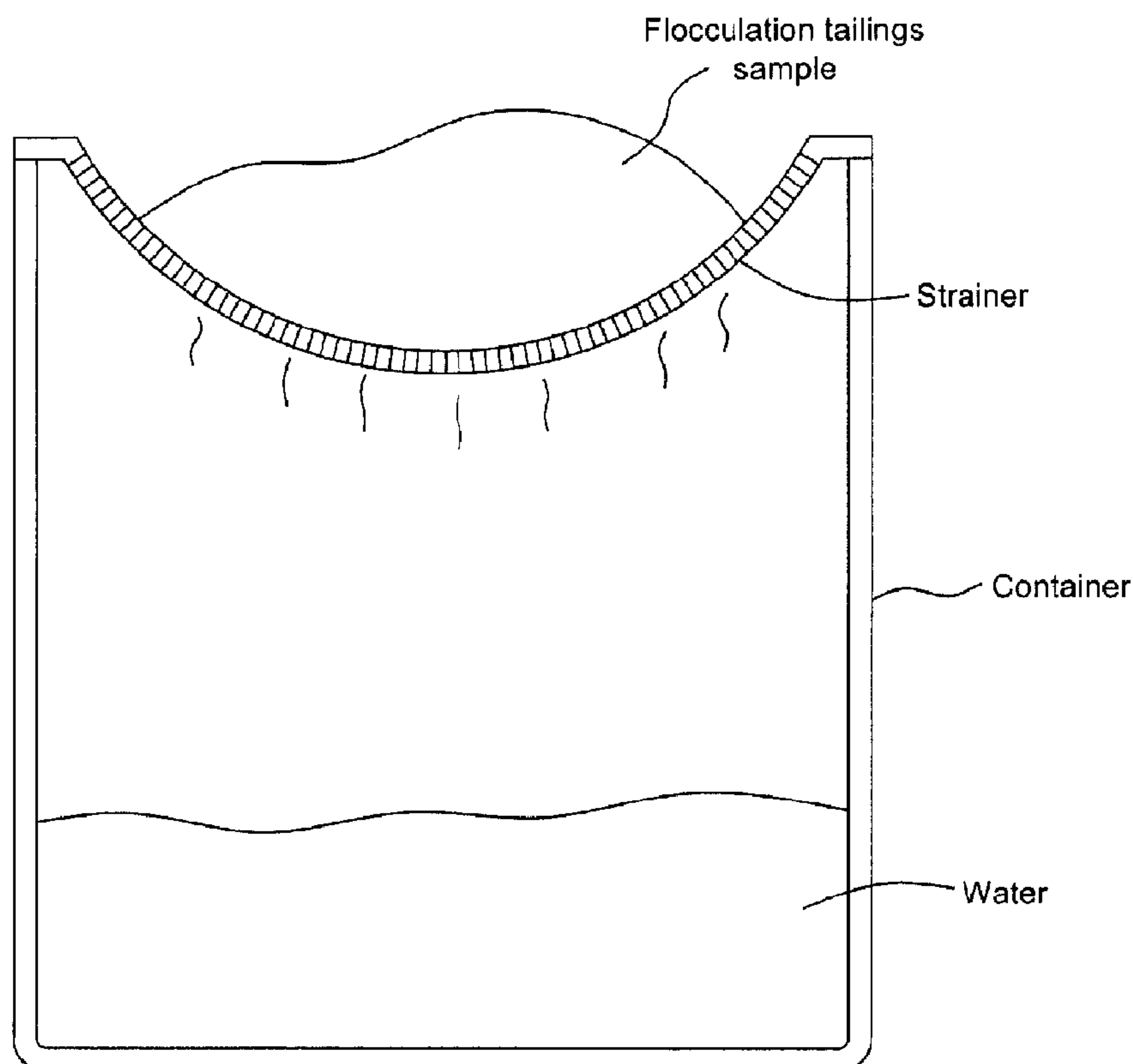




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(54) **Titre : SYSTEME ET METHODE DE TEST DESTINES A MESURER L'EAU LIBEREE DE RESIDUS FINS EPAIS FLOCULES ET
PROCEDE DE DESHYDRATATION CORRESPONDANT**
(54) **Title: TEST SYSTEM AND METHOD FOR MEASURING WATER RELEASE FROM FLOCCULATED THICK FINE TAILINGS AND
CORRESPONDING DEWATERING PROCESS**



(57) **Abrégé/Abstract:**

A system for testing water release from a sample of flocculated thick fine tailings can include a sample retrieval device for retrieving a sample of the flocculated thick fine tailings comprising a floc matrix and water; a strainer having a support surface for receiving the

(57) Abrégé(suite)/Abstract(continued):

sample of the flocculated thick fine tailings, the strainer comprising apertures sufficiently sized such that the support surface supports the floc matrix and allows a portion of the water to flow through the apertures as release water; a receptacle configured below on a downstream side of the strainer for receiving the release water passed through the apertures; and a measurement device for measuring the amount of release water received in the receptacle over a time period.

ABSTRACT

A system for testing water release from a sample of flocculated thick fine tailings can include a sample retrieval device for retrieving a sample of the flocculated thick fine tailings comprising a floc matrix and water; a strainer having a support surface for receiving the sample of the flocculated thick fine tailings, the strainer comprising apertures sufficiently sized such that the support surface supports the floc matrix and allows a portion of the water to flow through the apertures as release water; a receptacle configured below on a downstream side of the strainer for receiving the release water passed through the apertures; and a measurement device for measuring the amount of release water received in the receptacle over a time period.

TEST SYSTEM AND METHOD FOR MEASURING WATER RELEASE FROM FLOCCULATED THICK FINE TAILINGS AND CORRESPONDING DEWATERING PROCESS

FIELD OF THE INVENTION

- 5 The present invention generally relates to measurement and process control techniques for thick fine tailings, such as mature fine tailings that may be found in tailings ponds.

BACKGROUND

Tailings derived from mining operations, such as oil sands mining, are often placed in dedicated disposal ponds for settling.

- 10 The settling of fine solids from the water in tailings ponds can be a relatively slow process. Certain techniques have been developed for dewatering thick fine tailings. Dewatering of thick fine tailings can include contacting the fine tailings with a flocculant and then depositing the flocculated fine tailings in a deposition area where the deposited material can release water and eventually dry.
- 15 There are several factors that may influence performance of thick fine tailings dewatering operations and there are various challenges related to measurement and process control.

SUMMARY OF THE INVENTION

- In some implementations, there is provided a method of treating thick fine tailings, including: contacting the thick fine tailings with an aqueous solution including a
- 20 flocculating agent to disperse the flocculating agent into the thick fine tailings and to produce a flocculation tailings material; conditioning the flocculation tailings material, wherein the conditioning includes subjecting the flocculation tailings material to shear and modifying rheological properties of the flocculation tailings material in order to produce conditioned flocculated tailings; dewatering the conditioned flocculated tailings to produce
- 25 release water and a dewatered tailings material; allowing the dewatered tailings material to dry to obtain a dried tailings material; and regulating treatment of the thick fine tailings, including: determining dewatering characteristics of a sample of the conditioned flocculated tailings including measuring a Net Water Release (NWR) with respect to the

thick fine tailings, to thereby obtain a measured NWR parameter; and adjusting at least one operating condition in accordance with the measured NWR parameter to increase the release water produced in the dewatering step.

5 In some implementations, the at least one operating parameter includes: dosage of the flocculating agent with respect to the thick fine tailings; concentration of the flocculating agent in the aqueous solution; type of flocculating agent; flow rate of the thick fine tailings; and/or shear imparted to the flocculation tailings material.

10 In some implementations, adjusting the dosage of the flocculating agent with respect to the thick fine tailings includes modifying the concentration of the flocculating agent on a total clay basis of the thick fine tailings.

In some implementations, adjusting the dosage of the flocculating agent with respect to the thick fine tailings includes modifying the flow rate of the aqueous solution supplied into the thick fine tailings.

15 In some implementations, adjusting the dosage of the flocculating agent with respect to the thick fine tailings includes modifying the concentration of the flocculating agent in the aqueous solution.

In some implementations, adjusting the dosage of the flocculating agent with respect to the thick fine tailings includes modifying the flow rate of the thick fine tailings.

20 In some implementations, adjusting the concentration of the flocculating agent in the aqueous solution includes dissolving and/or dispersing a modified amount of the flocculating agent into water to form the aqueous solution.

In some implementations, adjusting the type of the flocculating agent includes selecting a flocculating agent from a set of candidate flocculating agents.

25 In some implementations, adjusting flow rate of the thick fine tailings includes modifying the volumetric or mass flow rate of the thick fine tailings.

In some implementations, adjusting the shear imparted to the flocculation tailings material includes modifying a configuration of a conditioning assembly through which the flocculation tailings material flows.

5 In some implementations, modifying the configuration of the conditioning assembly includes modifying a pipe length through which the flocculation tailings material flows.

In some implementations, adjusting the shear imparted to the flocculation tailings material includes modifying the flow rate of the thick fine tailings.

10 In some implementations, the step of determining dewatering characteristics of the conditioned flocculated tailings to measure the NWR includes obtaining the sample of the conditioned flocculated tailings prior to the dewatering step and determining the measured NWR parameter from the sample.

15 In some implementations, the step of monitoring the determining dewatering characteristics of the conditioned flocculated tailings includes a NWR testing scheme that includes at least one NWR test including: draining the sample for a given period of time; measuring an amount of water released from the sample during the given period of time, as a Gross Water Release (GWR); and subtracting a corresponding amount of added water present in the aqueous solution added to the thick fine tailings from the GWR, to obtain the measured NWR parameter.

20 In some implementations, the given period of time is at least 10 minutes, at least 1 hour, at least 12 hours, and/or at least 24 hours. In some implementations, the given period of time is between 20 minutes and 2 hours.

25 In some implementations, the NWR testing scheme further includes: conducting a first NWR test on a first portion of the sample, for a short given period of time, thereby obtaining a first measured NWR; conducting a second NWR test on a second portion of the sample, for a longer period of time, thereby obtaining a second measured NWR; comparing the first measured NWR and the second measured NWR, to determine

whether the dosage of the flocculating agent into the thick fine tailings is within an optimal range.

In some implementations, the longer given period of time is at least 6 times longer than the short period of time. In some implementations, the short given period of time is less than
5 1 hour. In some implementations, the short given period of time is less than 30 minutes. In some implementations, the longer given period of time is at least 6 hours. In some implementations, the longer given period of time is at least 12 hours.

In some implementations, if the first measured NWR is at least about 70% of the second measured NWR, the dosage of the flocculating agent into the thick fine tailings is
10 considered to be within an optimal range; and if the first measured NWR is below about 70% of the second measured NWR, the dosage of the flocculating agent into the thick fine tailings is considered to be outside of the optimal range, and the dosage of the flocculating agent is adjusted.

In some implementations, the method also includes adding an additional amount of the
15 flocculating agent to the sample; measuring the NWR to determine whether the sample is overdosed or underdosed in the flocculating agent; and adjusting the dosage of the flocculating agent with respect to the thick fine tailings if the sample is overdosed or underdosed, in order to increase the NWR.

In some implementations, adjusting the dosage of the flocculating agent includes
20 adjusting the flow rate of the thick fine tailings, adjusting the flow rate of the aqueous solution, and/or adjusting the concentration of the flocculating agent in the aqueous solution.

In some implementations, the measured NWR parameter is compared to pre-determined data for determining the step of adjusting the at least one operating condition.

25 In some implementations, the method includes conducting a flocculant dosing test to determine an initial dosage approximation of the flocculating agent required to flocculate

a sample of the thick fine tailings and obtain a positive measured NWR in response to shear conditioning beyond a peak static yield stress.

In some implementations, the initial dosage approximation of the flocculating agent is obtained by titration.

- 5 In some implementations, the method includes conducting a dose sweep test to determine variation of measured NWR as a function of dosage of flocculating agent around the initial dosage approximation; determining a revised dosage in accordance with a maximum NWR range; and utilizing the revised dosage to prepare the aqueous solution including the flocculating agent for the step of contacting with the thick fine
10 tailings.

- In some implementations, there is provided a method of treating thick fine tailings, including: contacting the thick fine tailings with an aqueous solution including a flocculating agent to disperse the flocculating agent into the thick fine tailings and to produce a flocculation tailings material; conditioning the flocculation tailings material,
15 wherein the conditioning includes subjecting the flocculation tailings material to shear and modifying rheological properties of the flocculation tailings material in order to produce conditioned flocculated tailings; dewatering the conditioned flocculated tailings to produce release water and a dewatered tailings material; allowing the dewatered tailings material to dry to obtain a dried tailings material; performing a flocculating agent dosage test
20 including determining an approximate dosage of the flocculating agent required to transformed a sample of the thick fine tailings into a sample conditioned flocculated tailings having a positive measured Net Water Release (NWR) in response to shear conditioning beyond a peak static yield stress; and adjusting at least one operating condition in accordance with the approximate dosage of the flocculating agent dosage
25 test, to obtain an optimal dosage range to increase the release water produced in the dewatering step.

In some implementations, the flocculant dosage test further includes: conducting a dose sweep test to determine variation of NWR as a function of dosage of flocculating agent around the approximate dosage that is considered as an initial dosage approximation;

determining a revised dosage in accordance with a maximum NWR range from the dose sweep test; and utilizing the revised dosage to prepare the aqueous solution including the flocculating agent for the step of contacting with the thick fine tailings.

5 In some implementations, the approximate dosage of the flocculating agent is obtained by titration techniques.

10 In some implementations, the measured NWR is determined according to a NWR testing scheme that includes at least one NWR test including: obtaining the sample of the conditioned flocculated tailings; draining the sample for a given period of time; measuring an amount of water released from the sample during the given period of time, as a Gross Water Release (GWR); and subtracting a corresponding amount of added water present in the aqueous solution added to the thick fine tailings from the GWR, to obtain the measured NWR parameter.

