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(54) **Titre : TRAITEMENT DE FLUX DE SABLES BITUMINEUX**
(54) **Title: PROCESSING OIL SAND STREAMS**

(57) **Abrégé/Abstract:**
Disclosed is a method of controlling an oil sand process. The method includes providing a feed stream comprising oil sand; analyzing the feed stream to obtain a fines parameter indicative of a fines content of the feed stream; and automatically adjusting a downstream additive dosage to the feed stream based on the obtained fines parameter.

ABSTRACT

Disclosed is a method of controlling an oil sand process. The method includes providing a feed stream comprising oil sand; analyzing the feed stream to obtain a fines parameter indicative of a fines content of the feed stream; and automatically adjusting a downstream additive dosage to the feed stream based on the obtained fines parameter.

PROCESSING OIL SAND STREAMS

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of oil sand processing.

Description of Related Art

[0002] This section is intended to introduce various aspects of the art, which may be associated with the present disclosure. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present disclosure. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0003] Modern society is greatly dependent on the use of hydrocarbon resources for fuels and chemical feedstocks. Hydrocarbons are generally found in subsurface formations that can be termed "reservoirs". Removing hydrocarbons from the reservoirs depends on numerous physical properties of the subsurface formations, such as the permeability of the rock containing the hydrocarbons, the ability of the hydrocarbons to flow through the subsurface formations, and the proportion of hydrocarbons present, among other things. Easily harvested sources of hydrocarbons are dwindling, leaving less accessible sources to satisfy future energy needs. As the costs of hydrocarbons increase, the less accessible sources become more economically attractive.

[0004] Recently, the harvesting of oil sand to remove heavy oil has become more economical. Hydrocarbon removal from oil sand may be performed by several techniques. For example, a well can be drilled to an oil sand reservoir and steam, hot air, solvents, or a combination thereof, can be injected to release the hydrocarbons. The released hydrocarbons may be collected by wells and brought to the surface. In another technique, strip or surface mining may be performed to access the oil sand, which can be treated with water, steam or solvents to extract the heavy oil.

[0005] Oil sand extraction processes are used to liberate and separate bitumen from oil sand so that the bitumen can be further processed to produce synthetic crude oil or mixed with diluent to form "dilbit" and be transported to a refinery plant. Numerous oil sand extraction processes have been developed and commercialized, many of which involve the use of water as a processing medium. Where the oil sand is treated with water, the technique may be referred to as water-based extraction (WBE). WBE is a commonly used process to extract bitumen from mined oil sand. Other processes are non-aqueous solvent-based processes. An example of a solvent-based process is described in Canadian Patent Application No. 2,724,806 (Adeyinka *et al*, published June 30, 2011 and entitled "Process and Systems for Solvent Extraction of Bitumen from Oil Sands"), which is incorporated herein by reference. Solvent may be used in both aqueous and non-aqueous processes.

[0006] One WBE process is the Clark hot water extraction process (the "Clark Process"). This process typically requires that mined oil sand be conditioned for extraction by being crushed to a desired lump size and then combined with hot water and perhaps other agents to form a conditioned slurry of water and crushed oil sand. In the Clark Process, an amount of sodium hydroxide (caustic) may be added to the slurry to increase the slurry pH, which enhances the liberation and separation of bitumen from the oil sand. Other WBE processes may use other temperatures and may include other conditioning agents, which are added to the oil sand slurry, or may operate without conditioning agents. This slurry is first processed in a Primary Separation Cell (PSC), also known as a Primary Separation Vessel (PSV), to extract the bitumen from the slurry.

[0007] In one bitumen extraction process, a water and oil sand slurry is separated into three major streams in the PSC: bitumen froth, middlings, and a PSC underflow.

[0008] Regardless of the type of WBE process employed, the process will typically result in the production of a bitumen froth that requires treatment with a solvent. For example, in the Clark Process, a bitumen froth stream comprises bitumen, solids, and water. Certain processes use naphtha to dilute bitumen froth before separating the product bitumen by centrifugation. These processes are called naphtha froth treatment (NFT) processes. Other

processes use a paraffinic solvent, and are called paraffinic froth treatment (PFT) processes, to produce pipelineable bitumen with low levels of solids and water. In the PFT process, a paraffinic solvent (for example, a mixture of iso-pentane and n-pentane) is used to dilute the froth before separating the product, diluted bitumen, by gravity. A portion of the asphaltenes in the bitumen is also rejected by design in the PFT process and this rejection is used to achieve reduced solids and water levels. In both the NFT and the PFT processes, the diluted tailings (comprising water, solids and some hydrocarbon) are separated from the diluted product bitumen.

[0009] Solvent is typically recovered from the diluted product bitumen component before the bitumen is delivered to a refining facility for further processing.

[0010] The PFT process may comprise at least three units: Froth Separation Unit (FSU), Solvent Recovery Unit (SRU) and Tailings Solvent Recovery Unit (TSRU). Mixing of the solvent with the feed bitumen froth may be carried out counter-currently in two stages in separate froth separation units. The bitumen froth comprises bitumen, water, and solids. A typical composition of bitumen froth is about 60 wt. % bitumen, 30 wt. % water, and 10 wt. % solids. The paraffinic solvent is used to dilute the froth before separating the product bitumen by gravity. The foregoing is only an example of a PFT process and the values are provided by way of example only. An example of a PFT process is described in Canadian Patent No. 2,587,166 to Sury, which is incorporated herein by reference.

[0011] From the PSC, the middlings, comprising bitumen and about 10-30 wt. % solids, or about 20-25 wt. % solids, based on the total wt. % of the middlings, is withdrawn and sent to the flotation cells to further recover bitumen. The middlings are processed by bubbling air through the slurry and creating a bitumen froth, which is recycled back to the PSC. Flotation tailings (FT) from the flotation cells, comprising mostly solids and water, are sent for further treatment or disposed in an external tailings area (ETA).

[0012] In ETA tailings ponds, a liquid suspension of oil sand fines in water with a solids content greater than 2 wt. %, but less than the solids content corresponding to the

Liquid Limit are called Fluid Fine Tailings (FFT). FFT settle over time to produce Mature Fine Tailings (MFT), having above about 30 wt. % solids.

