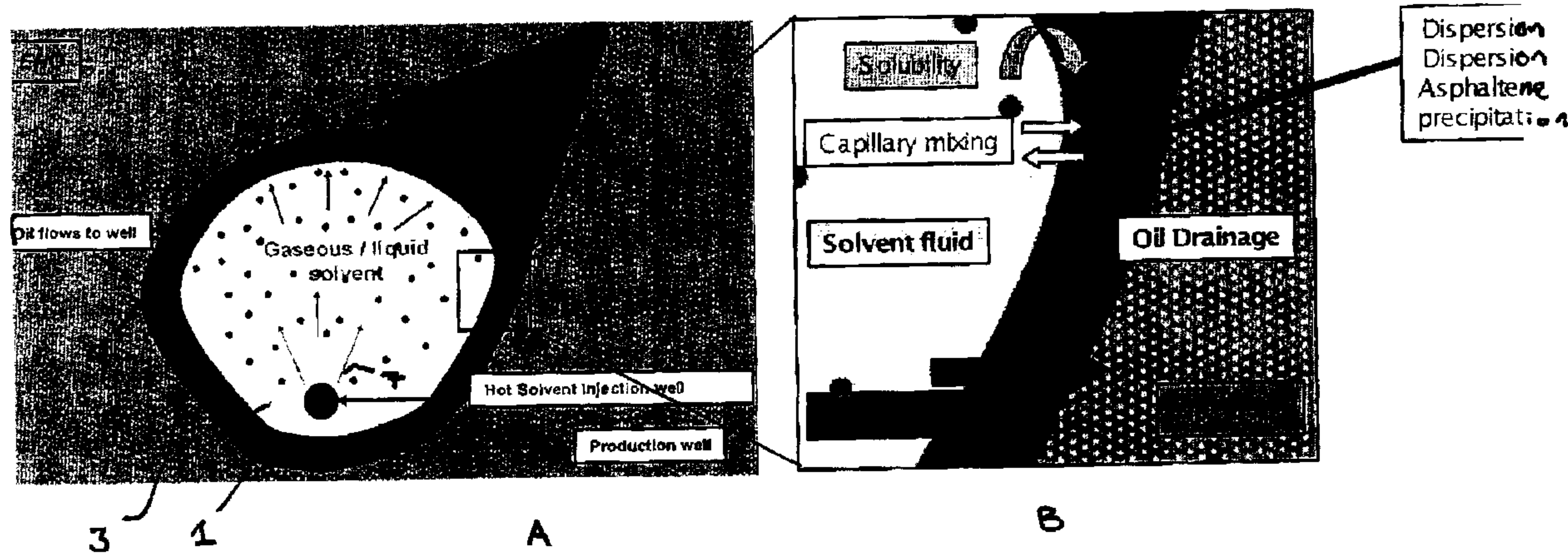




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(54) Titre : PROCÉDE D'EXTRACTION PAR INJECTION DE SOLVANTS
(54) Title: SOLVENT INJECTION RECOVERY PROCESS



(57) **Abrégé/Abstract:**

A process for the recovery of hydrocarbon such as bitumen/EHO from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps: preheating an area around and between the wells by circulating hot solvent through the completed interval of each of the wells until sufficient hydraulic communication between both wells is achieved; injecting one of more hydrocarbon solvents into the upper injection well at or above critical temperature of the solvent or solvent mixture, thereby causing a mixture of hydrocarbon and solvent to flow by gravity drainage to the lower production well; and producing the hydrocarbon to the surface through the lower production well.

ABSTRACT

- 5 A process for the recovery of hydrocarbon such as bitumen/EHO from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps:
- 10 preheating an area around and between the wells by circulating hot solvent through the completed interval of each of the wells until sufficient hydraulic communication between both wells is achieved;
- 15 injecting one or more hydrocarbon solvents into the upper injection well at or above critical temperature of the solvent or solvent mixture, thereby causing a mixture of hydrocarbon and solvent to flow by gravity drainage to the lower production well; and
- producing the hydrocarbon to the surface through the lower production well.