In some implementations, the given period of time is at least 10 minutes, at least 1 hour, at least 12 hours, at least 24 hours, or between 20 minutes and 2 hours.

15 In some implementations, the NWR testing scheme further includes: conducting a first NWR test on a first portion of the sample, for a short given period of time, thereby obtaining a first measured NWR; conducting a second NWR test on a second portion of the sample, for a longer period of time, thereby obtaining a second measured NWR; comparing the first measured NWR and the second measured NWR, to determine
20 whether the dosage of the flocculating agent into the thick fine tailings is within an optimal range.

In some implementations, the longer given period of time is at least 6 times longer than the short period of time. In some implementations, the short given period of time is less than 1 hour. In some implementations, the short given period of time is less than 30 minutes.

25 In some implementations, the longer given period of time is at least 6 hours. In some implementations, the longer given period of time is at least 12 hours.

In some implementations, if the first measured NWR is at least about 70% of the second measured NWR, the dosage of the flocculating agent into the thick fine tailings is considered to be within an optimal range; and if the first measured NWR is below about 70% of the second measured NWR, the dosage of the flocculating agent into the thick
5 fine tailings is considered to be outside of the optimal range, and the dosage of the flocculating agent is adjusted.

In some implementations, the method includes adding an additional amount of the flocculating agent to the sample; measuring the NWR to determine whether the sample is overdosed or underdosed in the flocculating agent; and adjusting the dosage of the
10 flocculating agent with respect to the thick fine tailings if the sample is overdosed or underdosed, in order to increase the NWR.

In some implementations, adjusting the dosage of the flocculating agent includes adjusting the flow rate of the thick fine tailings, adjusting the flow rate of the aqueous solution, and/or adjusting the concentration of the flocculating agent in the aqueous
15 solution.

In some implementations, there is provided a method of determining flocculating agent dosage for flocculating thick fine tailings, including: obtaining a sample of the thick fine tailings; adding different dosages of the flocculating agent to the sample of the thick fine tailings to obtain a flocculating sample material; subjecting the flocculating sample
20 material to shear conditioning beyond a peak static yield stress thereof; and selecting an initial dosage approximation of the flocculating agent that enables a positive measured Net Water Release (NWR) in response to the shear conditioning beyond the peak static yield stress.

In some implementations, there is provided a system for testing water release from a
25 sample of flocculated thick fine tailings, including: a sample retrieval device for retrieving a sample of the flocculated thick fine tailings including a floc matrix and water; a strainer having a support surface for receiving the sample of the flocculated thick fine tailings, the strainer including apertures sized such that the support surface supports the floc matrix and allows a portion of the water to flow through the apertures as release water under

gravity induced drainage; a receptacle configured below on a downstream side of the strainer for receiving the release water passed through the apertures; and a measurement device for measuring the amount of release water received in the receptacle over a time period.

- 5 In some implementations, the strainer has an upward concave construction.

In some implementations, the apertures have a pre-determined size that is sufficiently small to prevent substantially all of the floc matrix from passing there-through.

In some implementations, the strainer a metal mesh. In some implementations, the mesh is at most 1 millimeter.

- 10 In some implementations, the strainer is composed of a non-absorbent material.

In some implementations, the strainer is composed of plastic.

In some implementations, the measurement device includes a volumetric measurement device for measuring a volume of the entire contents of the receptacle.

- 15 In some implementations, the receptacle includes measurement indicia for allowing volumetric measurement of the release water over time. In some implementations, the receptacle includes a measurement cylinder. In some implementations, the receptacle includes a bucket.

- 20 In some implementations, the measurement device includes a drying apparatus for drying the contents of the receptacle to determine an amount of solids contained in the contents of the receptacle and thereby for determining a liquid water release value.

- 25 In some implementations, there is provided a method for testing water release from a sample of flocculated thick fine tailings, comprising: retrieving a sample of the flocculated thick fine tailings comprising a floc matrix and water; placing the sample of the flocculated thick fine tailings on a strainer having a support surface and apertures sized such that the support surface supports the floc matrix and allows a portion of the water to flow through

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the apertures as release water under gravity drainage conditions; receiving the release water passed through the apertures in a receptacle configured below on a downstream side of the strainer; and measuring an amount of release water received in the receptacle over a time period.

- 5 In some implementations, there is provided a process for flocculating and dewatering thick fine tailings, comprising: adding a flocculant to the thick fine tailing to form a flocculation tailings material; subjecting the flocculating material to conditioning to produce a conditioned flocculated thick fine tailings; dewatering the conditioned flocculated thick fine tailings; and testing water release from a sample of the conditioned
10 flocculated thick fine tailings using the system as defined above.

In some implementations, there is provided a process for flocculating and dewatering thick fine tailings, comprising: contacting the thick fine tailings with an aqueous solution including a flocculating agent to disperse the flocculating agent into the thick fine tailings and to produce a flocculation tailings material; conditioning the flocculation tailings
15 material, wherein the conditioning includes subjecting the flocculation tailings material to shear and modifying rheological properties of the flocculation tailings material in order to produce conditioned flocculated tailings; dewatering the conditioned flocculated tailings to produce release water and a dewatered tailings material; and testing water release from a sample of the conditioned flocculated thick fine tailings using the system as defined
20 above.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1 represents layers for a tailings pond.

Fig 2 is a perspective view schematic of a dewatering operation.

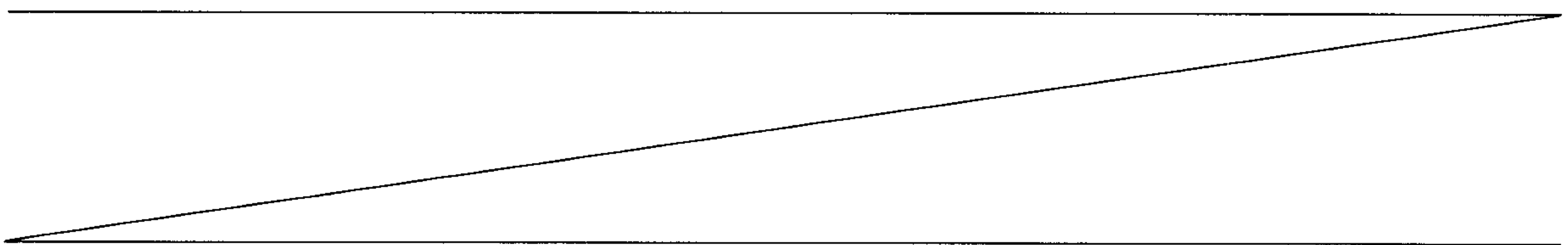


Fig 3 represents a schematic view of a dewatering operation.

Fig 4 represents a graph of shear yield stress versus time.

Fig 5 represents the effect of Net Water Release (NWR) on drying times.

Fig 6 represents variation of the NWR and yield stress as a function of mixing. Fig 7
5 represents variations of NWR and strength versus the length of a pipeline.

Fig 8 represents a sample of flocculation tailings on a strainer.

Fig 9 represents a decision tree.

Fig 10 represents variations of the NWR versus the Clay to Water Ratio (CWR).

Fig 11 represents variations of dose on a clay basis versus yield stress.

10 Fig 12 represents variation of the NWR versus dose.

Fig 13 represents an embodiment of the tailing laboratory test methodology, including
dose find test (phase I) and a dose sweep test (phase II) and optionally a full
characterization test (phase III) and/or an optional standard drying test (phase IV).

Fig 14 represents variations of the NWR versus the Clay to Water Ratio (CWR).

15 **DETAILED DESCRIPTION**

The present invention generally relates to measurement and process control techniques
for dewatering operations of thick fine tailings, such as mature fine tailings that may be
found in tailings ponds.

20 "Thick fine tailings" are suspensions derived from a mining operation and mainly include
water and fines. The fines are small solid particulates having various sizes up to about 44
microns. The thick fine tailings have a solids content with a fines portion sufficiently high
such that the fines tend to remain in suspension in the water and the material has slow
consolidation rates. More particularly, the thick fine tailings may have a ratio of coarse

particles to the fines that is less than or equal to 1. The thick fine tailings has a fines content sufficiently high such that flocculation of the fines and conditioning of the flocculated material can achieve a two phase material where release water can flow through and away from the flocs. For example, thick fine tailings may have a solids
5 content between 10 wt% and 45 wt%, and a fines content of at least 50 wt% on a total solids basis, giving the material a relatively low sand or coarse solids content. The thick fine tailings may be retrieved from a tailings pond, for example, and may include what is commonly referred to as "mature fine tailings" (MFT).

10 "MFT" refers to a tailings fluid that typically forms as a layer in a tailings pond and contains water and an elevated content of fine solids that display relatively slow settling rates. For example, when whole tailings (which include coarse solid material, fine solids, and water) or thin fine tailings (which include a relatively low content of fine solids and a high water content) are supplied to a tailings pond, the tailings separate by gravity into different layers over time. The bottom layer is predominantly coarse material, such as
15 sand, and the top layer is predominantly water. The middle layer is relatively sand depleted, but still has a fair amount of fine solids suspended in the aqueous phase. This middle layer is often referred to as MFT. MFT can be formed from various different types of mine tailings that are derived from the processing of different types of mined ore. While the formation of MFT typically takes a fair amount of time when derived from certain
20 whole tailings supplied from an extraction operation (e.g., between 1 and 3 years under gravity settling conditions in the pond), it should be noted that MFT and MFT-like materials may be formed more rapidly depending on the composition and post-extraction processing of the tailings, which may include thickening or other separation steps that may remove a certain amount of coarse solids and/or water prior to supplying the
25 processed tailings to the tailings pond.

Brief overview of flocculation and dewatering operations

In some implementations, the thick fine tailings are suspensions derived from an oil sands mining operation and are oil sands mature fine tailings (MFT) stored in a tailings pond. For illustrative purposes, the techniques described below are described in

reference to this example type of thick fine tailings, i.e., MFT, however, it should be understood that the techniques described can be used for thick fine tailings derived from sources other than an oil sands mining operation.

Referring to Fig 1, tailings are left over material derived from mining operations. As a non limiting example of tailings to be considered according to the invention, the tailings may be produced from an extraction process, such as a process for extracting bitumen from the oil sands. Fig 1 displays typical settling layers for tailings ponds. The middle layers are composed of the fine particles including clays suspended in water. Initially, the tailings with a relatively low fines content may be referred to as thin fine tailings (TFT), which consolidate typically over the course of two to three years and become mature fine tailings (MFT) with higher fines contents. As mentioned above, MFT is an example of thick fine tailings.

Fig 2 represents a general view of a dewatering operating for the treatments of thick fine tailings. For illustrative purposes, the techniques and systems are described in the context of MFT, however, it should be understood that other types of thick fine tailings can be used.

More particularly, as illustrated on Fig 3, thick fine tailings 1 may be pumped by a pump 3 from a tailing pond (as illustrated in Figs 1 and 2) and flows through a pipeline 5 which is provided with a chemical addition portion 7 including an injector 9 for in-line addition of a solution including a flocculating agent 11, forming a flocculation tailings. The pipeline 5 may also include a downstream portion (which may also be referred to as a "header") that may include branches 13 allowing expelling the flocculation tailings 15 into a deposition cell 17.

In some implementations, the pipeline may have certain dimensions for processing. For example, the downstream portion of the pipeline may have a 12 inch diameter. It may also have an overall length from the chemical addition portion 7 to the outlet spigots of less than 100 meters. Various types of pumps may be used to move the fluid through the pipeline.

Fig 4 illustrates general stages of the flocculation reaction over time, particularly in relation to static yield stress.

Fig 5 displays the effect of Net Water Release (NWR) has on the drying times of flocculated fine tailings. NWR is a metric that has been developed and is a measure of the differential in water between the starting thick fine tailings and the treated and drained thick fine tailings after a given draining time. In other words, NWR is a difference in moisture contents. The draining time may be 24 hours, 12 hours, 20 minutes, or 19 minutes, for example, or another representative time period for drainage in commercial applications. There are two main ways to calculate the NWR by volumetric or solid content difference. Example formula to calculate the NWR are as follows:

$$NWR = \left(\frac{\text{Quantity of water Recovered} - \text{Quantity of Flocculant Water Added}}{\text{Quantity of initial Fine Tailings Water}} \right)$$

$$NWR = 1 - \left(\frac{1}{tMFT \text{ wt\% mineral} + \text{wt\% Bitumen} - 1} \right) \div \left(\frac{1}{MFT \text{ wt\% mineral} + \text{wt\% Bitumen} - 1} \right)$$

A NWR test may be conducted using immediate drainage of a flocculation tailings sample for a drainage time of about 20 minutes. In this regard, for optimal dosage range and good flocculation, the water release in 10 or 20 minutes may be about 80% of the water release that would occur over a 12 to 24 hour period. For underdosed or overdosed samples, the water release in 20 minutes may be about 20% to 60% of the water release that would occur over a 12 to 24 hour period. The 20 minute NWR test may therefore be followed by a longer NWR test, e.g. 12 hour drainage time, which may use a water volume or solids content measurement approach. It is also noted that the laboratory and filed tests described herein used a volumetric 24 hour NWR test. Referring back to Fig 5, it can be seen that a greater initial water release results in a shorter drying duration that is required to achieve a certain solids target.

The NWR is dependent on several factors, including the dispersion of the flocculant into the thick fine tailings and the subsequent conditioning (including mixing) of the flocculation tailings. Rapid and thorough dispersion is preferred for increasing NWR.

Fig 6 displays four stages of treated flocculated tailings (tMFT) behaviour. Fig 6 is similar to Fig 4, but its stages will be presented in a different manner.