[0013] It would be desirable to have an alternative or improved method of controlling an oil sand process.

SUMMARY

[0014] It is an object of the present disclosure to provide a method of controlling an oil sand process.

[0015] Disclosed is a method of controlling an oil sand process. The method comprises providing a feed stream comprising oil sand; analyzing the feed stream to obtain a fines parameter indicative of a fines content of the feed stream; and automatically adjusting a downstream additive dosage to the feed stream based on the obtained fines parameter.

[0016] The foregoing has broadly outlined the features of the present disclosure so that the detailed description that follows may be better understood. Additional features will also be described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and other features, aspects and advantages of the disclosure will become apparent from the following description, appending claims and the accompanying drawings, which are briefly described below.

[0018] Fig. 1 is a graph illustrating oil sand fines content of an oil sands feed stream versus K40 measurements.

[0019] Fig. 2 is a graph illustrating the impact of caustic on bitumen losses as a function of K40 measurements.

[0020] Fig. 3 is a flow diagram of a bitumen extraction system using a fines analyzer to adjust additive dosage.

[0021] Fig. 4 is a flow chart of a process control scheme to automatically adjust additive dosage based on fine analyzer measurements.

[0022] Fig. 5 is a graph of caustic concentration versus fines parameter.

[0023] Fig. 6 is a graph illustrating automatic adjustment of caustic dosage when a set K40 value is achieved.

[0024] Fig. 7 is a graph of the impact of not increasing caustic dosage automatically after an increase in K40.

[0025] It should be noted that the figures are merely examples and no limitations on the scope of the present disclosure are intended thereby. Further, the figures are generally not drawn to scale, but are drafted for purposes of convenience and clarity in illustrating various aspects of the disclosure.

DETAILED DESCRIPTION

[0026] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the features illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications, and any further applications of the principles of the disclosure as described herein are contemplated as would normally occur to one skilled in the art to which the disclosure relates. It will be apparent to those skilled in the relevant art that some features that are not relevant to the present disclosure may not be shown in the drawings for the sake of clarity.

[0027] At the outset, for ease of reference, certain terms used in this application and their meaning as used in this context are set forth below. To the extent a term used herein is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Further, the present processes are not limited by the usage of the terms shown below, as all equivalents,

synonyms, new developments and terms or processes that serve the same or a similar purpose are considered to be within the scope of the present disclosure.

[0028] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0029] A "hydrocarbon" is an organic compound that primarily includes the elements of hydrogen and carbon, although nitrogen, sulfur, oxygen, metals, or any number of other elements may be present in small amounts. Hydrocarbons generally refer to components found in heavy oil or in oil sand. However, the techniques described are not limited to heavy oils but may also be used with any number of other reservoirs to improve gravity drainage of liquids. Hydrocarbon compounds may be aliphatic or aromatic, and may be straight chained, branched, or partially or fully cyclic.

[0030] "Bitumen" is a naturally occurring heavy oil material. Generally, it is the hydrocarbon component found in oil sand. Bitumen can vary in composition depending upon the degree of loss of more volatile components. It can vary from a very viscous, tar-like, semi-solid material to solid forms. The hydrocarbon types found in bitumen can include aliphatics, aromatics, resins, and asphaltenes. A typical bitumen might be composed of:

19 weight (wt.) % aliphatics (which can range from 5 wt. % - 30 wt. %, or higher);

19 wt. % asphaltenes (which can range from 5 wt. % - 30 wt. %, or higher);

30 wt. % aromatics (which can range from 15 wt. % - 50 wt. %, or higher);

32 wt. % resins (which can range from 15 wt. % - 50 wt. %, or higher); and

some amount of sulfur (which can range in excess of 7 wt. %), the weight % based upon total weight of the bitumen.

In addition, bitumen can contain some water and nitrogen compounds ranging from less than 0.4 wt. % to in excess of 0.7 wt. %. The percentage of the hydrocarbon found in bitumen can vary. The term "heavy oil" includes bitumen as well as lighter materials that may be found in a sand or carbonate reservoir.

[0031] "Heavy oil" includes oils which are classified by the American Petroleum Institute ("API"), as heavy oils, extra heavy oils, or bitumens. The term "heavy oil" includes bitumen. Heavy oil may have a viscosity of about 1,000 centipoise (cP) or more, 10,000 cP or more, 100,000 cP or more, or 1,000,000 cP or more. In general, a heavy oil has an API gravity between 22.3° API (density of 920 kilograms per meter cubed (kg/m^3) or 0.920 grams per centimeter cubed (g/cm^3)) and 10.0° API (density of 1,000 kg/m^3 or 1 g/cm^3). An extra heavy oil, in general, has an API gravity of less than 10.0° API (density greater than 1,000 kg/m^3 or 1 g/cm^3). For example, a source of heavy oil includes oil sand or bituminous sand, which is a combination of clay, sand, water and bitumen.

[0032] "Fine particles" or "fines" are generally defined as those solids having a size of less than 44 microns (μm), as determined by laser diffraction particle size measurement.

[0033] "Coarse particles" are generally defined as those solids having a size of greater than 44 microns (μm).

[0034] The term "solvent" as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0035] The terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numeral ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and are considered to be within the scope of the disclosure.

[0036] The articles "the", "a" and "an" are not necessarily limited to mean only one, but rather are inclusive and open ended so as to include, optionally, multiple such elements.

[0037] The term "paraffinic solvent" (also known as aliphatic) as used herein means solvents comprising normal paraffins, isoparaffins or blends thereof in amounts greater than 50 wt. %. Presence of other components such as olefins, aromatics or naphthenes may counteract the function of the paraffinic solvent and hence may be present in an amount of only 1 to 20 wt. % combined, for instance no more than 3 wt. %. The paraffinic solvent may be a C_4 to C_{20} or C_4 to C_6 paraffinic hydrocarbon solvent or a combination of iso and normal components thereof. The paraffinic solvent may comprise pentane, iso-pentane, or a combination thereof. The paraffinic solvent may comprise about 60 wt. % pentane and about 40 wt. % iso-pentane, with none or less than 20 wt. % of the counteracting components referred above.

