loaded.

This database allows the operative to gain considerable time and accuracy for the accuracy of the value of the load on the bucket CG obtained in accordance with the method of the invention.

It goes without saying that if a special case arises the database can be modified on site by the operative.

According to a particular embodiment, a database **C** is created with the data about the usual terrain, and this database **C** includes at least the following elements:

- a list of the terrain conditions and their principal characteristics, where appropriate with a subjective indication of quality.

With the best current embodiment, a proposal of six terrain conditions is made to the operative, which cover almost all if not all of the situations encountered. If a special case arises the database can be modified on site by the operative.

Preferably, also created is a database **D** of tyre data from the tyre manufacturers, and this database **D** includes at least the following elements:

- a list of all the tyres in the range GC with, for each one:
  - dimension;
  - tread pattern;
  - type of rubber compound;
  - range of use as a function of terrain;
  - limit of use as a function of speed;
  - load limit;
  - limit of pressure;
  - pressure as a function of load.

According to a particular embodiment which is the best current embodiment, equations 1 and 3 are as follows:

$$CG = VG \times DM \times \frac{\mathrm{TR}}{100} \qquad \text{(equation 1);}$$

$$V = \frac{CG}{CB} \times 100 \qquad \text{(equation 3);}$$

where CG = bucket load

VG = capacity of the bucket in m^3,

DM = density of the material to be loaded in kg/m^3,

TR = level of filling of the bucket in %,

V = estimate of the overload on the front axle resulting from the load on the bucket, expressed as % of the tipping load of the vehicle, and

CB = tipping load of the vehicle in kg.

According to a particular embodiment which is the best current embodiment, the load transfer equations are as follows:

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG \qquad \text{(equation 6.1); and}$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG \qquad \text{(equation 6.2);}$$

where ZAV = load on the front axle,

ZAR = load on the rear axle,

VAV = load on the front axle when empty,

CG, CB, VAR are as defined above.

According to a particular embodiment which is the best current embodiment, equations 2 and 4 are as follows:

$$CG = \frac{V}{100} \times CB \qquad \text{(equation 2);}$$

$$\mathrm{TR} = \frac{CG}{VG \times DM} \times 100 \qquad \text{(equation 4).}$$

Preferably, the average speed *speed* is calculated from equation 5 below:

$speed = L \times Nb$ (equation 5);

where:

L = length of the cycle for loading/unloading;

Nb = number of cycles per hour;

the other variables being as defined above.

Those skilled in the art will appreciate that, with the exception of entering parameters or corrected parameters, the said operations are carried out using at least one algorithm. It goes without saying that designing this algorithm will not pose any problems for those skilled in the art.

The invention also relates to a system for advocating tyres on site and for calculating on site inflation pressures for the said tyres, for a so-called construction vehicle having a front axle, a rear axle and a bucket intended to receive a load, in particular of ore or similar materials, for implementing the method above. This system is characterised in that it includes an electronics unit, at least one memory element and at least one algorithm which are suitable for:

- containing equations 1 to 6;
- utilising them; and
- calculating by way of the said equations a value for the load CG on the bucket and loads on the tyres of the front and rear axles.

It goes without saying that those skilled in the art will have no difficulty in designing the electronics unit, memory elements and capacities, and algorithm(s).

According to a particular embodiment, the system also includes means for containing the databases **A** to **D**.

Preferably, the system also comprises an algorithmic means in order to identify from the databases **D** (tyres) and **A** (vehicle manufacturer), the most appropriate values among those chosen for average speed and the characteristics of the terrain, and values for the loads on the tyres of the front and rear wheels respectively, the type or types of tyres, tread pattern and quality of the rubber compound, and means of displaying these.

Those skilled in the art will know how to create an algorithm of this kind without any difficulty.

According to a particular embodiment, the said system also comprises an algorithmic means in order to identify the optimum value for the inflation pressure of the said tyre or tyres selected, means of displaying these values, and means of selecting each of the values and where appropriate making a final correction, and where appropriate printing or transferring a file.

The invention will be more readily understood on reading the description with the attached drawing, in which:

- Figure 1 shows, in the form of a summarising flow chart, the first part of the method according to the invention; and
- Figure 2 shows, in the form of a summarising flow chart, the second part of the method according to the invention.

In the text below, a loader will be used as an example.

The method according to the invention may very easily be loaded onto a laptop computer using a specific program or parameterising a software application such as a spreadsheet.