As can be seen from Fig 6, the rheological evolution of thick fine tailings that is subjected to flocculation may include the following stages:

- 5 (a) A dispersion stage where a flocculation reagent is rapidly mixed into the thick fine tailings and the flocculation begins, forming the flocculation tailings material.
- 10 (b) A floc build-up stage where the flocculation tailings increases in yield stress. In this stage, the flocculation tailings reaches a peak yield stress. Up to and around this peak yield stress the flocculation tailings material may be said to be “under-mixed” because insufficient mixing or conditioning has been performed to begin to breakdown the flocculated matrix and allow increased water release. Fig 6 shows that the water release is effectively nil up to a certain point just after the peak yield stress, after which the water release increases up to an initial maximum. Within this floc build-up and under-mixed stage, the flocculation tailings can resemble a gel state material and this stage also becomes smaller with improved dispersion.
- 15 (c) A floc breakdown stage where the flocculation tailings decreases in yield shear stress. This stage includes a water release zone where water is released from the flocculated matrix. Fig 6, for example, illustrates the water release zone beginning at a certain point within the floc breakdown stage, after the peak water release, and spanning a certain mixing time interval over which the water release gradually decreases. In this stage, the flocculated matrix takes on a more permeable state having two phases of flocs and water facilitating water to be released and separated from the flocs.
- 20 (d) An over-shear zone, which is avoided, where the flocs are broken down to a point that the material generally returns to a similar states as the initial thick fine tailings. Little to no water can release from the broken down flocculation matrix.
- 25

In order to facilitate efficient dewatering operations, the flocculation tailings may be consistently deposited within the water release zone.

Testing and control methodologies

Various testing and control methodologies will be described in further detail.

5 Net Water Release (NWR)

One test method includes determining the NWR of a sample of flocculation tailings. It should be noted that determining the NWR may be done in connection with a process control technique for adjusting or controlling a dewatering operation. Determining the NWR may also be done in the design or conception stage of a thick fine tailings dewatering plant, where sample of the thick fine tailings are treated at laboratory or pilot scale in order to determine certain process variables to be used for scale up to commercial applications.

The method for determining the NWR may first include obtaining a sample of flocculation tailings. The sample of flocculation tailings may be obtained from a commercial or pilot scale dewatering operation, for example from the outlet of the conditioning pipeline that supplies the flocculation tailings into the deposition cell or from freshly deposited flocculation tailings within the deposition cell proximate or advancing away from the outlets. More particularly, the flocculation tailings are deposited in thin lifts on a beach of the deposition cell. Alternatively, the sample of flocculation tailings may be prepared in the laboratory by mixing of a flocculant into a sample of thick fine tailings.

Once the flocculation tailings sample is obtained, the method then includes straining the sample for a given period of time.

Referring to Fig 8 shows an example setup for straining the flocculation tailings sample. The sample may be placed on a strainer. The strainer may have an upward concave construction or may be flat. An upward concave construction may prevent the sample from flowing off of the strainer in the event the sample has sufficiently low yield stress. The strainer may have a pore size that is pre-determined and sufficiently small to prevent

substantially all of the flocs of the sample from passing through. The pore size of the strainer may vary depending on the flocculant, the type of tailings, and the dispersion and conditioning steps. For example, the pore size of the strainer may be between about 0.1 mm to 10 mm. In one scenario, an 18 mesh (1 mm sieve size) flat screen was employed.

5 The pore size is sufficient to allow release water to drain out of the flocculation tailings and pass through the strainer into a receptacle, as illustrated schematically in Fig 8.

The strainer may be composed of a variety of materials and may have various configurations. For example, it may include a metal mesh or a mesh composed of another material. In some implementations, the parts of the strainer that are in contact

10 with the sample are composed of a non-absorbent material, e.g. metal or plastic.

The strainer may have a configuration such that a substantial amount of the release water passing through it is downward and due to gravity induced drainage mechanism. Alternatively, if the strainer is configured to be at least partially in contact with side portions of the sample, a portion of the release water may pass through the strainer as

15 lateral release.

The release water is allowed to drain through the strainer and then can be collected in a receptacle. The receptacle may include a collection bucket or a measuring cylinder, for example. The measuring cylinder may be configured to allow measuring water release rate over time, as the volume of water may be taken from the level of the measuring

20 cylinder. The method then includes measuring an amount of water released from the sample during the given period of time, as a Gross Water Release (GWR). This measurement may be conducted in a number of ways. For example, the measurement may be done by determining the volume in the receptacle into which the release water was collected. This collected material contains mainly water, but may also contain an

25 amount of suspended solids that were not captured in the flocculation tailings. Thus a simple volumetric measurement may be considered as an estimate of the release water but can be used as the measured GWR. Another method of measuring the amount of release water is by using a drying technique, e.g. by collecting all of the passing material collected in the receptacle, weighing it, and subjecting it to evaporation to determined

how much water was contained in the material. It is understood that the first method would be a faster way of estimating the GWR compared to the second, and the second method may allow greater accuracy. It is also noted that both methods may be performed for a same NWR determination scheme, and they may be compared to determine the amount of solids contained in the material passed through the strainer.

The method for determining the NWR also includes subtracting an amount of added water present in the flocculating agent solution from the GWR, to obtain the measured NWR. Since the flocculant may be added as part of an aqueous solution, dissolved and/or dispersed in the solution, water may be added to the thick fine tailings upon addition of the flocculant. This amount of water may thus be subtracted from the GWR to obtain an estimate of the net amount of water that was released from the flocculation tailings.

In one example of determining NWR, a 300 ml to 500 ml flocculation tailings sample may be obtained from flocculation tailings that is flowing, depositing or has been deposited on the deposition area. The sample is then poured over a strainer, e.g. as illustrated in Fig 8, and allowed to drain for a period of time such as 24 hours. The water release is then measured, for example using a graduated cylinder.

A variety of time periods may be used for allowing the sample to release water. Different release water times may also provide an indication as to whether flocculant dosage may be improved. For example, for optimal flocculant dosage range and good mixing/flocculation, the water release in 20 minutes has been found to be about 80% of the water release that would occur over a 12 to 24 hour period. At better flocculant dosage, dispersion and handling conditions, water releases faster and the NWR over a shorter period of time is closer to the total water that is released from the flocculation tailings. For underdosed or overdosed samples, the water release in 20 minutes may only be about 20% to 60% of the water release that would occur over a 12 to 24 hour period. A 20 minute NWR test may therefore be followed by a longer NWR test, e.g. 12 hour drainage time, which may use a water volume or solids content measurement approach.

In some scenarios, the NWR testing scheme may include one or more individual NWR tests on the same or different samples. In some cases, the NWR at different drainage times may be tracked for a dewatering operation, and one or more operating parameters may be adjusted based on the NWR measurements. For example, if the measured NWR starts to decrease, operating parameters may be adjusted until the NWR increases.

Flocculant dosage testing

Another test method includes determining optimal flocculant dosage ranges for flocculating and dewatering the thick fine tailings.

In general, the flocculant dosage testing may include determining an amount of the flocculating agent required to transform a sample of the thick fine tailings into a sample of flocculation tailings having a positive measured Net Water Release (NWR) in response to shear conditioning beyond a peak static yield stress.

In particular, the dosage testing may include a dose find test (Phase I) and a dose sweep test (Phase II).

The Phase I test may include incremental addition of an amount of flocculant to the sample of thick fine tailings until flocculation and water release are observed. For example, 1 to 5 ml of flocculant solution may be incrementally added to the thick fine tailings sample. The sample is subjected to mixing during the flocculant addition, which may be constant rotations per minute of an impeller mixer blade. Each increment of flocculant is well mixed into the sample before adding the next amount of flocculant. Incremental addition may be viewed as a titration to determine an approximate dosage of flocculant for flocculating the given sample and achieving a water release zone. The incremental addition is repeated until a change in the structure of the sample and water release is observed. The water release may be measured by various means, including one of the NWR tests described herein and/or a Capillary Suction Time (CST) test.

The Phase II test may be conducted where the flocculant for a given approximate dosage (e.g. determined in Phase I or previously estimated from data sets) is injected all at once.

The flocculant may be added to a thick fine tailings sample and then the sample may be subjected to mixing, which may be a two stage mixing of rapid shear mixing to induce dispersion of the flocculant into the sample followed by a slower mixing to shear condition the flocculation sample until it reaches the water release zone. NWR may be determined for each dosage of the sweep. For example, dosages 100 PPM either side of the approximate dosage from Phase I may be determined to produce a dosage curve for each sample (e.g. NWR vs. dosage). Additional dosages beyond those may also be tested to provide a more complete curve. The Phase II dose results may be a reasonable indicator of the dosage requirements in up-scaled commercial application of flocculation and dewatering operations. Fig 12 illustrates NWR as a function of dose of flocculant according to dose find test (Phase I) and dose sweep test (Phase II). It is noted that the dose is slightly higher in Phase I than in Phase II, and consequently the NWR can be slightly lower. NWR may also be lower in Phase II if dispersion is not effective in Phase II.

Thus, the flocculant dosage test may include conducting a first dosage test (e.g. Phase I) to identify an initial dosage approximation at which positive NWR occurs and a second dosage sweep test (e.g. Phase II) to determine variation of NWR as a function of dosage of flocculating agent around the initial dosage approximation. The next step may include determining a revised dosage in accordance with a maximum NWR range or value from the dose sweep test. The dosage giving the maximum NWR value may also be extrapolated from the dosage sweep curve if it appears that the maximum dosage would be between two adjacent doses that were actually tested. The revised dosage can then be used for implementing and/or adjusting a flocculation and dewatering operation.

Optionally, as illustrated in Fig 13, the dosage test (e.g. Phase I) and the dosage sweep test (e.g. Phase II), may be followed by full characterization tests (e.g. Phase III) and/or a standard drying test (Phase IV). The full characterization tests (e.g. Phase III) allow the determination of the water release, YS, Viscosity and/or CST in different mixing zones. A single injection may be used. The standard drying test (e.g. Phase IV) allows the determination of the effect of dose and water release on drying rates and rheology.

It is also noted that flocculant dosage is dependent on clay content of the thick fine tailings. An increase in clay content will often result in an increase in flocculant dosage requirements, unless other process variables are modified.

Water release has also been correlated with clay to water ratio (CWR). The optimal dose may be correlated with the % clay and the static yield stress of the thick fine tailings and/or the amount of shearing imparted to the thick fine tailings prior to flocculation (pre-shearing, which reduces yield stress). Also, it has been noted that the static yield stress of the flocculation tailings may be correlated with CWR. The dose find test may therefore be used to determine a particular thick fine tailings sensitive to dose of flocculating agent.

Fig 10 illustrates NWR as a function of CWR. Water release for the laboratory mixer at an initial mixing rate of 320 rpm is a function of the CWR. A high NWR was observed at lower CWR. It is also noted that the NWR in commercial operations has been noted to be higher than the laboratory settings. Fig 14 illustrates further data regarding NWR as a function of CWR.

Fig 11 shows that the dose on a clay basis is correlated with the static yield stress of the thick fine tailings. Modeling may be performed to determine the approximate dose from the static yield stress and % SBW of the fine tailings. Thick fine tailings can also be "pre-sheared" lowering the yield stress and dose.

Some integrated testing methods and process control

Implementation and/or adjustment of operating parameters of the flocculation and dewatering operation may be performed in light of various test methodologies. Various tests may be conducted in order to determine whether to adjust one or more operating parameters of the dewatering process.

When flocculation tailings are not optimal with respect to expected or desired NWR values, then a collected sample can be further treated to determine an appropriate adjustment measure to take in order to improve dewatering performance.

For example, the collected sample may be further treated with additional mixing and/or flocculant addition according to one or more steps as outlined in the decision tree illustrated in Fig. 9. This decision tree can enable determining if the flocculation tailings are under-dosed in flocculant, over-dosed in flocculant, under-mixed or over-mixed.

- 5 Dosage, mixing and shear conditioning are factors that can influence the flocculation and dewatering performance. Upon determining one or more probable causes of lower water release, appropriate changes or adjustments to one or more operating parameters of the process can be determined and implemented.

- 10 Referring still to Fig 9, a sample of flocculation tailings may be collected and first evaluated to determine if the sample have good flocs and/or good NWR (see Fig 6 for images and qualitative descriptions of the flocs). In some implementations, the macroscopic structure of the flocs may be observed to determine whether good flocs are present. It may also be possible to conduct microscopic observations of the floc structure to make this determination. If good flocs and water release are observed, the sample may
15 be considered to be optimally dosed and mixed. However, when the sample does not have optimal NWR and/or good flocs, then the sample may be subjected to the following set of steps:

Scenario A (if the sample does not have a poor floc structure)

- 20 A sample having good floc structure may be stirred (e.g. in a lab mixer to impart additional shear conditioning) until some thinning occurs (e.g. reduction in yield stress), and determine whether there is water release. If so, then the original sample was likely properly dosed but under-mixed. The additional shear conditioning was sufficient to reach the water release zone to enable water to separate from the flocs. The commercial application may be adjusted in order to impart additional shear conditioning to the
25 flocculation tailings, e.g. by flowing the flocculation tailings through a longer pipeline section prior to deposition.

If additional mixing does not result in water release, additional flocculant may be added to the sample. The amount of flocculant may be 10 ml, for example. The new mixture is then stirred (e.g. in a lab mixer to impart additional shear conditioning). If there is water release,

then the original sample was likely under-dosed in flocculant. One may then take note of the additional polymer that was added in order to achieve a dose enabling increased water release. The commercial application may be adjusted in order to increase the dosage, e.g. by increasing the flocculant concentration in the flocculant solution added to the tailings and/or by increasing the flow rate of the flocculant solution relative to the tailings.

If the first increment of additional flocculant does not lead to water release, incremental addition may continue as per the above paragraph, in order to gradually increase the flocculant dosage in the sample and observe the effect on water release after imparting shear to the mixture. If many increments of additional flocculant are added without any observed increase in water release, this indicates that the original sample was likely marginally over-dosed. The commercial application may be adjusted by lowering the dose slightly.