[0038] Bitumen extraction from mined oil sand via hot water extraction processes requires the use of one or more process aids such as caustic to aid separation of bitumen from the oil sand. Process aids such as caustic are particularly helpful in maintaining separation efficiency when an amount of fines increases in the oil sand. However, a common problem has been determining the appropriate dosage or controlling the dosage for an effective operation as the oil sand quality changes in real-time. This problem is also tied to the ability to reliably determine fines in the oil sand in real-time. In the absence of either real-time determination of fines content or a reliable measurement, an oil sand operator typically uses a fixed dosage of the process aids based on the anticipated amount of fines based on a static geological model. While this approach may function to some extent, process aid may be wasted where the fines are lower than expected or be insufficient where the fines are higher than expected, therefore, resulting in sub-optimal bitumen recovery.

[0039] The inventors have shown that fines parameters in an oil sand feed stream can be valuable information and can be used to adjust additive dosage in the stream.

[0040] Fig. 1 is a graph illustrating fines content of an oil sands feed stream versus K40 measurements of the oil sands feed stream. As seen, a somewhat proportional relationship (positive correlation) exists. To estimate fines content of the oil sands feed stream, samples were taken from the oil sands feed stream provided underneath the fines

analyzer location. The sample was then processed through a Dean-Stark extraction method to estimate the amount of bitumen, solids and water content of the oil sands feed stream. Further, a sub-sample from the separated solids was then analyzed by laser diffraction particle size measurement techniques to estimate fines contents. This was done for all the data shown in the Fig 1.

[0041] Fig. 2 is a graph illustrating the impact of caustic on bitumen losses as a function of K40 measurements. To estimate the bitumen loss, samples from PSC underflow slurry stream were taken. These samples were then analyzed by a Dean-Stark method to estimate wt. % of the bitumen in the total PSC underflow stream. In particular, Fig. 2 illustrates the amount of bitumen lost to the tailings (waste) stream (a measure of separation efficiency) from a primary separation cell (PSC) relative to the K40 measurement and caustic dosage. It can be seen that higher K40 measurements correlate to higher bitumen lost to the tailings if the caustic dosage is not increased. Bitumen lost to tailings reduces as the caustic is increased. The inventors have found that the K40 measurements (or similar measurement) can be used to proactively adjust caustic (or other additive) in a feed-forward process control manner. The observations from Fig. 2 have advantageously been used to develop a feed-forward process control scheme that adjusts additive dosage appropriately in relation to the fines content (or a fines parameter indicative of a fines content) estimated in real-time. This may result in more optimal use of the additives and/or improve consistency of separation efficiency, which may in turn improve bitumen recovery.

[0042] The present disclosure provides a method of controlling an oil sand process. First, a feed stream comprising oil sand is provided. The "feed stream" (or "oil sands feed stream") is any suitable feed stream comprising oil sand, for instance mined oil sand. The "oil sand process" simply means processing the feed stream. Then, the feed stream is analyzed to obtain a fines parameter indicative of a fines content of the feed stream. Next, a downstream additive dosage is automatically adjusted to the feed stream based on the obtained fines parameter, to use as an adjusted additive dosage. An example of this method is provided in Fig. 3.

[0043] Fig. 3 is a flow diagram of a bitumen extraction system using a fines analyzer to adjust additive dosage. In particular, a feed stream (302) comprising oil sand is fed to a dry ore handling system (304). The feed stream is analyzed, for instance using a K40 analyzer (306), to obtain a fines parameter indicative of a fines content of the feed stream. The feed stream (302) is passed to a slurry preparation plant (308) and to hydrotransport (310). Within the slurry preparation plant or hydrotransport, an additive, for instance caustic, may be added using an additive injection system (312). The additive addition is based on the analysis to automatically adjust a downstream additive dosage to the feed stream based on the obtained fines parameter. Following hydrotransport, the feed stream may be sent to a bitumen extraction plant (314) for bitumen extraction and further processing (316) as described, for instance, in the background section. In this context, "downstream" simply means downstream of the analysis and the additive addition would typically be prior to bitumen extraction.

[0044] The present disclosure also provides a method of controlling an oil sand process, the method comprising:

a. providing a feed stream comprising oil sand;
b. analyzing the feed stream to obtain a fines parameter indicative of a fines content of the feed stream;
c. determining whether the obtained fines parameter is above or below a predetermined threshold, and
    i. where the obtained fines parameter is below the predetermined threshold, automatically providing a baseline additive dosage to the feed stream; and
    ii. where the obtained fines parameter is above the predetermined threshold, automatically adjusting an additive dosage to the feed stream, wherein the adjusted additive dosage is greater than the baseline additive dosage, to assist downstream separation of bitumen from the feed stream; and
d. repeating steps a) to c).

[0045] An example of this method is provided in Figure 4. Fig. 4 is a flow chart of a process control scheme to automatically adjust additive dosage. In particular, the feed stream is analyzed (402) to obtain a fines parameter indicative of a fines content of the feed stream. Where the obtained fines parameter is below the predetermined threshold (T), a baseline additive dosage (D) is automatically provided to the feed stream (404). Baseline additive dosage can be changed over time based on extraction recovery performance. For example, in case of caustic as an additive, this baseline additive dosage may range from 0 – 50 ppmw of the feed stream. Similarly, predetermined threshold can be determined by using Fig 1 and selecting a set-point, running the extraction process and observing separation efficiency. The plant operating data were collected over time that covered a range of set-points, K40 measurements, fines content of the oil sands, amount of caustic (additive) added, and resulting extraction recovery or amount of bitumen in the tailing (waste) stream. This data was then analyzed to build and understand the relationship of the impact of caustic (additive) dosage on the extraction recovery over a range of K40 measurements and identifying an optimum caustic (additive) dosage that resulted in improved extraction recovery. One such relationship is shown in Fig. 5 which is a graph of caustic (ppm) injection versus fines parameter (c/s, counts per second) generated in this way that is shown to improve the extraction recovery without under/overdosing of the caustic (additive) for an estimated fines content (K40 measurement) of the oil sands. Returning to Fig. 4, where the obtained fines parameter is above the predetermined threshold (T), an adjusted additive dosage is automatically provided to the feed stream (406), wherein the adjusted additive dosage is greater than the baseline additive dosage (D), to assist downstream separation of bitumen from the feed stream. The adjusted additive dosage is held for a period of time (408) (Y) after which the feed stream is again analyzed (410). As shown in Figure 4, where the obtained fines parameter is below the predetermined threshold (T), a return to the baseline additive dosage (D) is automatically effected (412). Where the obtained fines parameter is above the predetermined threshold (T), the adjusted additive dosage is again automatically provided to the feed stream (414). In preferred embodiments, the predetermined threshold (T) is selected such that it corresponds to 5% to 15%, 5% to 10%, or less than 10% of the fines content of the feed stream.