The first part of the method according to the invention is shown in Figure 1.

The operative will first of all create the databases **A** to **D** (whereof the majority are in any case already in existence, such as the databases of vehicle manufacturers, ore, tyres, etc.), but it may be necessary to complete or modify on site in particular specific characteristics of the ore, particular characteristics of the vehicle in some cases, for example the capacity of the bucket, which the user may have modified, the condition of the terrain, etc. Step 100.

He then starts the system up by entering the type of vehicle in question (step 110).

He identifies the nature of the ore on the site and enters an estimate of the density of the material to be loaded (step 120). As has been said, the algorithm of the system may use either a value for the density of the material to be loaded DM or optionally the density of the ore and its proportion in the material to be loaded.

According to a first option, the operative enters an estimate of the level of filling of the bucket TR (step 131). This estimate is obtained from a visual observation of the vehicle loaded to its maximum load on the site. It may also be confirmed by discussion with the person operating the vehicle.

The system then calculates and displays the overload on the front axle V, expressed as a percentage of the tipping load CB of the vehicle (obtained from database A) and the load on the bucket CG (step 141). This overload V corresponds to the increase in load on the front axle between the situations when the bucket is empty and when it is loaded.

The load on the bucket CG is calculated using equation 1 below:

$$CG = VG \times DM \times \frac{\mathrm{TR}}{100} \;;$$

in which VG is the capacity of the bucket in m^3 and DM is an estimate of the density of the material to be loaded in kg/m^3.

The overload on the front axle V is calculated using equation 3 below:

$$V = \frac{CG}{CB} \times 100 \;;$$

in which CB is the in-line tipping load, obtained from the database **A**.

The operative then verifies whether the value calculated V corresponds properly to his own visual observations or his own measurements (step 151).

If the operative validates the calculation of V, he also validates the calculation of the load on the bucket CG (step 160). This first part thus has the objective of providing a validated estimate of this bucket load (step 170).

If the operative thinks that the overload on the front axle V and/or the load on the bucket CG are not satisfactory, he goes back to step 120.

According to a second option, after step 120 the operative may enter an estimate of the overload on the front axle V (step 132). This estimate may be based on visual observations made by the operative between the "empty" and "maximum load" situations of use for the site and the vehicle in question. It may also be based on measurements, as will be described.

The system then calculates and displays the filling level of the bucket TR which is achieved, for example 70%, and the load on the bucket CG (step 142).

The load on the bucket is calculated using equation 2 below:

$$CG = \frac{V}{100} \times CB \;;$$

in which CB is the tipping load of the vehicle (obtained from database A).

The level of filling of the bucket TR is calculated using equation 4 below:

$$\text{TR} = \frac{CG}{VG \times DM} \times 100 \;;$$

in which, as above, VG is the capacity of the bucket in m^3 (obtained from database A) and DM is the density of the material to be loaded in kg/m^3 (obtained from estimate).

The operative then verifies whether the value calculated for TR corresponds properly to his own visual observations and discussions with the person operating the vehicle (step 152).

If the operative validates the calculation of TR, he also validates the calculation of the load on the bucket CG (step 160).

If the operative thinks that the level of filling TR and/or the load on the bucket CG are not satisfactory, he goes back to step 120.

It goes without saying that in this iterative procedure he has a free choice of using option 1 or option 2, or one after the other in whatever order he chooses.

Advantageously, the system includes alerts which are triggered when one of the values entered or calculated is too high: for example, if the value V is such that the vehicle becomes unstable (load on the bucket is greater than the capacity of the bucket expressed by mass, or greater than the tipping load in configuration with out-of-line wheels, etc.). These alerts cooperate to give a good estimate of the bucket load.

As has been indicated, the value V may be estimated or validated by visual observations or measurements. Very preferably, the following measurements are carried out for V:

- with the vehicle in question equipped with a known type of tyre inflated to a given pressure and loaded at the level of filling provided for the bucket, the operative measures a wheel reference (height with respect to the ground), preferably using an accurate measuring system such as a laser pen;
- the bucket of the vehicle is then emptied without being moved and the operative measures the same reference of height of wheel to ground under load; and
- the operative enters in the system again either the two heights measured, with the system subtracting to calculate dH, or entering dH directly.