Scenario B (the sample has a poor floc structure)

A sample having poor floc structure may be stirred (e.g. in a lab mixer to impart addition shear conditioning) until thinning occurs. An amount of flocculant may then be added to the thinned mixture, for example 10 ml of flocculant. The resulting mixture is then stirred again to disperse the flocculant into the sample.

If the sample thickens, one may observe whether there is any water release. If there is water release, then the original sample was likely under-dosed in flocculant and the commercial application may be adjusted in order to increase the dosage. If there is little to no water release, then the step of adding an amount of flocculant (e.g. 10 ml) followed by stirring may be repeated. If a subsequent iteration results in observed water release, then the original sample was likely under-dosed in flocculant. The added amount of flocculant to enable water release may be noted and used to adjust and/or design the commercial operation.

If the sample, after repeated iterations of flocculant addition and stirring, does not release water, then it can be considered as over-dosed in flocculant. At this stage, certain

observations can be made regarding the sample. For example, if the floc structure changed without an increase in yield stress, the original sample was likely over-dosed and the commercial application may be adjusted in order to reduce the dosage. If the sample is shiny, then the original sample was likely over-dosed and the commercial
5 application may be adjusted in order to reduce the dosage.

On the other hand, if the floc structure did not change without an increase in yield stress, or the sample is not shiny, then the original sample was likely at an appropriate dose but was entering or within an oversheared zone. One may take note whether there was water release in the original sample, to determine to what approximate extent the additional
10 stirring may have caused the sample to be oversheared.

CLAIMS

1. A system for testing water release from a sample of flocculated thick fine tailings, comprising:
 - a sample retrieval device for retrieving a sample of the flocculated thick fine tailings comprising a floc matrix and water;
 - a strainer having a support surface for receiving the sample of the flocculated thick fine tailings, the strainer comprising apertures sized such that the support surface supports the floc matrix and allows a portion of the water to flow through the apertures as release water under gravity induced drainage;
 - a receptacle configured below on a downstream side of the strainer for receiving the release water passed through the apertures; and
 - a measurement device for measuring the amount of release water received in the receptacle over a time period.
2. The system of claim 1, wherein the strainer has an upward concave construction.
3. The system of claim 1 or 2, wherein the apertures have a pre-determined size that is sufficiently small to prevent all of the floc matrix from passing there-through.
4. The system of any one of claims 1 to 3, wherein the strainer is a metal mesh.
5. The system of claim 4, wherein the mesh is at most 1 millimeter.
6. The system of any one of claims 1 to 5, wherein the strainer is composed of a non-absorbent material.

7. The system of claim 6, wherein the strainer is composed of plastic.
8. The system of any one of claims 1 to 7, wherein the measurement device comprises a volumetric measurement device for measuring a volume of the entire contents of the receptacle.
9. The system of any one of claims 1 to 7, wherein the volumetric measurement device comprises the receptacle, and the receptacle includes measurement indicia for allowing volumetric measurement of the release water over time.
10. The system of claim 9, wherein the receptacle includes a measurement cylinder.
11. The system of any one of claims 1 to 7, wherein the receptacle includes a bucket.
12. The system of any one of claims 1 to 7, wherein the measurement device comprises a weighing apparatus and a drying apparatus for drying the contents of the receptacle to determine an amount of solids contained in the contents of the receptacle and thereby determine a liquid water release value.
13. The system of any one of claims 1 to 12, wherein the thick fine tailings comprise oil sands mature fine tailings.
14. The system of any one of claims 1 to 13, wherein the thick fine tailings have a mineral solids content between about 10 wt% and about 45 wt% and have a fines content of at least 50 wt% on a total solids basis.
15. The system of any one of claims 1 to 14, wherein the sample retrieval device is configured to retrieve the sample from an operating flocculation and dewatering process.

16. A method for testing water release from a sample of flocculated thick fine tailings, comprising:
 - retrieving a sample of the flocculated thick fine tailings comprising a floc matrix and water;
 - placing the sample of the flocculated thick fine tailings on a strainer having a support surface and apertures sized such that the support surface supports the floc matrix and allows a portion of the water to flow through the apertures as release water under gravity drainage conditions;
 - receiving the release water passed through the apertures in a receptacle configured below on a downstream side of the strainer; and
 - measuring an amount of release water received in the receptacle over a time period.
17. The method of claim 16, wherein the strainer has an upward concave construction.
18. The method of claim 16 or 17, wherein the apertures have a pre-determined size that is sufficiently small to prevent substantially all of the floc matrix from passing there-through.
19. The method of any one of claims 16 to 18, wherein the strainer is a metal mesh.
20. The method of claim 19, wherein the mesh is at most 1 millimeter.
21. The method of any one of claims 16 to 20, wherein the strainer is composed of a non-absorbent material.

22. The method of any one of claims 16 to 21, wherein the strainer is composed of plastic.
23. The method of any one of claims 16 to 22, wherein the measuring of the release water is performed using a measurement device that comprises a volumetric measurement device for measuring a volume of the entire contents of the receptacle.
24. The method of claim 23, wherein the volumetric measurement device comprises the receptacle, and the receptacle includes measurement indicia for allowing volumetric measurement of the release water over time.
25. The method of claim 24, wherein the receptacle includes a measurement cylinder.
26. The method of any one of claims 16 to 24, wherein the receptacle includes a bucket.
27. The method of any one of claims 16 to 22, wherein the measuring of the release water is performed using a measurement device that comprises a weighing apparatus and a drying apparatus for drying the contents of the receptacle to determine an amount of solids contained in the contents of the receptacle and thereby determine a liquid water release value.
28. The method of any one of claims 16 to 27, wherein the time period is between 12 hours and 24 hours.
29. The method of any one of claims 16 to 27, wherein the time period is between 10 minutes and 2 hours.
30. The method of any one of claims 16 to 27, wherein the time period is at least 10 minutes.

31. The method of any one of claims 16 to 27, wherein the time period is at least 1 hour.
32. The method of any one of claims 16 to 27, wherein the time period is at least 12 hours.
33. The method of any one of claims 16 to 27, wherein the time period is sufficiently long to achieve 80% of the water release that would occur over a 12 hour to 24 hour period.
34. A process for flocculating and dewatering thick fine tailings, comprising:
 - adding a flocculant to the thick fine tailing to form a flocculation tailings material;
 - subjecting the flocculating material to conditioning to produce a conditioned flocculated thick fine tailings;
 - dewatering the conditioned flocculated thick fine tailings, wherein the dewatering comprises gravity drainage of water; and
 - testing water release from a sample of the conditioned flocculated thick fine tailings using the system as defined in any one of claims 1 to 15 or the method as defined in any one of claims 16 to 33.
35. The process of claim 34, wherein the dewatering comprises expelling the conditioned flocculated thick fine tailings from a pipeline.
36. The process of claim 35, wherein the dewatering comprises expelling the conditioned flocculated thick fine tailings from the pipeline onto a deposition area.
37. The process of claim 36, wherein the deposition area comprises a beach.

38. The process of claim 36 or 37, wherein the conditioned flocculated thick fine tailings are deposited in multiple lifts.
39. The process of any one of claims 34 to 38, wherein the adding of the flocculant to the thick fine tailings comprises in-line addition of a flow an aqueous solution including the flocculant into a flow of the thick fine tailings.
40. The process of any one of claims 34 to 39, wherein the dewatering is performed on the conditioned flocculated thick fine tailings within a water release zone thereof.
41. The process of any one of claims 34 to 40, further comprising adapting the process based on the amount of release water received in the receptacle over the time period.
42. A process for flocculating and dewatering thick fine tailings, comprising:
 - contacting the thick fine tailings with an aqueous solution including a flocculating agent to disperse the flocculating agent into the thick fine tailings and to produce a flocculation tailings material;
 - conditioning the flocculation tailings material, wherein the conditioning includes subjecting the flocculation tailings material to shear and modifying rheological properties of the flocculation tailings material in order to produce conditioned flocculated tailings;
 - dewatering the conditioned flocculated tailings to produce release water and a dewatered tailings material, wherein the dewatering comprises gravity drainage of the release water; and

testing water release from a sample of the conditioned flocculated thick fine tailings using the system as defined in any one of claims 1 to 15 or the method as defined in any one of claims 16 to 33.