[0046] It should be noted that in another envisioned embodiment, the system may be operated with no set predetermined threshold (T) and no set baseline additive dosage (D). In this embodiment, the additive dosage is simply adjusted over a full range of operating conditions according to a predetermined correlation between an optimum additive dosage and the fines content such as illustrated in Figure 5.

[0047] The process may also be run continuously without the holding step (408) (i.e., where Y is essentially equal to 0).

[0048] The adjusted additive dosage may either be a preselected amount or may be based on the measured fines parameter, for instance using an additive dosage versus fines parameter relationship as illustrated in Fig. 5. In the latter case, the process scheme of Fig. 4 is not needed. Rather, the fines parameter may simply be obtained and an additive dosage may be used based on the obtained fines parameter, and this may be effected continuously.

[0049] Fig. 6 is a graph illustrating automatic adjustment of caustic dosage when a set K40 value is achieved. In particular, Fig. 6 illustrates an example from a plant operation of auto-adjustment of caustic dosage when a pre-determined value of K40 measurement is triggered. As can be seen from Fig 6, increased caustic resulted in keeping the amount of bitumen lost within the operating target which otherwise would not have been achieved (as shown in Fig. 7). Fig. 7 is a graph of the impact of not increasing caustic dosage automatically after an increase in the K40 measurements. To estimate the bitumen loss, samples from PSC underflow slurry stream were taken. These samples were then analyzed by a Dean-Stark method to estimate wt. % of the bitumen in the total PSC underflow stream.

[0050] The adjusted additive dosage may be a predetermined dosage. The adjusted additive dosage may be based on the obtained fines parameter. Steps b) to c) may be repeated at predetermined intervals. Steps a) to c) may be effected continuously by continuously supplying the feed stream, continuously analyzing the feed stream, and continuously adjusting the downstream additive dosage, that is, without any holding step.

[0051] The fines parameter may be obtained using natural gamma radiation detection. The natural gamma radiation detection may comprise measuring gamma radiation emitted during decay of potassium-40, uranium-238, or thorium-232. The fines parameter may be expressed as counts per second as a function of either individual potassium-40, uranium-238, or thorium-232, or as a combined count per seconds of potassium-40, uranium-238, and thorium-232.

[0052] The fines parameter may be obtained using PGNAA (Prompt Gamma Neutron Activation Analysis), LIBS (Laser-Induced Breakdown Spectroscopy), reflectance Hyperspectroscopy, XRF (X-Ray Fluorescence), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), or Atomic Absorption (AA). The analysis may be effected online, inline, offline, or atline.

[0053] The method may further comprise adding water to the feed stream for use as a bitumen extraction fluid. The water may comprise a process aid. The process aid may comprise caustic. The process aid may comprise sodium silicate, soda ash, sodium tri-phosphate, lime, borax, kerosene, diesel, or sodium citrate.

[0054] The method may further comprise passing a combined stream of the feed stream, the added water, and the additive to a bitumen extraction process. The method may further comprise extracting bitumen from the combined stream. The additive may be added to the feed stream in a hydrotransport pipeline or slurry preparation plant.

[0055] The additive may comprise a process aid. The process aid which is added as the additive may comprise caustic. The process aid which is added as the additive may comprise sodium silicate, soda ash, sodium tri-phosphate, lime, borax, kerosene, diesel, or sodium citrate.

[0056] It should be understood that numerous changes, modifications, and alternatives to the preceding disclosure can be made without departing from the scope of the disclosure. The preceding description, therefore, is not meant to limit the scope of the disclosure. Rather, the scope of the disclosure is to be determined only by the appended claims and their

equivalents. It is also contemplated that structures and features in the present examples can be altered, rearranged, substituted, deleted, duplicated, combined, or added to each other.

CLAIMS:

1. A method of controlling an oil sand process, the method comprising:
   a) providing a feed stream comprising oil sand;
   b) analyzing the feed stream to obtain a fines parameter indicative of a fines content of the feed stream; and
   c) automatically adjusting a downstream additive dosage to the feed stream based on the obtained fines parameter, to use as an adjusted additive dosage.

2. A method of controlling an oil sand process, the method comprising:
   a) providing a feed stream comprising oil sand;
   b) analyzing the feed stream to obtain a fines parameter indicative of a fines content of the feed stream;
   c) determining whether the obtained fines parameter is above or below a predetermined threshold, and
      i. where the obtained fines parameter is below the predetermined threshold, automatically providing a baseline additive dosage to the feed stream; and
      ii. where the obtained fines parameter is above the predetermined threshold, automatically adjusting an additive dosage to the feed stream, wherein the adjusted additive dosage is greater than the baseline additive dosage, to assist downstream separation of bitumen from the feed stream; and
   d) repeating steps a) to c).

3. The method of claim 1 or 2, wherein the adjusted additive dosage is a predetermined dosage.

4. The method of claim 1 or 2, wherein the adjusted additive dosage is based on the obtained fines parameter.

5. The method of claim 4, wherein the adjusted additive dosage is based on a predetermined caustic injection rate to fines parameter correlation.

6. The method of claim 2, wherein the predetermined threshold corresponds to 5 to 15% of the fines content of the feed stream.

7. The method of any one of claims 1 to 6, wherein steps b) and c) are repeated at predetermined intervals.

8. The method of any one of claims 1 to 6, wherein steps a) to c) are effected continuously by continuously supplying the feed stream, continuously analyzing the feed stream, and continuously adjusting the downstream additive dosage.

9. The method of any one of claims 1 to 8, wherein the fines parameter is obtained using natural gamma radiation detection.