SOLVENT INJECTION RECOVERY PROCESS

Field of the Invention

5 The present invention relates to a solvent injection method for recovery of bitumen and extra heavy oil (EHO).

Background of the Invention

10 Recent recovery methods include steam assisted drainage (SAGD) and the solvent co-injection variant thereof. Another method is the so-called N-Solv process.

SAGD (Albahlani, A.M., Babadagli, T., "A Critical review of the Status of SAGD: Where Are We and What is Next?", SPE 113283, 2008 SPE Western Regional, Bakersfield California) is a method of recovering bitumen and EHO which dates back to the 1960's. A pair of wells is drilled, one above the other. The upper well is used to inject steam, optionally with a solvent. The lower well is used to collect the hot bitumen or EHO and condensed water from the steam. The injected steam forms a chamber that grows within the formation. The steam heats the oil/bitumen and reduces its viscosity so that it can flow into the lower well. Gases thus released rise in the steam chamber, filling the void space left by the oil. Oil and water flow is by a countercurrent gravity driven drainage into the lower well bore. Condensed water and the bitumen or EHO is pumped to the surface. Recovery levels can be as high as 70% to 80%. SAGD is more economic than with the older pressure-driven steam process.

25 The solvent co-injection variant of the SAGD process (Gupta, S., Gittins, S., Picherack, P., "Insights Into Some Key Issues With Solvent Aided Process", JCPT, February 2003, Vol 43, No 2) aims to improve the performance of SAGD by introducing hydrocarbon solvent additives to the injected steam. The operating conditions for the solvent co-injection process are similar to SAGD.

30 In the N-Solv process (Nenniger, J.E., Gunnewiek, L., "Dew Point vs Bubble Point: A Misunderstood Constraint on Gravity Drainage Processes", CIPC 2009, paper 065; Nenniger, J.E., Dunn, S.G. "How Fast is Solvent Based Gravity Drainage", CIPC 2008, paper 139), heated solvent vapour is injected into a gravity drainage chamber. Vapour

flows from the injection well to the colder perimeter of the chamber where it condenses, delivering heat and fresh solvent directly to the bitumen extraction interface. The N-Solv extraction temperature and pressure are lower than with *in situ* steam SAGD. The use of solvent is also capable of extracting valuable components in bitumen while
5 leaving high molecular weight coke forming species behind. Condensed solvent and oil then drain by gravity to the bottom of the chamber and are recovered via the production well. Some details of solvent extraction processes are described in CA 2 351 148, CA 2 299 790 and CA 2 552 482.

10 Definition of the Invention

In its broadest sense, the present invention provides a process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, wherein there is hydraulic communication
15 between said wells, the method comprising the steps:

injecting one or more hydrocarbon solvents into the upper injection well at or above critical temperature of the solvent or solvent mixture, thereby causing a mixture of hydrocarbons and solvent to collect in the lower production well; and
20

extracting the hydrocarbons from the lower production well.

In another broad sense, the present invention also provides a process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper
25 injection well and a lower production well wherein there is hydraulic communication between said wells, the method comprising the steps:

injecting one or more hydrocarbon solvents into the upper injection well so that the temperature of the solvent or solvent mixture in the upper injection well is 90°C or
30 more, thereby causing a mixture of hydrocarbons and solvent to collect in the lower production well; and

extracting the hydrocarbons from the lower production well.

A first aspect of the present invention provides a process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps:

5 preheating an area around and between the wells by circulating hot solvent through at least part of both of the wells until hydraulic communication between both wells is achieved;

10 injecting one of more hydrocarbon solvents into the upper injection well at or above critical temperature of the solvent or solvent mixture, thereby causing a mixture of hydrocarbons and solvent to collect in the lower production well; and

extracting the hydrocarbons from the lower production well.