The measurement of dH corresponds to the variation in the sagging of the tyre between the empty and loaded situations. Given that the characteristics of the tyre in question and the effective inflation pressure during measurement are known, the system determines the variation in load undergone by the tyre between these two conditions. It then calculates the total overload on the front axle and standardises this value by dividing by the tipping load of the vehicle. This gives a very good estimate of the variable V.

The importance of the relative measurement dH is that it is unencumbered by errors of measurement of sagging of the tyre which may result from the amount of wear of the tyre, the tyre sinking into the ground, etc.

Figure 2 shows the second part of the method according to the invention.

Once the load on the bucket CG has been validated (step 170), the system calculates and displays the loads on the front and rear axles and the load on each front tyre. As regards the load on each rear tyre, the system can systematically predict the half load when empty on the rear axle or prompt the operative for any other value he chooses (step 180).

The total load on the front axle is calculated using equation 6.1:

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG \;;$$

and the total load on the rear axle is calculated using equation 6.2:

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG .$$

The variables of these two equations for load transfer have already been defined.

In step 190, the system prompts the user to enter the average speed of the vehicle and to indicate the nature of the terrain. Six choices are presented as a function of the harshness of the terrain.

Based on this data and the load values, in step 200 the system identifies in the databases **A** (vehicle manufacturer) and **D** (tyre) all the appropriate tyres, and the recommended inflation pressures, as a function of the maximum loads calculated. This search may be carried out among the tyres authorised for the vehicle concerned (generally, a list of ten or so possible references, including the type, make, quality of rubber compound, type of tread pattern, range of pressures, etc.). If necessary, the operative may also choose to widen his search beyond the tyres authorised by the vehicle manufacturer.

As a function of priority parameters specified in the algorithm, the system can display a list of selections in decreasing order of preference, for example:
preferred, option 1, option 2, etc.

The list appears in decreasing order of the dimensions authorised by the vehicle manufacturer (standard, option 1, option 2, etc.) and for each dimension, as a function of priority parameters specified in the algorithm, in decreasing order of preference of the selections.

The operative can then select one of the options displayed, and the system then displays the inflation pressures calculated as a function of the factors of load on the wheel calculated above for the front and rear tyres.

The operative then validates the choices in step 210, and that ends the program.

We thus arrive at the advocated value sought with a level of accuracy and a level of safety and optimisation (including that regarding the output of the vehicle) which is greatly superior to that obtained by the prior art.

This result can be further refined by exploring the limits of the advocated result, as explained above.

The operative has means (for example cursors or +/- ranges to click on) allowing him to impose values on the speed of the vehicle, stability factors (greater or lesser tyre pressure) AND the incompatible parameter of flotation on soft or muddy terrain, and factors such as terrain type which were not the initial parameters. It is thus possible to verify, as explained above, that the advocated result is within the conditions present AND within a certain range of tolerances for the terrain, speed, stability/flotation. If the tolerance is considered to be too small in the case of one or more of the factors, exceeding the initial data provided, then the operative will have to search for a different tyre selection among those displayed to give sufficient tolerance.

The extremely high accuracy of the method and the system according to the invention will therefore be apparent.

If the operative does not validate the choice proposed, he goes back to step 190 and can enter new values for the terrain or the speed or add a complementary criterion of stability and/or flotation of the tyres.

Finally, the operative can impose a final advocated value for a pressure using his personal judgment.

The invention also covers all those embodiments and applications which will be directly obvious to those skilled in the art from reading the present application, from his or her own knowledge and where appropriate from simple routine tests.

2003214101 09 Aug 2007

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of advocating tyres on a worksite and calculating on the worksite the inflation pressures of said tyres for a construction vehicle having a front axle, a rear axle and a bucket intended to receive a load of material having a density DM, comprising the steps of:

a) making an estimate of a filling level TR of the bucket in conditions of maximum load for use on the worksite;

b) calculating a load CG created by the material filled to the filling level TR in the bucket from the bucket capacity VG and the estimated values for density DM and filling level TR;

c) calculating an overload V on the front axle from a tipping load CB which would produce a tipping of said vehicle;

d) verifying the value obtained for the overload V on the front axle from observations made when the vehicle is loaded to its maximum load for use on the worksite and when empty;

e) if the result of the verification of step D is negative, correcting the estimates of the density DM and/or the filling level TR and performing again the verification of the value obtained for the overload V on the front axle;

f) if the result of the verification of step D is positive, validating the estimate of the maximum load on the bucket CG in the conditions of use on the worksite;