10. The method of claim 9, wherein the natural gamma radiation detection comprises measuring gamma radiation emitted during decay of potassium-40, uranium-238, or thorium-232.

11. The method of any one of claims 1 to 10, wherein the fines parameter is expressed as counts per second as function of either individual potassium-40, uranium-238, or thorium-232, or as a combined count per seconds of potassium-40, uranium-238, and thorium-232.

12. The method of any one of claims 1 to 8, wherein the fines parameter is obtained using PGNAA (Prompt Gamma Neutron Activation Analysis), LIBS (Laser-Induced BreakdownSpectroscopy), reflectance Hyperspectroscopy, XRF (X-Ray Fluorescence),

Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), or Atomic Absorption (AA).

13. The method of any one of claims 1 to 12, further comprising adding water to the feed stream for use as a bitumen extraction fluid.

14. The method of claim 13, wherein the water comprises a process aid.

15. The method of claim 14, wherein the process aid comprises caustic.

16. The method of claim 15, wherein a baseline caustic in the process aid is 0 to 50 ppmw of the feed stream.

17. The method of claim 14, wherein the process aid comprises sodium silicate, soda ash, sodium tri-phosphate, lime, borax, kerosene, diesel, or sodium citrate.

18. The method of any one of claims 13 to 17, further comprising passing a combined stream of the feed stream, the added water, and the additive to a bitumen extraction process.

19. The method of claim 18, further comprising extracting bitumen from the combined stream.

20. The method of any one of claims 1 to 19, wherein the additive is added to the feed stream in a hydrotransport pipeline or slurry preparation plant.

21. The method of any one of claims 1 to 20, wherein the additive comprises a process aid.

22. The method of claim 21, wherein the process aid which is added as the additive comprises caustic.

23. The method of claim 21, wherein the process aid which is added as the additive comprises sodium silicate, soda ash, sodium tri-phosphate, lime, borax, kerosene, diesel, or sodium citrate.