15 A second aspect of the present invention provides a process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps:

20 preheating an area around and between the wells by circulating hot solvent through the completed interval of each of the wells until hydraulic communication between both wells is achieved;

25 injecting one of more hydrocarbon solvents into the upper injection well so that the temperature of the solvent or solvent mixture in the upper injection well is 90°C or more, thereby causing a mixture of hydrocarbons and solvent to collect in the lower production well; and

extracting the hydrocarbons from the lower production well.

30 A third aspect of the present invention provides a process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the following steps:

preheating an area around and between the wells by circulating hot solvent through at least part of both of the wells until sufficient hydraulic communication between both wells is achieved;

5 injecting one or more hydrocarbon solvents into the upper injection well at or above critical temperature of the solvent or solvent mixture, thereby:

- i) creating a hot solvent chamber consisting of solvent vapour and liquid,
- ii) mixing of the bitumen and the solvent at the boundary of the solvent chamber so formed, and
- 10 iii) causing a mixture of the hydrocarbon and solvent to drain downwards by gravity and sideways by pressure gradient towards the lower production well; and

producing the mixture to the surface through the lower production well.

15 A fourth aspect of the present invention provides a process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps:

20 preheating the region between the wells by circulating hot solvent through at least part of both of the wells until hydraulic communication between both wells is achieved;

injecting one or more hydrocarbon solvents into the upper injection well so that the temperature of the solvent or solvent mixture within the upper injection well is 90°C or more, thereby:

- 25 i) creating a hot solvent chamber consisting of solvent vapour and liquid,
- ii) mixing of the bitumen and the solvent at the boundary of the solvent chamber so formed, and
- iii) causing a mixture of the hydrocarbon and solvent to drain downwards by gravity and sideways by pressure gradient towards the lower production well; and
- 30

producing the mixture to the surface through the lower production well.

The N-Solv process operates at low temperatures (typically up to 70 °C,) and uses propane as the preferred solvent. This can result in low drainage rates.

5 SAGD and SAGD with solvent co-injection operate above 200 °C so the energy usage is high.

10 The present invention offers lower energy utilisation rates and does not require any use of water. CO₂ emissions are also considerably lower. The present invention also achieves faster oil drainage rates than the N-Solv process due to employing a significantly higher solvent chamber temperature than N-Solv extraction temperature. De-asphalting of the bitumen/EHO at the boundary layer between the solvent chamber and the bitumen/EHO region can occur also in the high temperature solvent injection process of the present invention.

15 Detailed Description of the Invention

In essence, the present invention is a gravity-based thermal recovery process of bitumen and extra heavy oil. A preferred class of embodiments of this recovery process entails use of a pair of substantially parallel horizontal wells, located above
20 each other, at a vertical distance of typically from 2 to 20 metres, say 5 metres, placed at the bottom of the reservoir.

25 The area around and between the wells is heated by circulating hot solvent through the completed interval of each of the wells until sufficient hydraulic communication between the wells is achieved.

After the pre-heating period is finished the upper well is converted to an injector and the bottom well to a producer.

30 A hydrocarbon solvent (or mixture of hydrocarbon solvents) of technical grade is injected in the upper well at or above critical temperature.

A mixture of bitumen/EHO and solvent is produced through the bottom well.

35 The solvent is separated from the produced well stream and recycled.

At the end of the production period, the solvent is back produced by means of injection of non-condensable gases and pressure reduction. A non-condensable gas (which is less dense than the solvent / solvent mixture) is injected in the injection well, and displaces the solvent / solvent mixture by gravity driven flooding process. The solvent / solvent mixture and the injected non-condensable gas are produced through the producer well. The non-condensable gas is separated from the solvent / solvent mixture at the surface and re-injected until sufficient recovery of the solvent / solvent mixture is achieved.