g) using the value for the maximum load CG to calculate total loads ZAV and ZAR on the front axle and the rear axle, respectively;

h) calculating the load on each front tyre by dividing by two the total load ZAV on the front axle calculated in step G, and choosing a load value for each tyre of the rear axle greater than the total load ZAR on the rear axle divided by two;

i) determining the conditions of the terrain on the worksite and the average speed of use of the vehicle;

j) making a search of data from tyre manufacturers for the type or types of tyres and characteristics of tyres, including type, tread pattern and rubber compound quality, which most closely correspond to the loads calculated for the tyres of the front axle and the rear axle, for the conditions of use of the vehicle on the worksite, including the conditions of the terrain, and the average speed of use;

k) making a search of data from tyre manufacturers for the operating pressures of the tyres selected in step J on the front axle and rear axle respectively, corresponding to the loads calculated for the tyres of the front axle and rear axle in step H; and

l) choosing the operating pressures and the tyres for said vehicle.

2. A method according to claim 1 wherein the verifying of the overload V on the front axle in steps D and E comprises measuring the sagging of at least one of the tyres of the vehicle, between the sag value with no load and the sag value when the tyre in question is loaded.

3. A method according to claim 1 wherein the load CG is calculated in step B from the equation

$$CG = VG \times DM \times \frac{\mathrm{TR}}{100}$$

and the overload V is calculated in step C from the equation

$$CG = \frac{V}{100} \times CB$$

where CG=bucket load

VG=capacity of the bucket in m^3,

DM=density of the material to be loaded in kg/m^3,

TR=level of filling of the bucket in %,

V=estimate of the overload on the front axle resulting from the load on the bucket, expressed as % of the tipping load of the vehicle, and

CB=tipping load of the vehicle in kg.

4. A method according to claim 1 wherein the total loads ZAV and ZAR are calculated in step G from the equations:

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG$$

where ZAV=load on the front axle;
ZAR=load on the rear axle;
VAV=load on the front axle when empty;
VAR=load on the rear axle when empty;
CG=bucket load;
CB=tipping load of the vehicle in kg.

5. A method according to claim 1 wherein the average speed is determined in step I from the equation

speed=LxNb

where:
L=length of the cycle for loading/unloading in km;
Nb=number of cycles per hour.

6. A method of advocating tyres on a worksite and calculating on the worksite the inflation pressures of said tyres for a construction vehicle having a front axle, a rear axle and a bucket intended to receive a load of material having a density DM, comprising the following steps:

a) making an estimate of an overload V on the front axle in conditions of maximum use of the bucket from observations made when the vehicle is at maximum load for use on the worksite and when empty;

b) calculating and displaying a load CG in the bucket from a tipping load CB which would produce a tipping of the vehicle, from the equation:

$$CG = \frac{V}{100} \times CB$$

c) calculating a filling level TR of the bucket under said conditions of maximum load for use from the capacity VG of the bucket of said vehicle and estimating the values above DM and V from the equation:

$$TR = \frac{CG}{VG \times DM} \times 100$$

d) verifying the value obtained for the filling level TR of the bucket from observations made when the vehicle is loaded to its maximum load for use on the worksite;

e) if the result of the verification of step D is negative, correcting the estimates of the density DM and/or the overload V on the front axle and performing again the verification of the value obtained for the filling level TR of the bucket;

f) if the result of the verification of step D is positive, validating the estimate of the maximum load CG on the bucket in the conditions of use on the worksite;

g) using the value for the maximum load CG on the bucket validated in step F, to calculate total loads ZAV and ZAR on the front axle and the rear axle, respectively, from the equations

$$ZAV = VAV + \left(\frac{CB + VAR}{CB}\right) \times CG$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG$$

where ZAV=load on the front axle,

ZAR=load on the rear axle,

VAV=load on the front axle when empty,

VAR=load on the rear axle when empty

h) calculating the load on each front tyre by dividing by two the total load ZAV on the front axle calculated in step G, and choosing a load value for each tyre of the rear axle greater than the total load ZAR on the rear axle divided by two;

i) determining the conditions of the terrain on the worksite and the average speed of use of the vehicle;

j) making a search of data from tyre manufacturers for the type or types of tyres and characteristics of tyres, including type, tread pattern and the rubber compound quality, which best correspond to the loads calculated for the tyres of the front axle and the rear axle, for the conditions of use of the vehicle on the worksite, including the conditions of the terrain, and the average speed of use;

k) making a search of data from tyre manufacturers for the operating pressures of the tyres selected in step J on the front axle and rear axle respectively, corresponding to the loads calculated for the tyres of the front axle and rear axle in step H; and

l) choosing the operating pressures and the tyres for said vehicle.