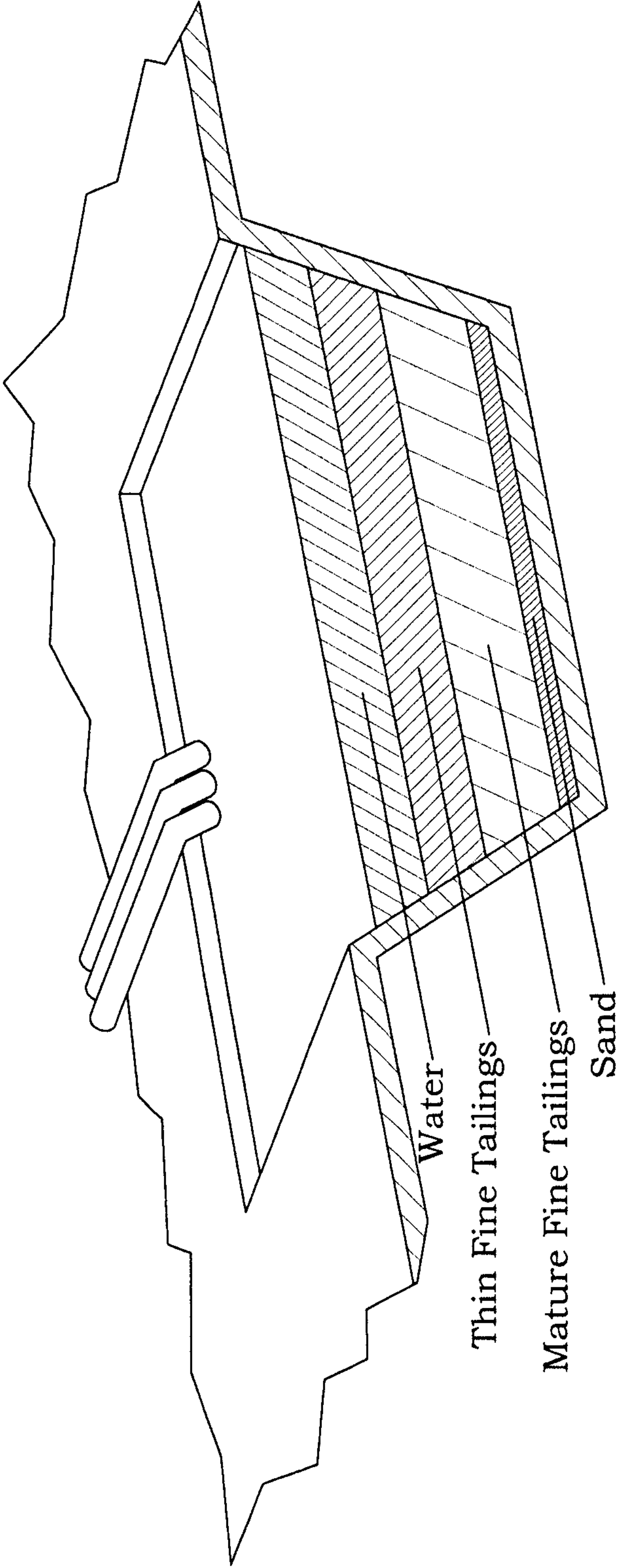


FIG. 1

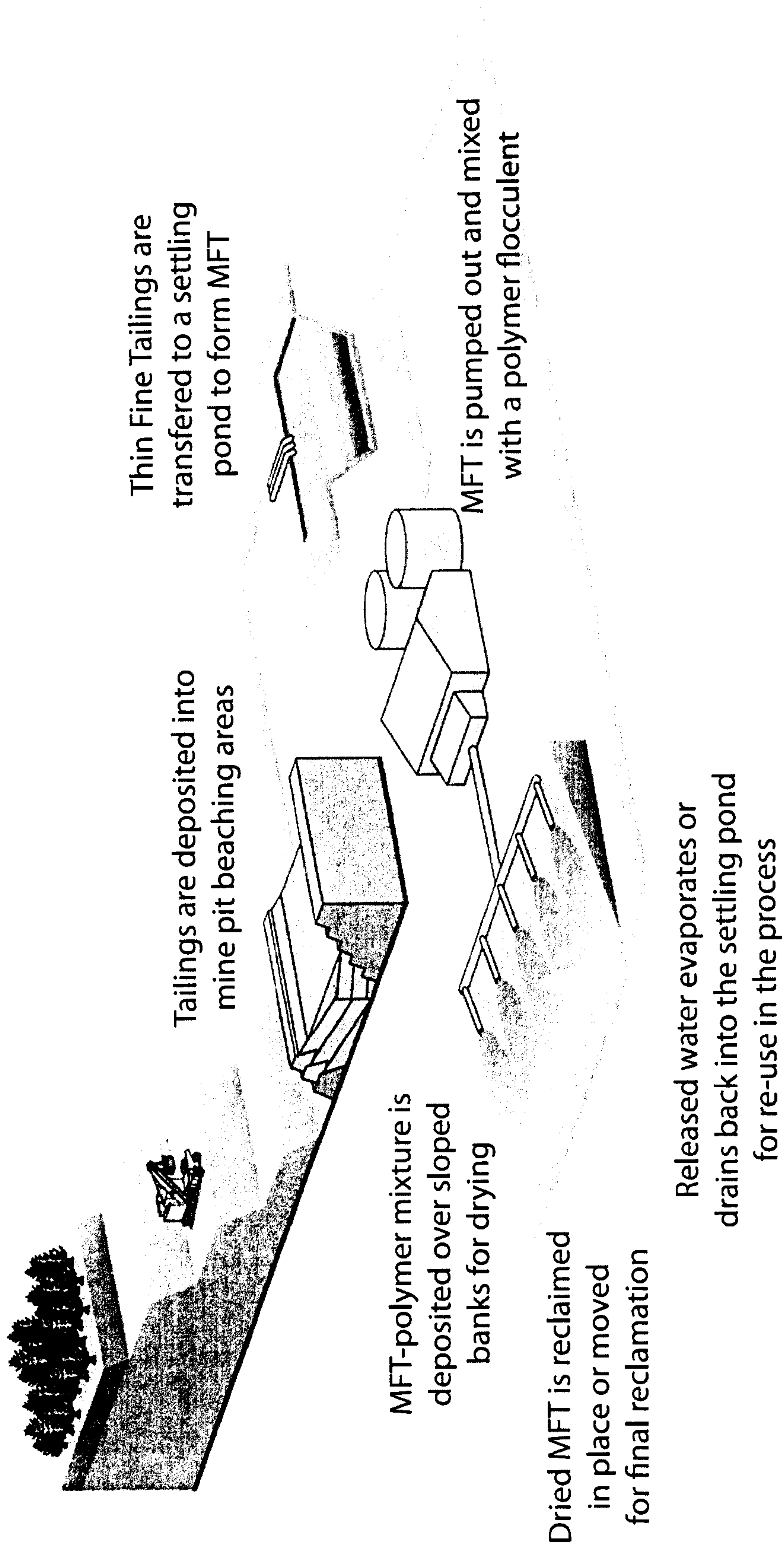
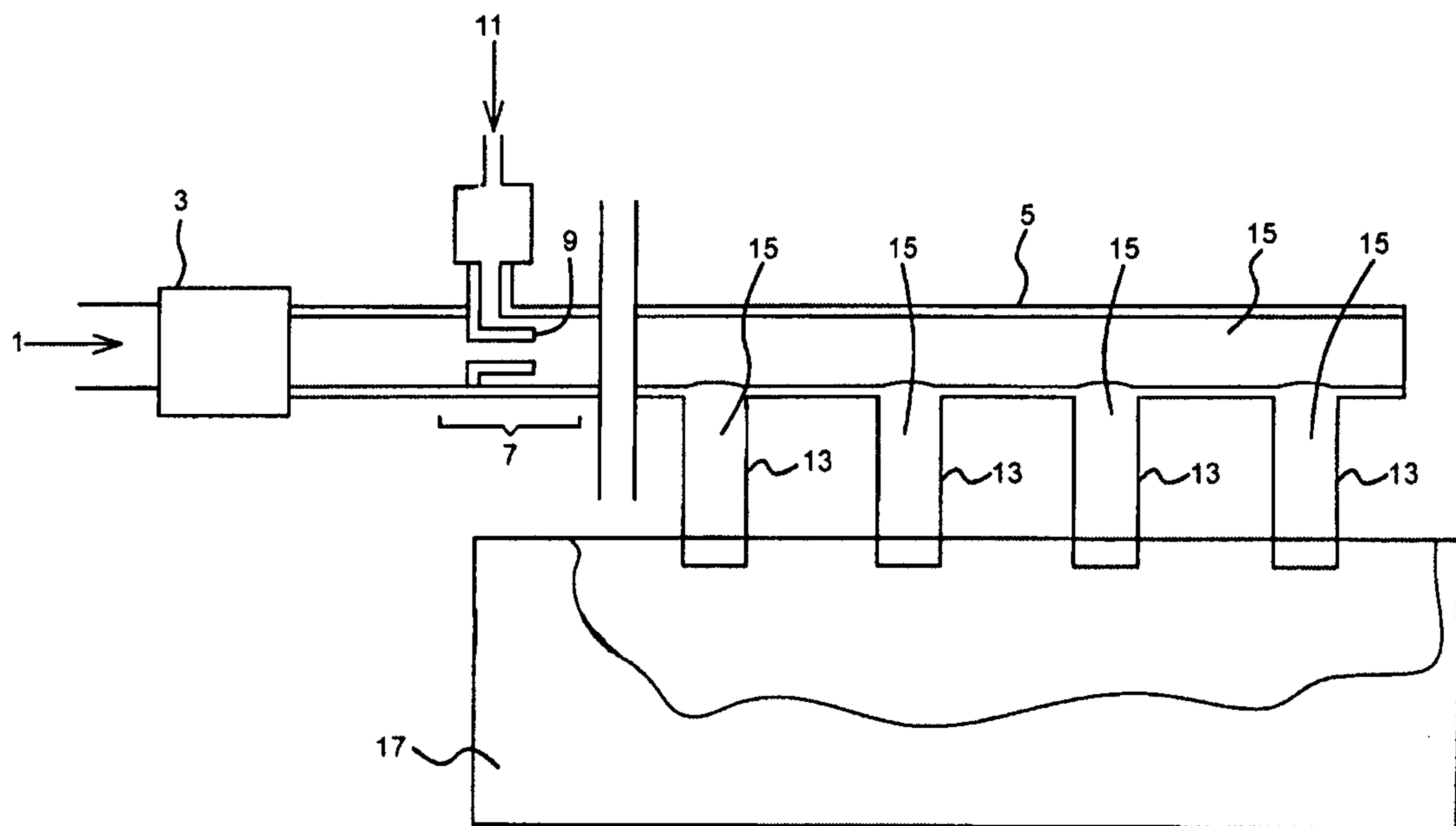
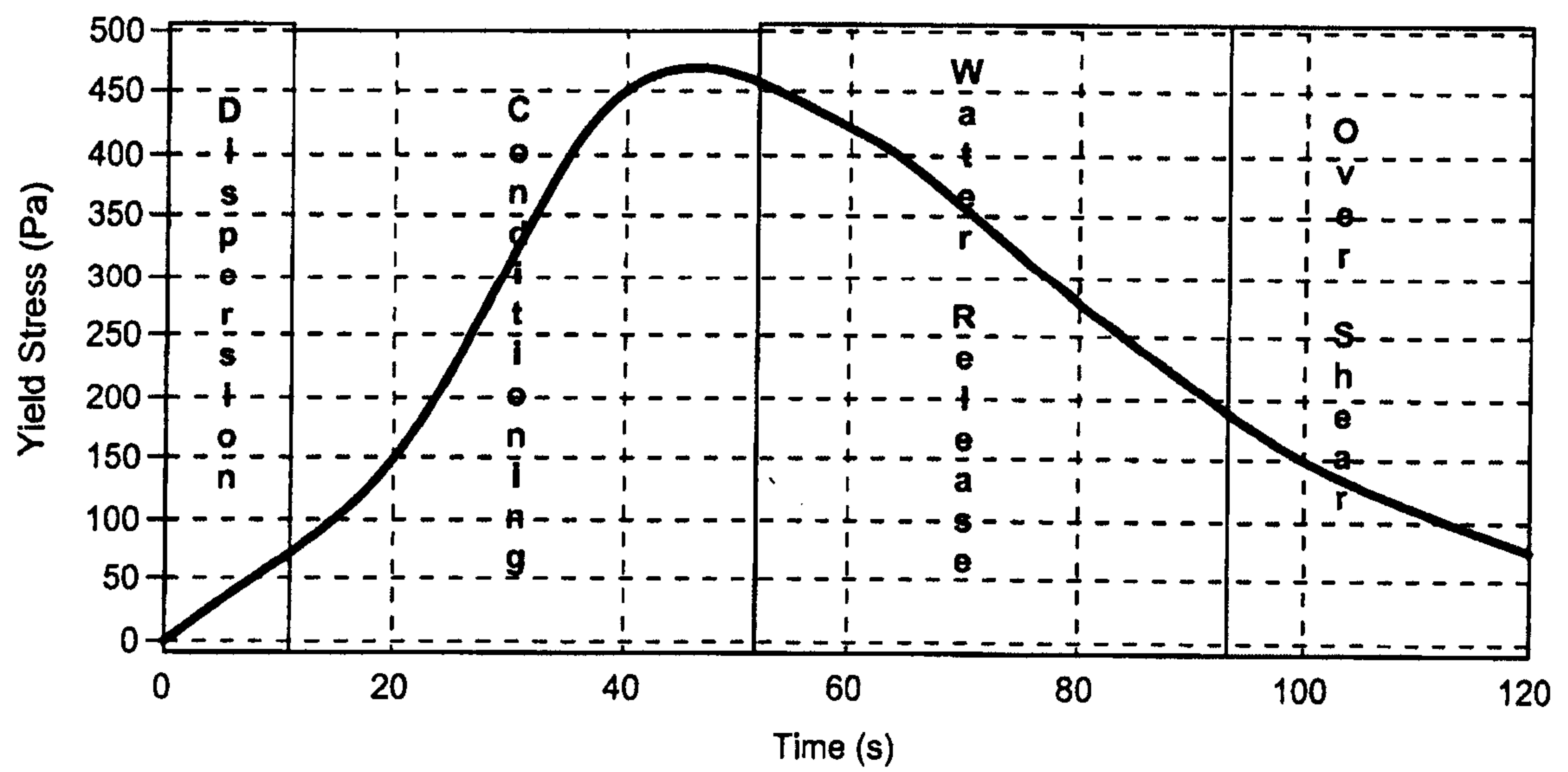


FIG. 2

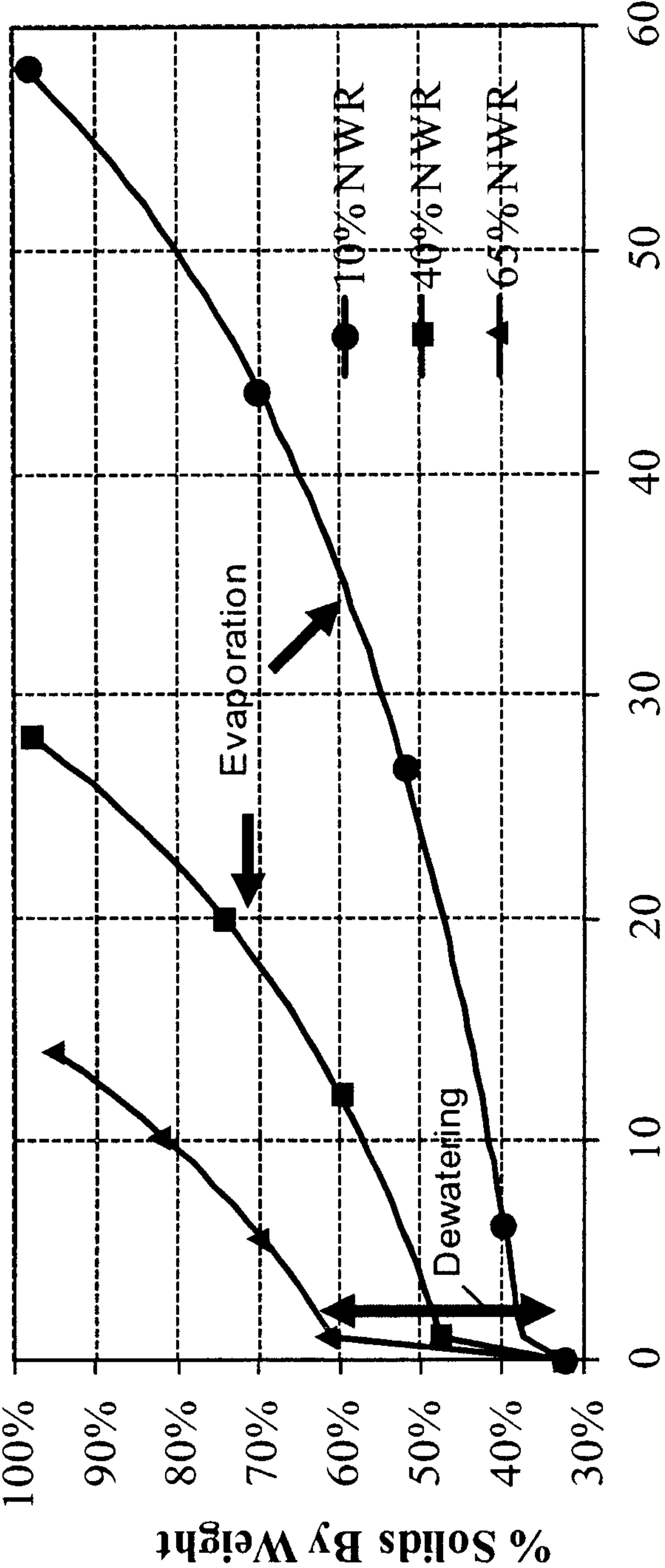
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FIG. 3