24. The method of any one of claims 1 to 23, wherein step b) is effected online, inline, offline, or atline.

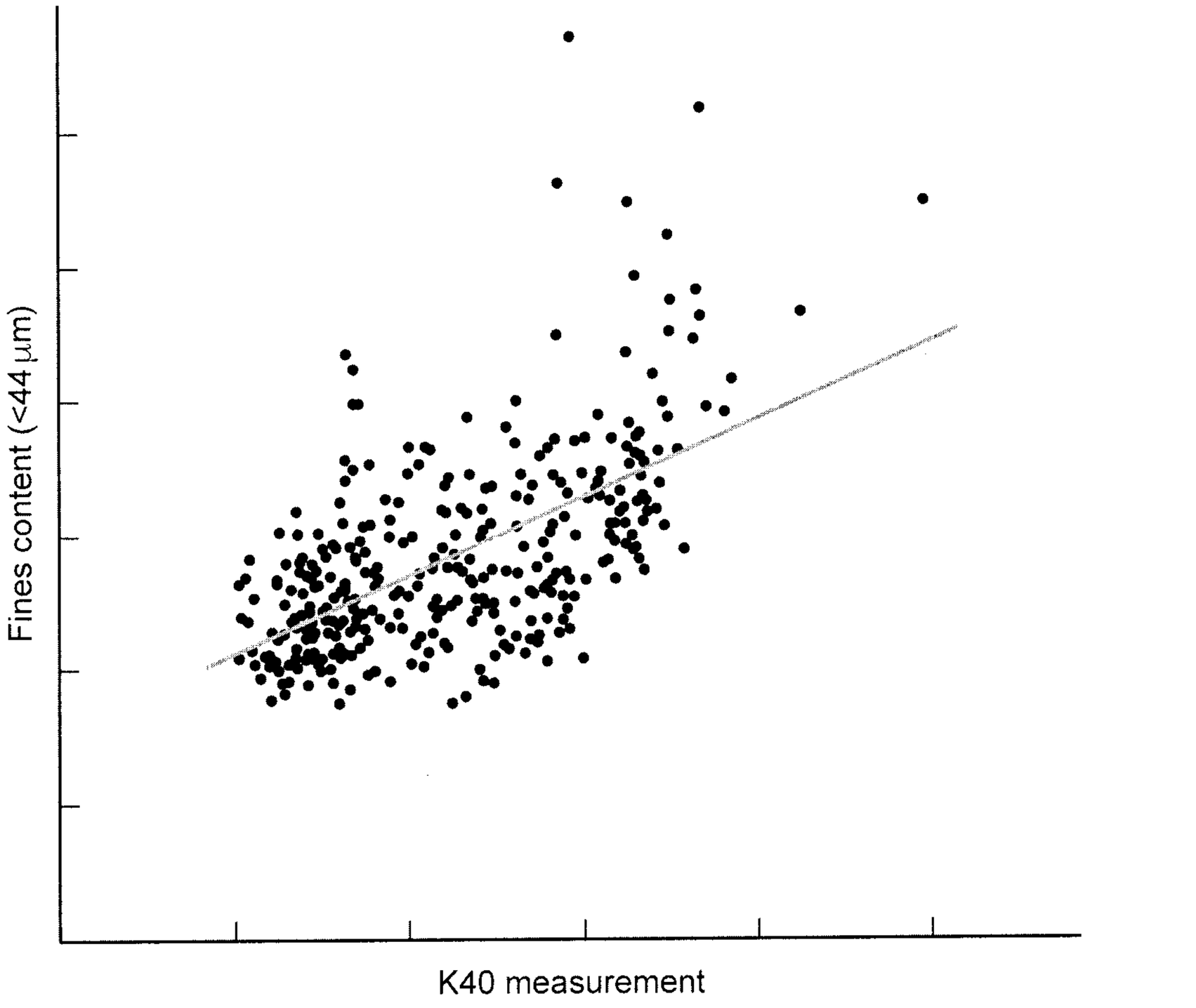

Fines content (<44 µm)
K40 measurement

FIG. 1

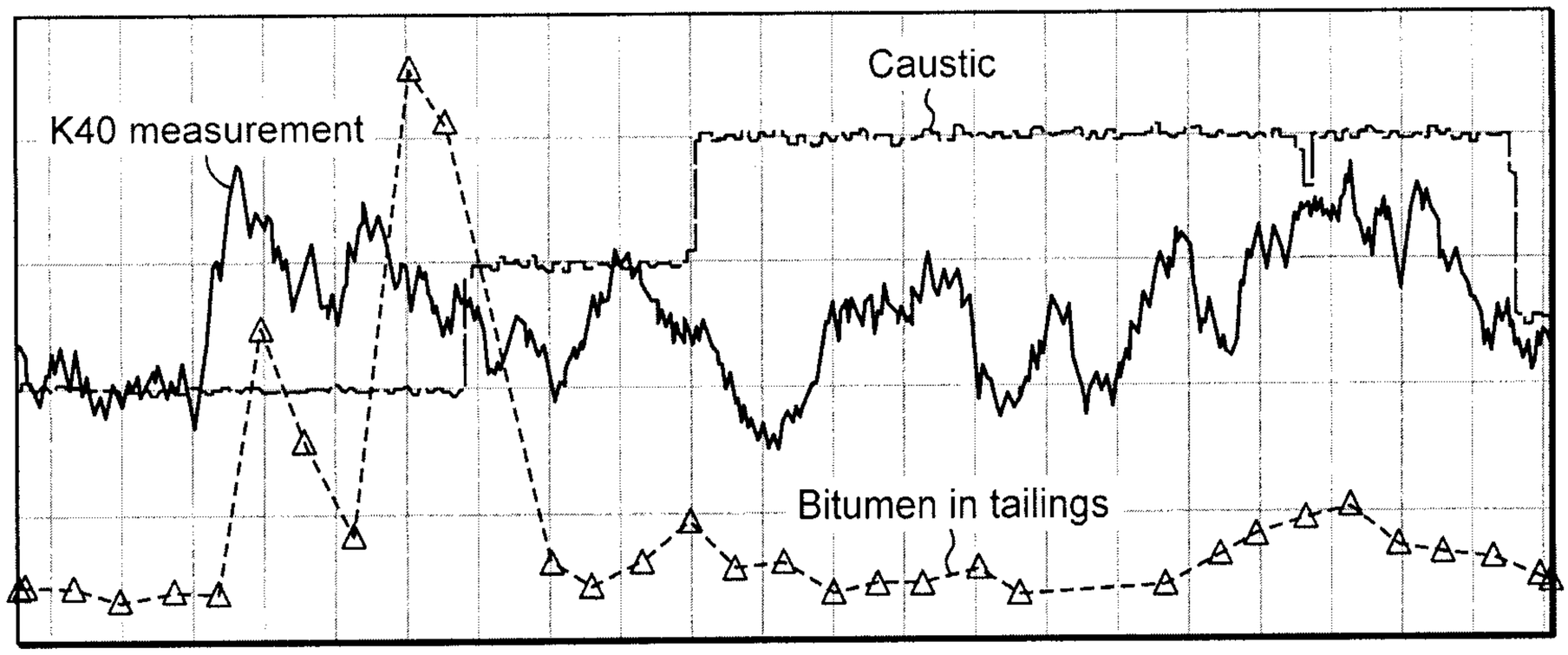

K40 measurement
Caustic
Bitumen in tailings

FIG. 2

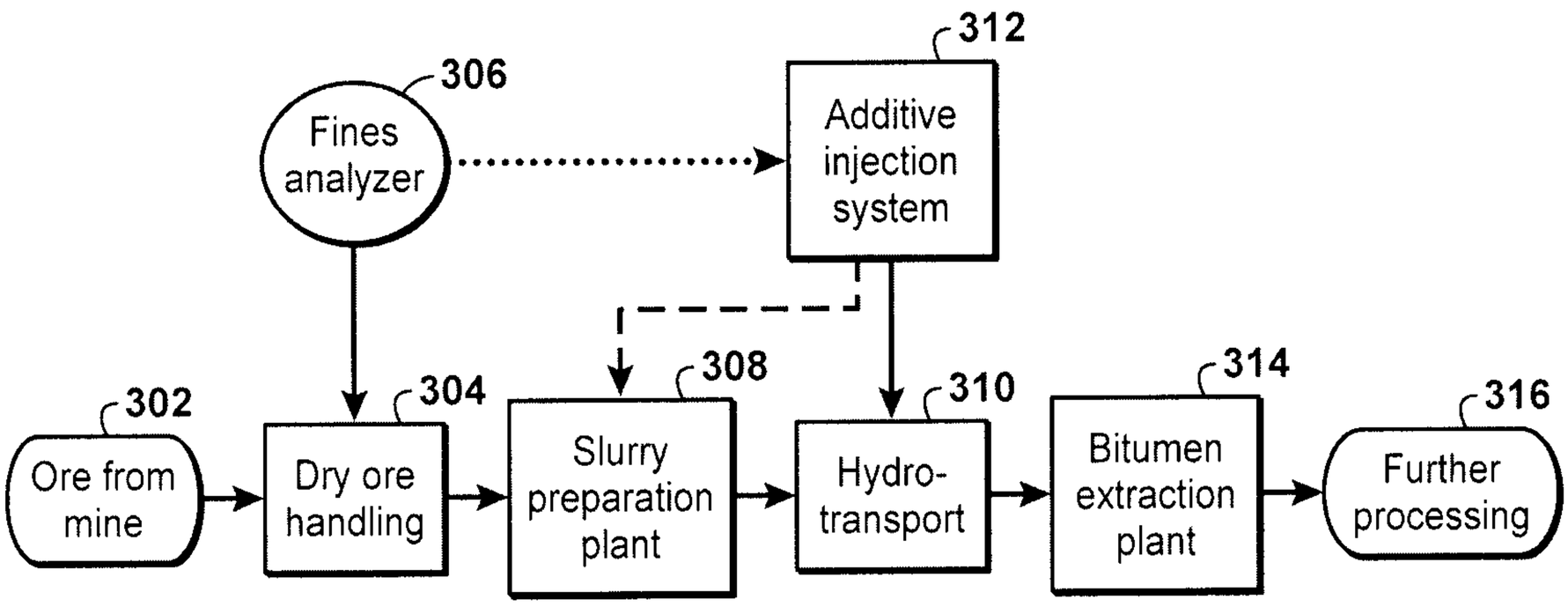

312
306
Fines analyzer
Additive injection system
308
314
316
302
304
310
Ore from mine
Dry ore handling
Slurry preparation plant
Hydro-transport
Bitumen extraction plant
Further processing