7. A method according to claim 6 wherein the estimating and/or verifying of the overload V on the front axle in steps D and E comprises measuring the sagging of at least one of the tyres of the vehicle, between the sag value with no load and the sag value when the tyre in question is loaded.

8. A method according to claim 6 wherein the load CG is calculated in step B from the equation

$$CG=VGxDMxCB$$

and the overload V is calculated in step A from the equation

$$CG=\frac{V}{100}x\frac{TR}{100}$$

where CG=bucket load

VG=capacity of the bucket m^3,

DM=density of the material to be loaded in kg/m^3,

TR=level of filling of the bucket in %,

V=estimate of the overload on the front axle resulting from the load on the bucket, expressed as % of the tipping load of the vehicle, and

CB=tipping load of the vehicle in kg.

9. A method according to claim 6 wherein the total loads ZAV and ZAR are calculated in step G from the equations:

$$ZAV=VAV+\left(\frac{CB+VAR}{CB}\right)\times CG$$

$$ZAR = VAR - \left(\frac{VAR}{CB}\right) \times CG$$

where ZAV=load on the front axle;

ZAR=load on the rear axle;

VAV=load on the front axle when empty;

VAR=load on the rear axle when empty;

CG=bucket load;

CB=tipping load of the vehicle in kg.

10. A method according to claim 6 wherein the average speed is determined in step I from the equation

speed=LxNb

where:

L=length of the cycle for loading/unloading in km;

Nb=number of cycles per hour.

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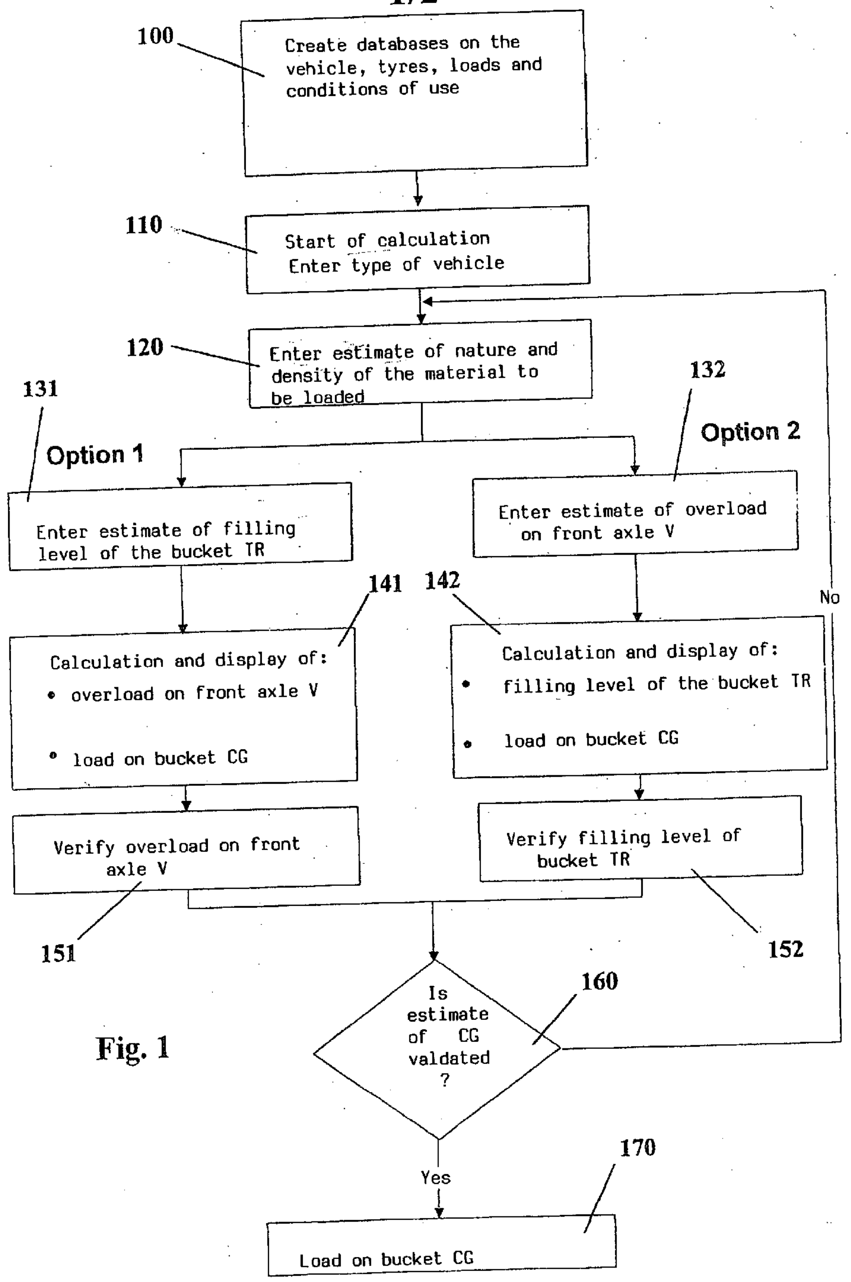
100
Create databases on the vehicle, tyres, loads and conditions of use
110
Start of calculation
Enter type of vehicle
120
Enter estimate of nature and density of the material to be loaded
131
Option 1
Enter estimate of filling level of the bucket TR
132
Option 2
Enter estimate of overload on front axle V
141
Calculation and display of:
• overload on front axle V
• load on bucket CG
142
Calculation and display of:
• filling level of the bucket TR
• load on bucket CG
Verify overload on front axle V
151
Verify filling level of bucket TR
152
No
Is estimate of CG valdated ?
160
Yes
Load on bucket CG
170