MFT Flocculent Reaction Stages

FIG. 4

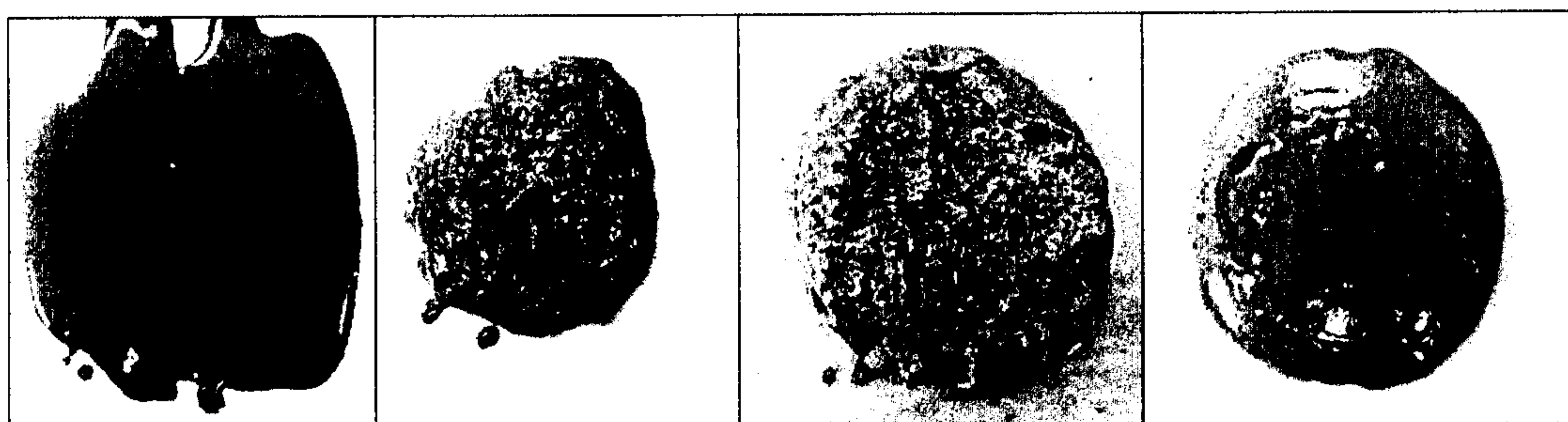
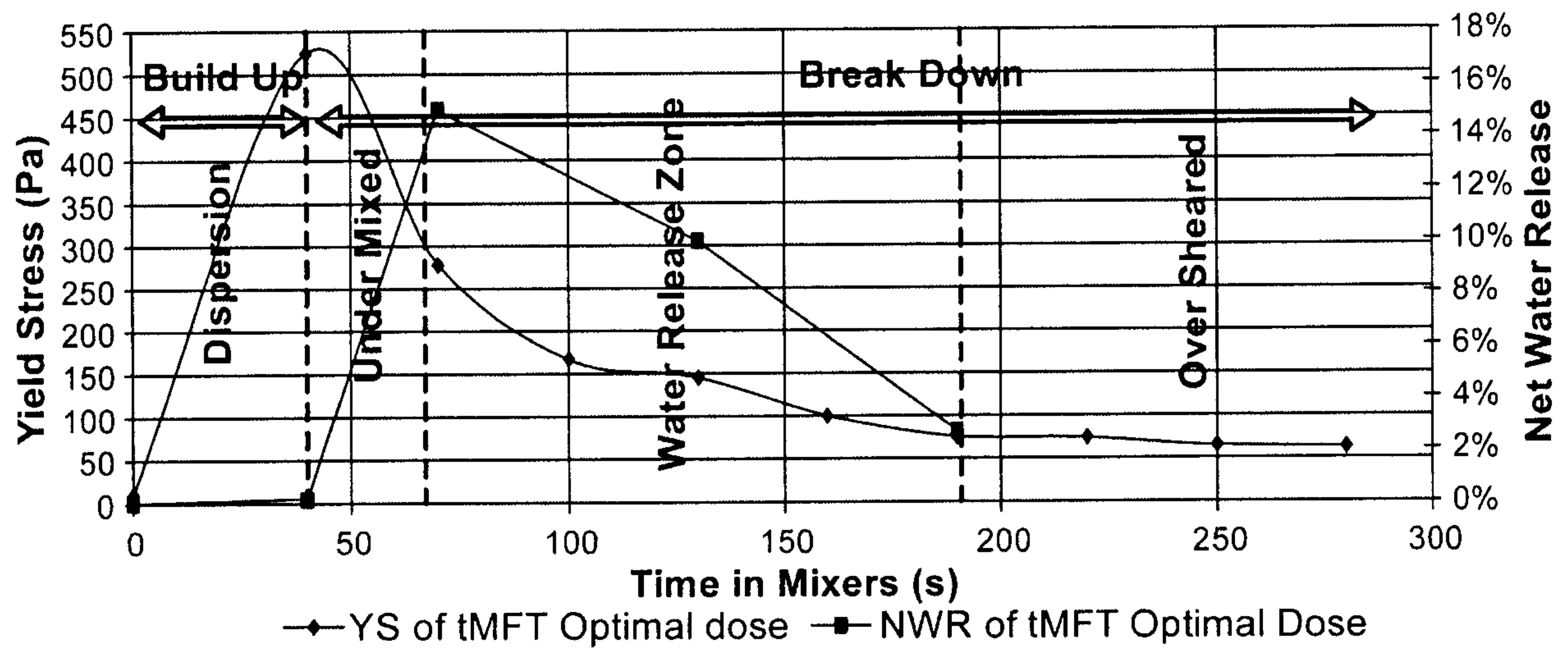
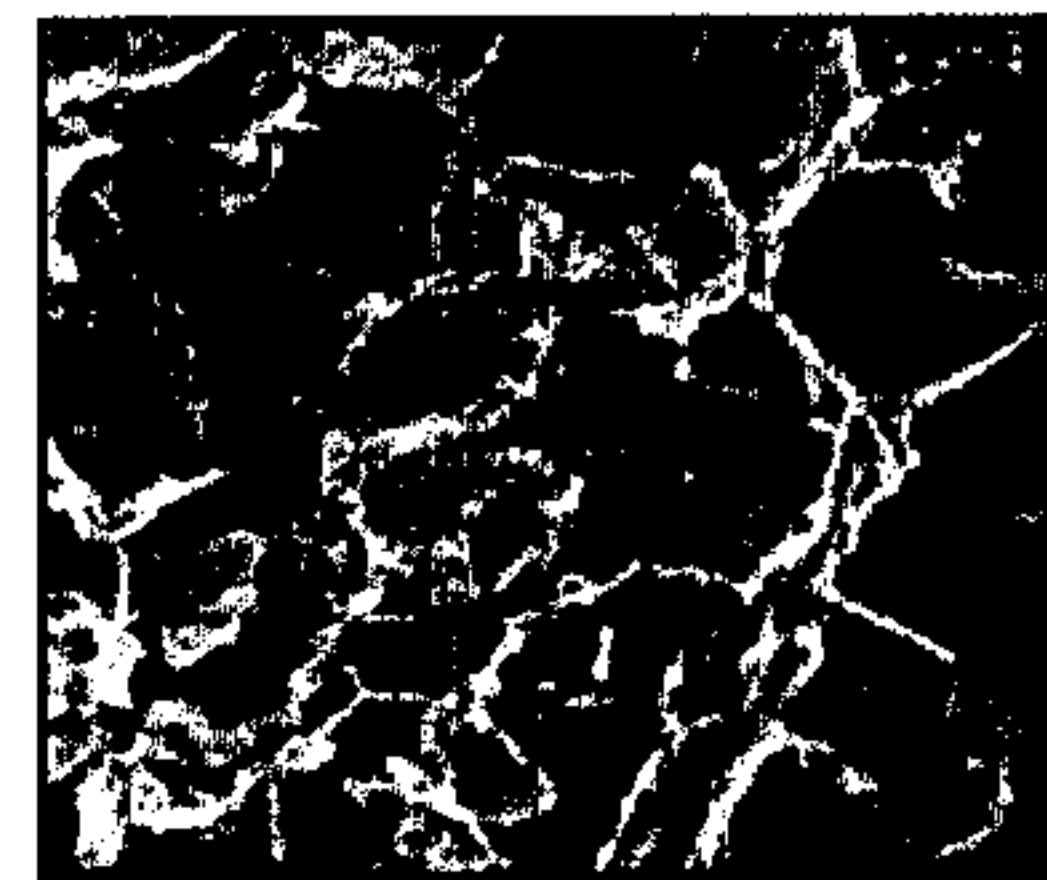
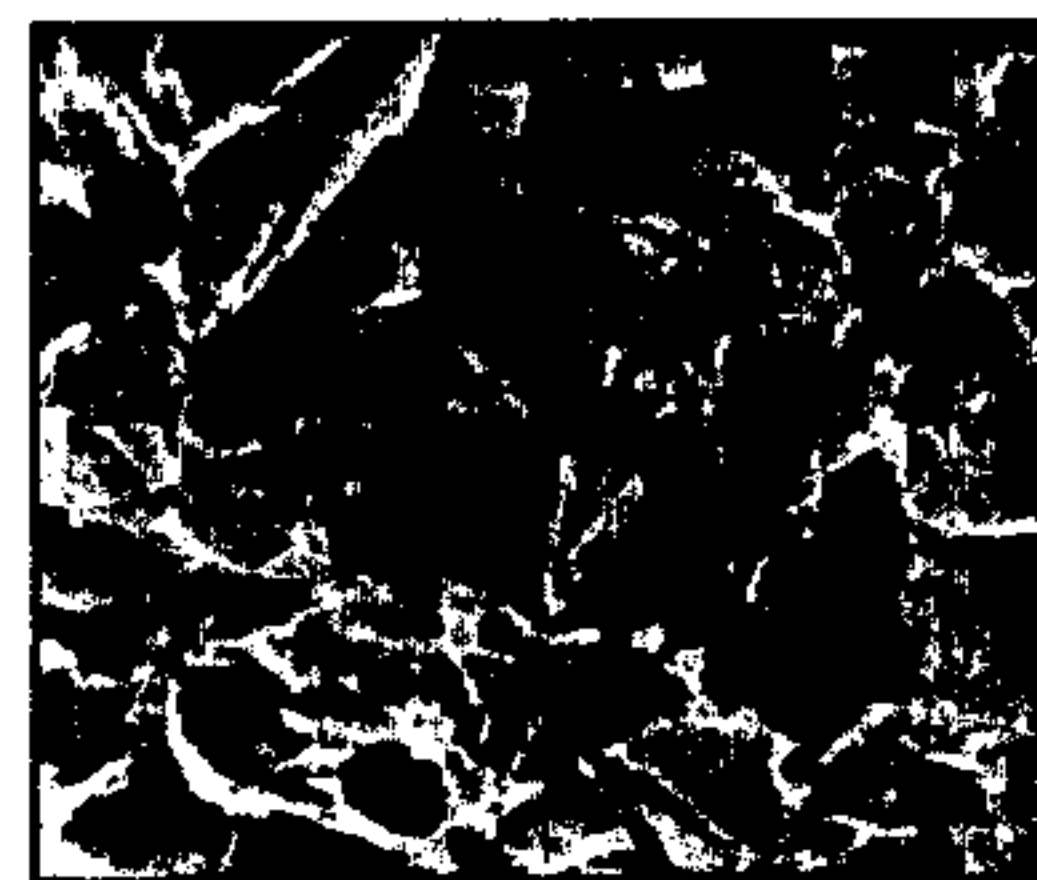
Effect of Net Water Release on Drying Times



Days to Dry

FIG. 5

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**MFT****Under Mixed****Optimal Mix****Over Sheared****MFT**

- No strength
- Liquid like
- Clay is in a random arrangement

Under Mixed

- No Water Release
- Looks Like a Gel
- Will Stack

Optimal Mix

- Lots of Water Release
- Looks like cottage cheese
- Will fill a cell
- tMFT becomes porous increasing its permeability allowing water release