FIG. 3

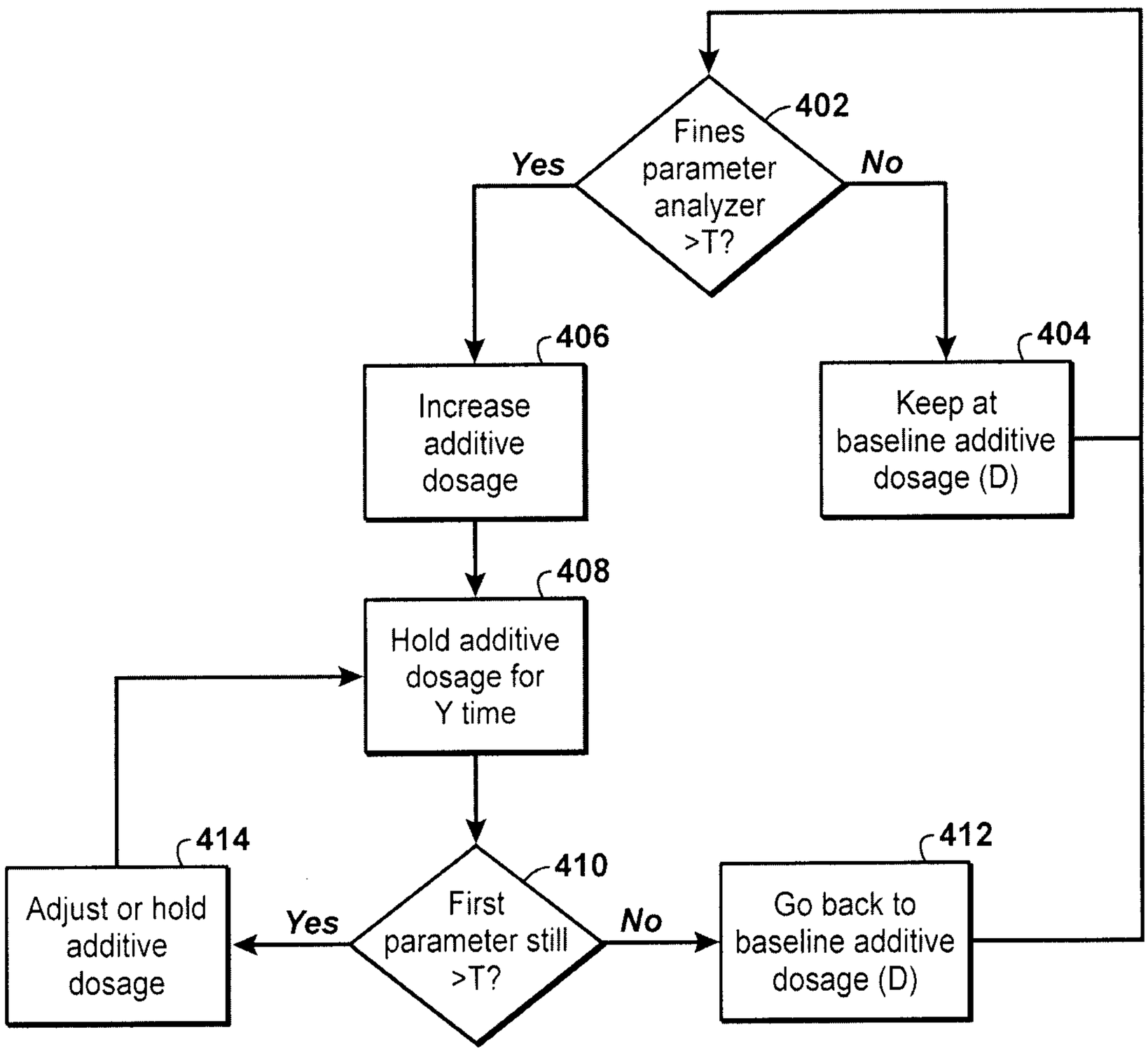

402
Fines parameter analyzer >T?
Yes
No
406
404
Increase additive dosage
Keep at baseline additive dosage (D)
408
Hold additive dosage for Y time
414
410
412
Adjust or hold additive dosage
Yes
First parameter still >T?
No
Go back to baseline additive dosage (D)

FIG. 4


Fines vs. Caustic Concentration Relationship
Caustic concentration - ppm
Fines - c/s