Fig. 1

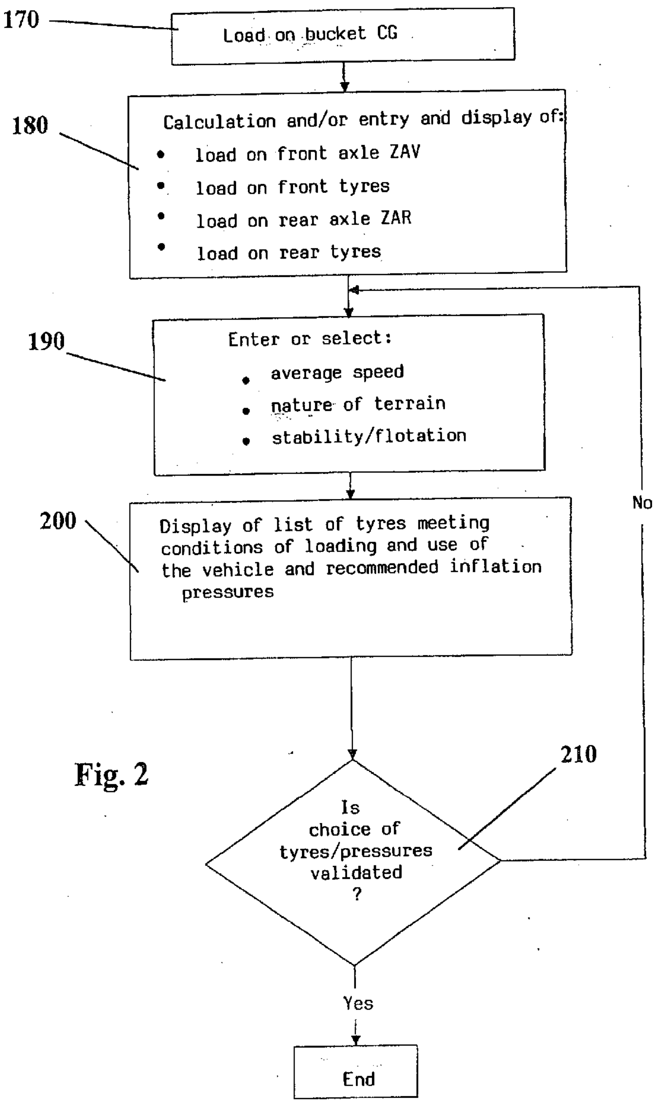
170
Load on bucket CG
180
Calculation and/or entry and display of:
• load on front axle ZAV
• load on front tyres
• load on rear axle ZAR
• load on rear tyres
190
Enter or select:
• average speed
• nature of terrain
• stability/flotation
200
Display of list of tyres meeting conditions of loading and use of the vehicle and recommended inflation pressures
210
Is choice of tyres/pressures validated ?
No
Yes
End

Fig. 2