Over Mixed

- No water release
- Looks liquid
- Will flow to bottom of cell

FIG. 6

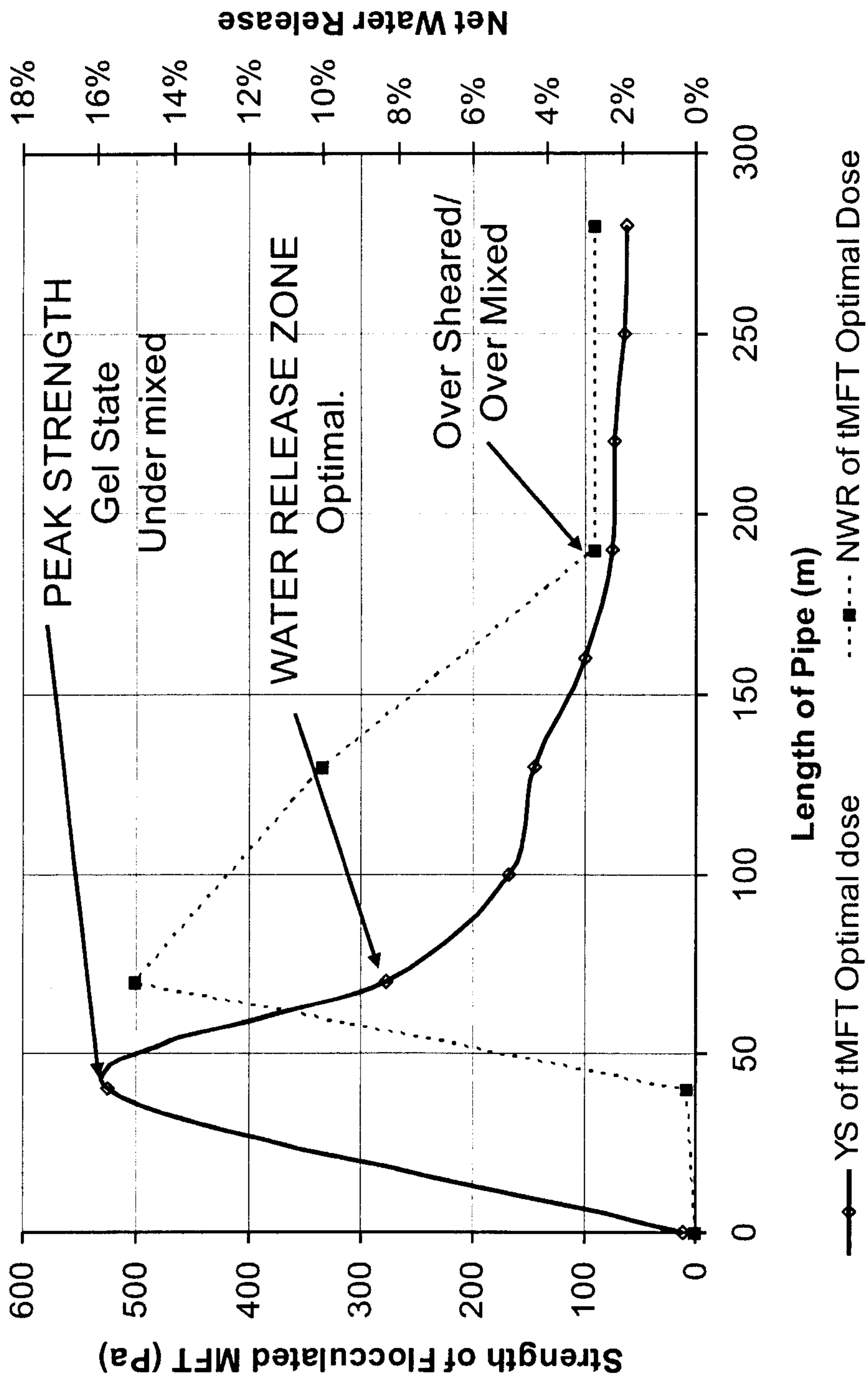


FIG. 7

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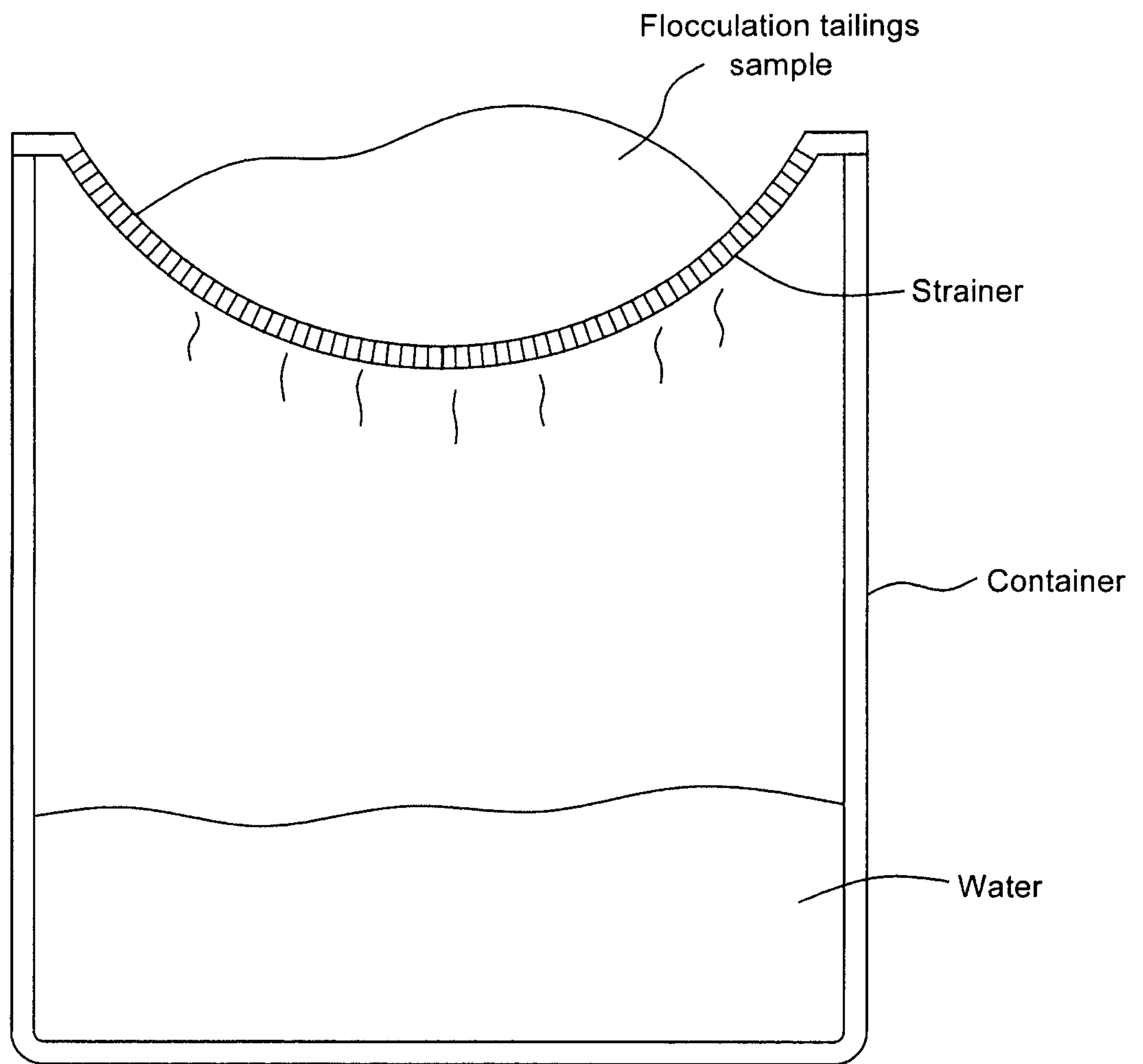


FIG. 8

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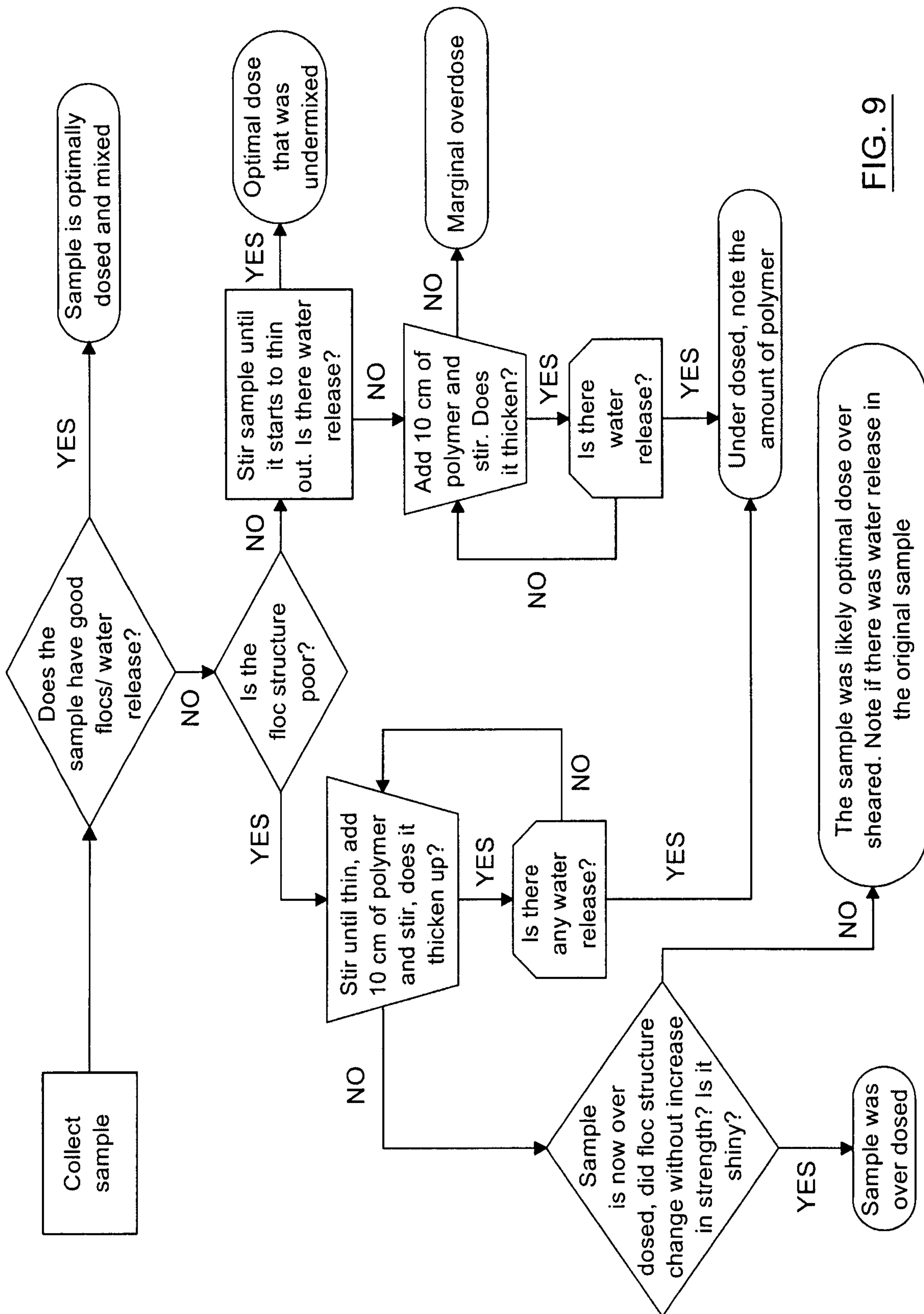
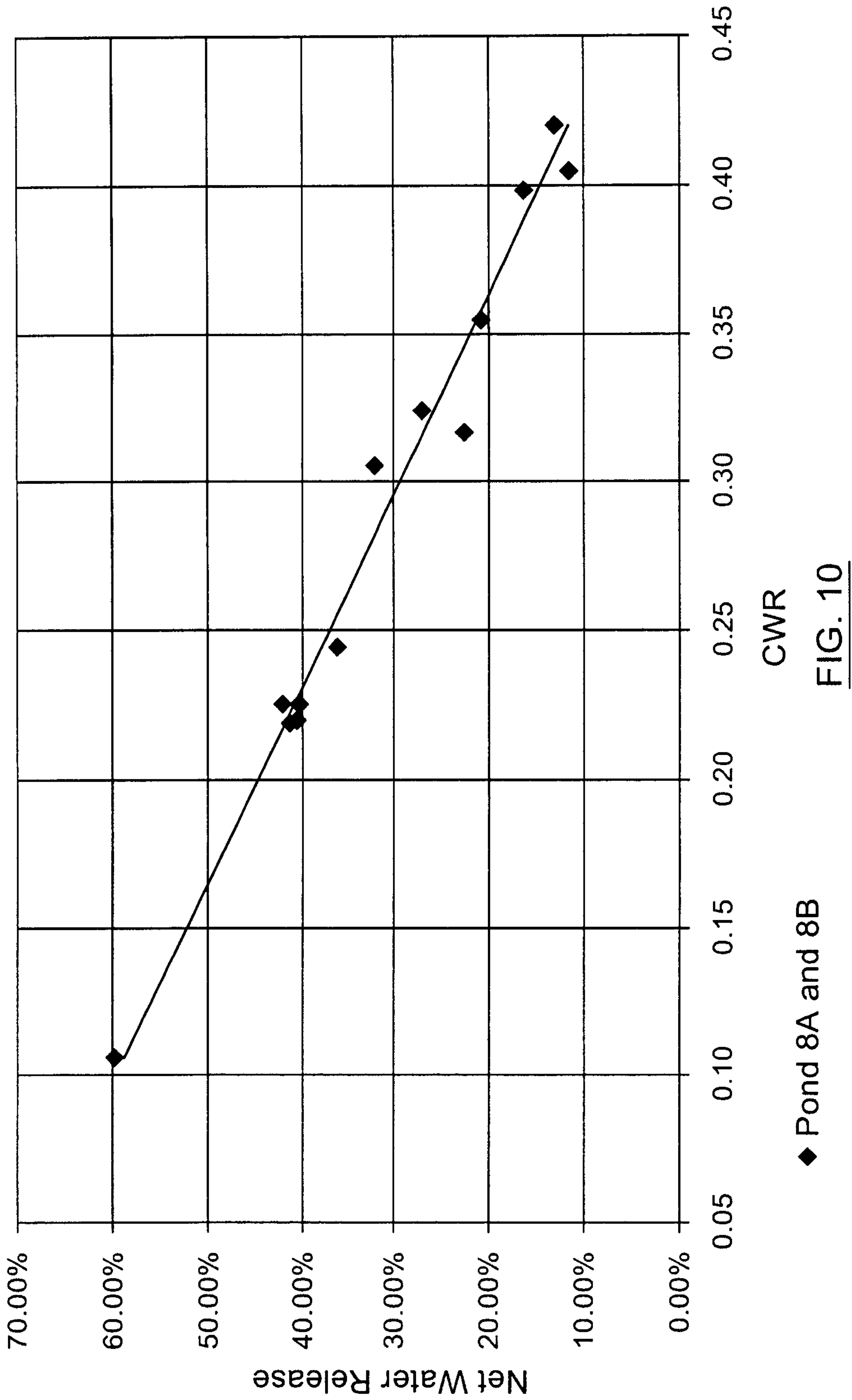