FIG. 5

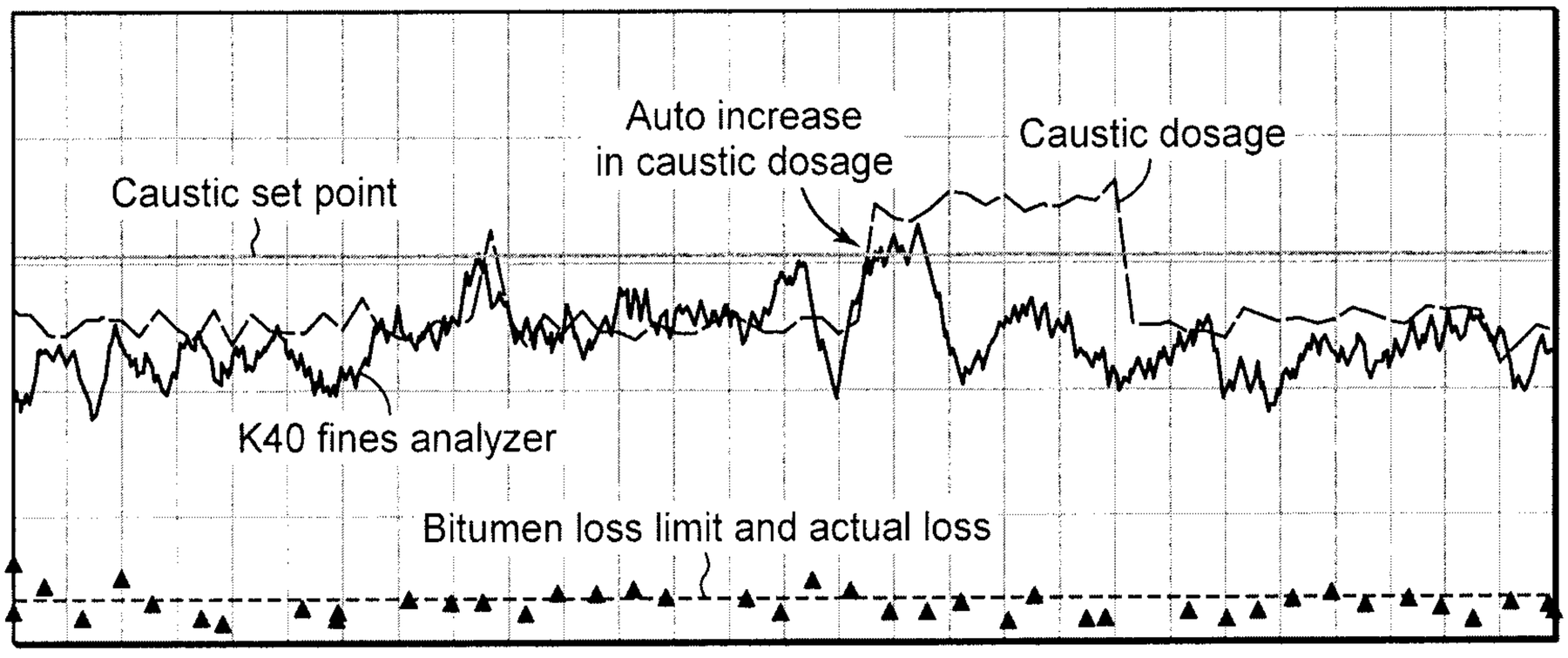

Auto increase
in caustic dosage
Caustic dosage
Caustic set point
K40 fines analyzer
Bitumen loss limit and actual loss

FIG. 6

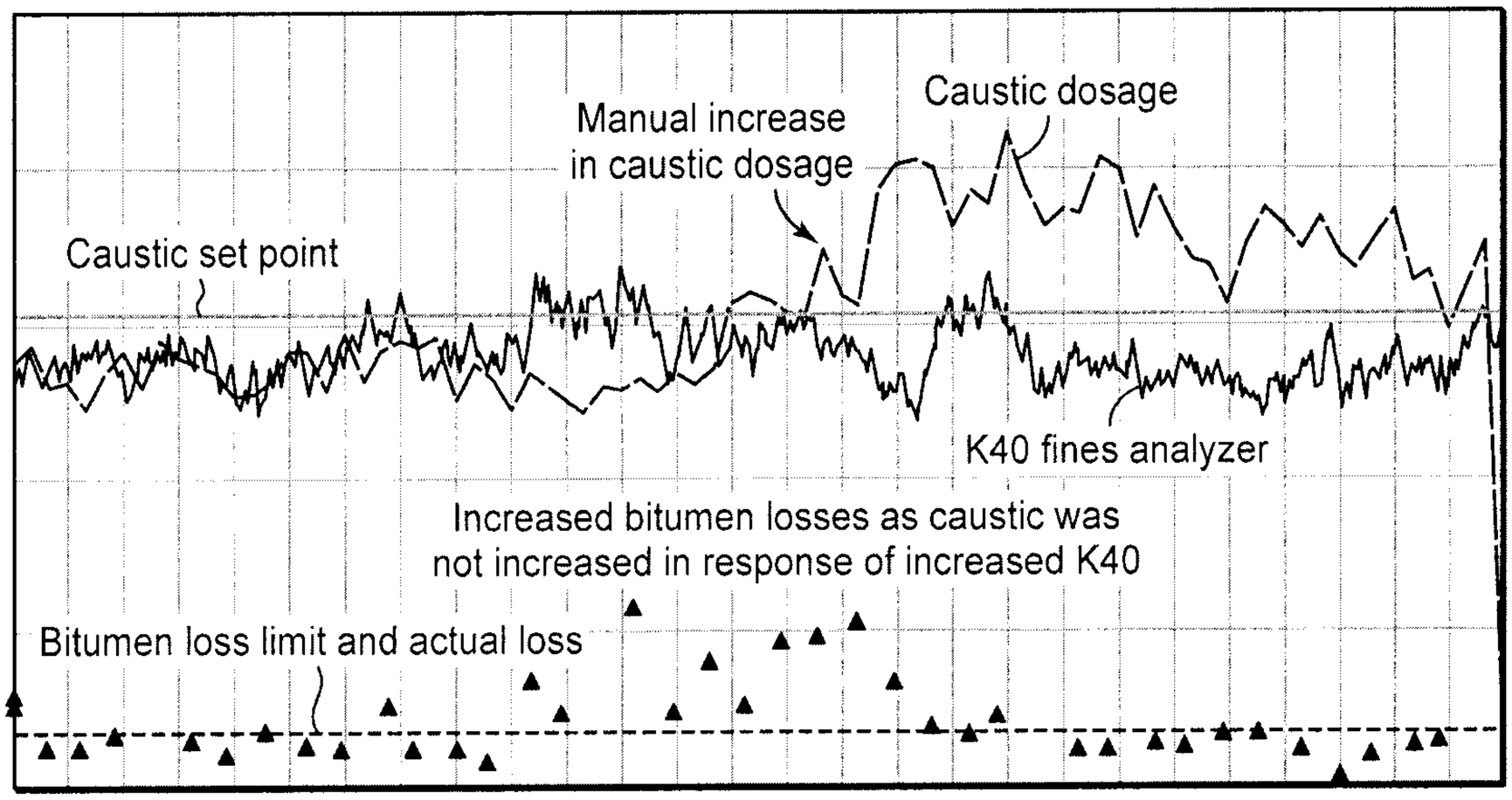

Manual increase
in caustic dosage
Caustic dosage
Caustic set point
K40 fines analyzer
Increased bitumen losses as caustic was
not increased in response of increased K40
Bitumen loss limit and actual loss

FIG. 7