FIG. 9



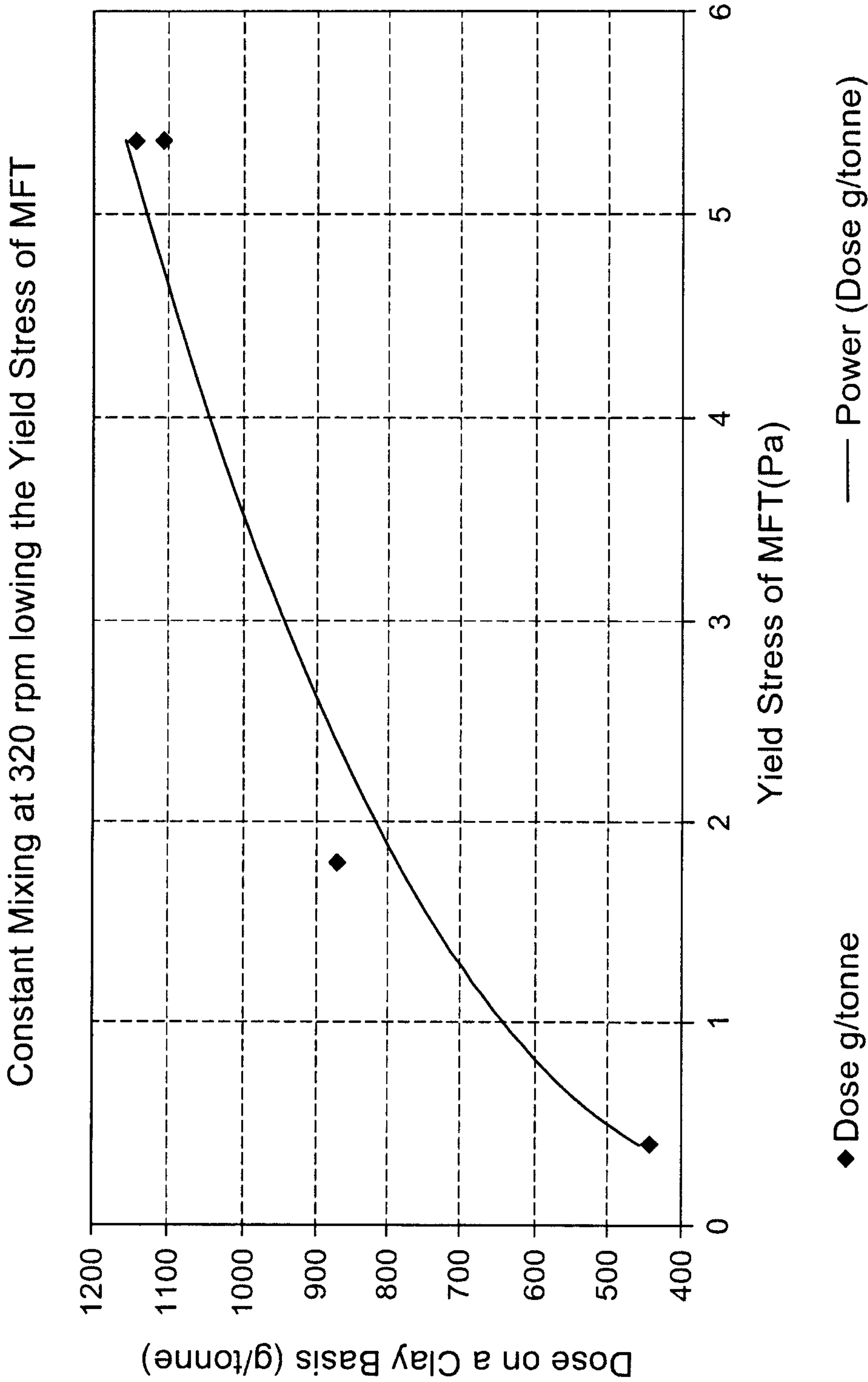


FIG. 11

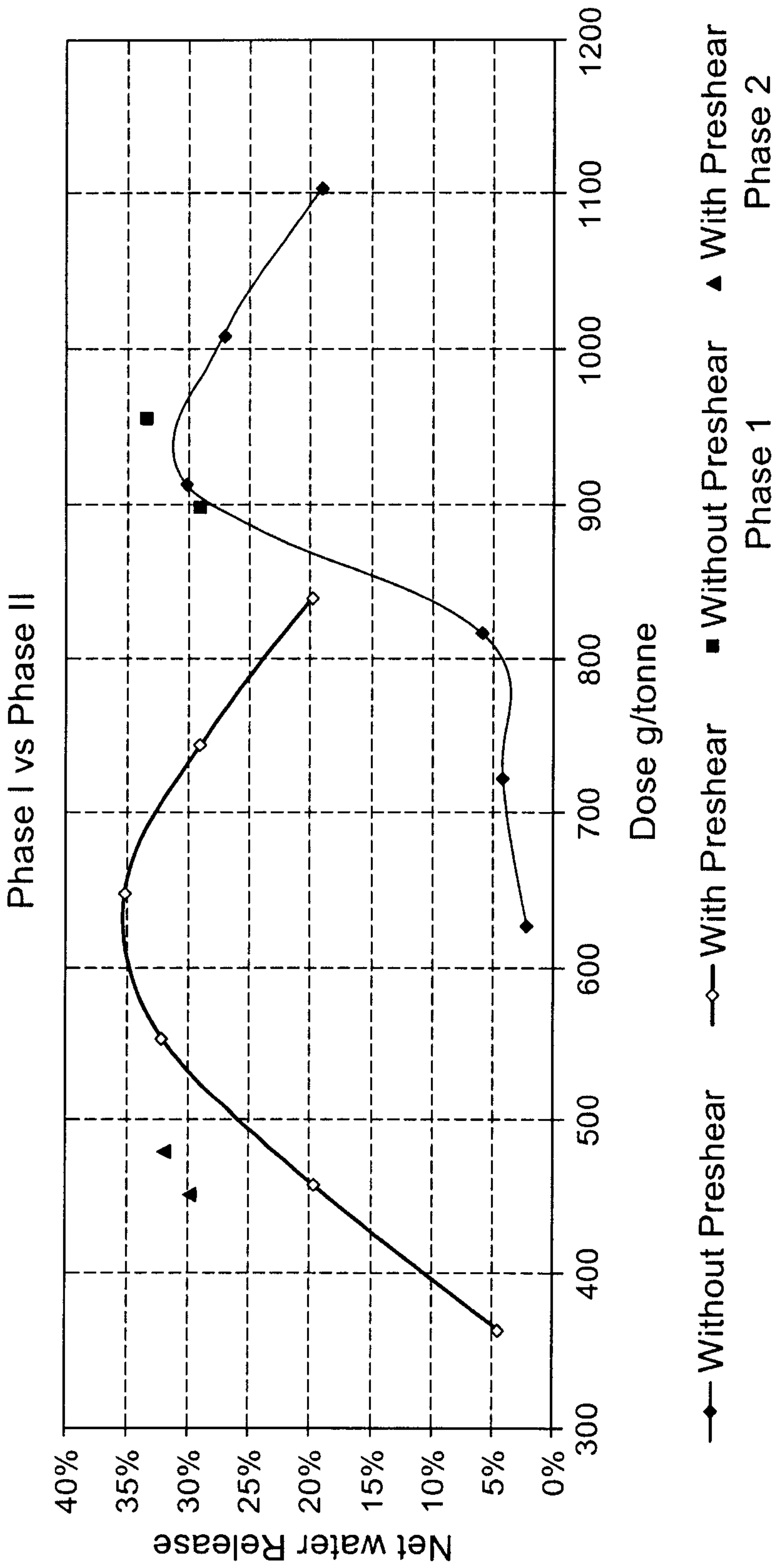


FIG. 12

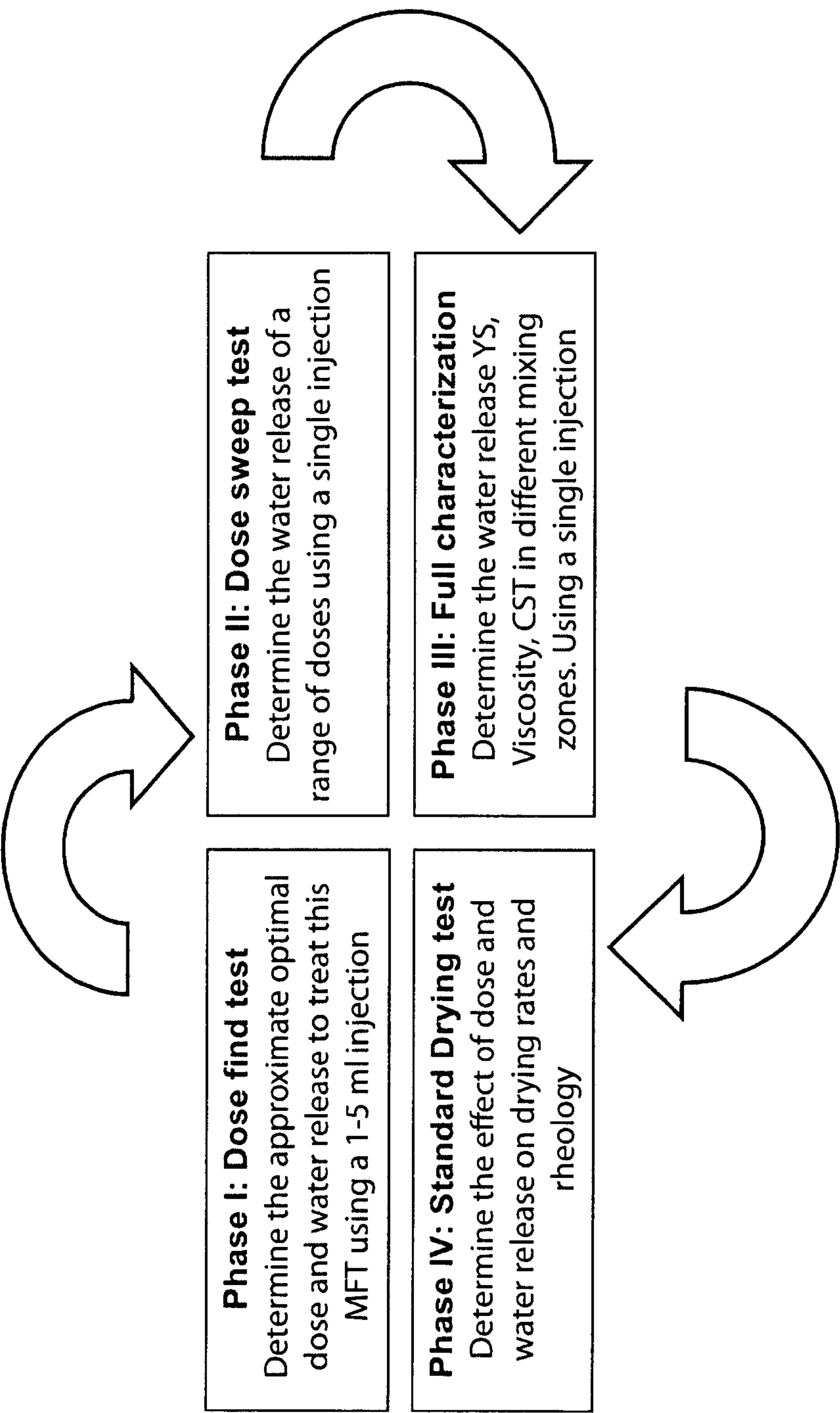


FIG. 13

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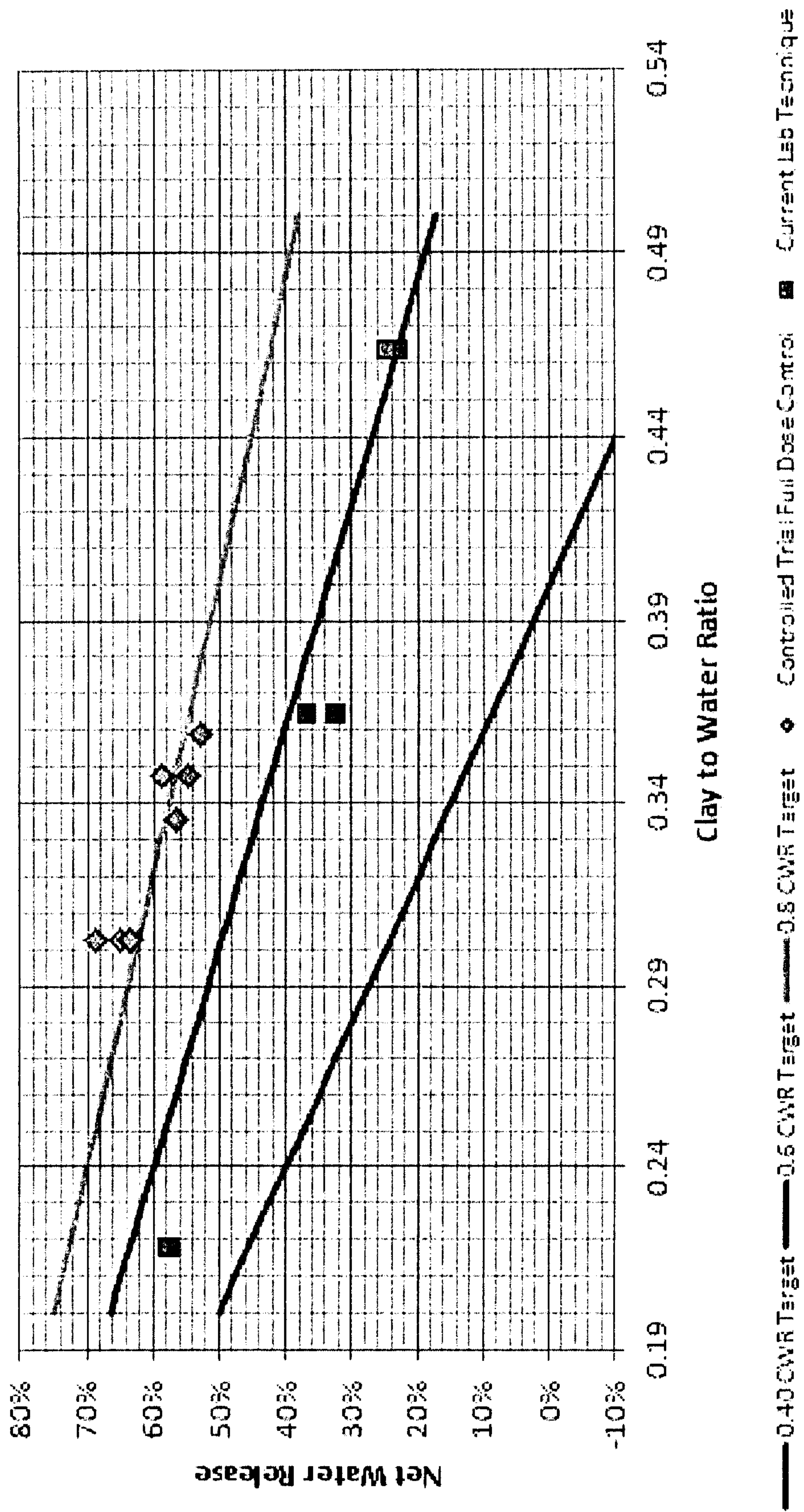


FIG. 14