10

The mechanisms which underlie this process are as follows:

- Establishment and expansion of a solvent chamber,
- Condensation of the solvent occurs far from the interface with the solvent chamber and the cold bitumen,
- The bitumen/EHO is heated by conduction to the solvent temperature in the vicinity of the solvent interface (typically a few meters),
- Solubilisation of solvent into oil by mechanical/convective mixing and thereby bitumen/extra heavy oil viscosity reduction,
- De-asphalting of the bitumen/EHO (upgrading and viscosity reduction of the bitumen/EHO),
- Gravity drainage of bitumen/EHO.

Typical solvents usable in this process of the present invention are lower alkanes, such as propane, butane or pentane, but not limited to these, and mixtures thereof. The critical temperature of a solvent or solvent mixture is readily obtainable from standard texts. However, typical operating well temperature ranges for the process of the present invention, are, particularly for the solvents listed, in the range of 90 – 400 °C.

30 Brief Description of the Drawings

Figure 1A shows a vertical cross section perpendicular to the horizontal well pair used in a recovery process according to the present invention, viewed along the wells; and

Figure 1B shows an expanded detail of the solvent chamber – bitumen/EHO transition region.

Description of Preferred Embodiments

5

Figure 1A shows a vertical section perpendicular to the horizontal well pair used in a recovery process according to the present invention. The outer boundary of the solvent chamber is denoted by reference numeral 3. Situated below the upper well 1 is a production well 5. Hot solvent in vapour form is injected into the upper injection well 1 as denoted by arrows 7.

10

During the start-up period and prior to well conversion, the volume / region between the injection well 1 and the producing well 5, is pre-heated by circulation of hot solvent until sufficient hydraulic communication is established between the upper and lower wells. Bitumen/EHO flows (9) into the well.

15

Injection of hydrocarbon solvents as mentioned above causes a mixture of bitumen/EHO and solvent to:

- 20 - drain downwards by gravity and sideways by pressure gradient to the lower well and
- be produced to the surface through the lower well by conventional well lifting means including down-hole pumps.

25 At the surface, the solvent can be recovered for recycling.

Figure 1B shows an expanded detail of the solvent chamber – bitumen/EHO transition region. Solubilisation of solvent into the bitumen/EHO occurs by diffusive and convective mixing in the solvent chamber – bitumen/EHO transition region. The bitumen/EHO is de-asphalted in the presence of higher solvent concentration. As a result of both phenomena stated above, a lower viscosity mixture of bitumen/EHO and solvent flows by gravity drainage to the producing well 5.

30

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps:

preheating the region between the wells by circulating hot solvent through at least part of both of the wells until hydraulic communication between both wells is achieved;

injecting one or more hydrocarbon solvents into the upper injection well at or above critical temperature of the solvent or solvent mixture, thereby:

- i) creating a hot solvent chamber consisting of solvent vapour and liquid,
- ii) mixing of the bitumen and the solvent at the boundary of the solvent chamber so formed, and
- iii) causing a mixture of the hydrocarbon and solvent to drain downwards by gravity and sideways by pressure gradient towards the lower production well; and

producing the mixture to the surface through the lower production well.

2. A process for the recovery of hydrocarbons from a hydrocarbon bearing formation in which are situated an upper injection well and a lower production well, the method comprising the steps:

preheating the region between the wells by circulating hot solvent through at least part of both of the wells until hydraulic communication between both wells is achieved;

injecting one or more hydrocarbon solvents into the upper injection well so that the temperature of the solvent or solvent mixture within the upper injection well is 90°C or more, thereby:

- i) creating a hot solvent chamber consisting of solvent vapour and liquid,
- ii) mixing of the bitumen and the solvent at the boundary of the solvent chamber so formed, and

- iii) causing a mixture of the hydrocarbon and solvent to drain downwards by gravity and sideways by pressure gradient towards the lower production well; and
producing the mixture to the surface through the lower production well.
3. A process according to claim 1 or 2, wherein solvent is separated from the extracted mixture for recycling.
 4. A process according to any one of claims 1 to 3, wherein during the preheating step, the wall of the upper injection well is preheated to a temperature in the range from 75°C to 500°C.
 5. A process according to claim 4, wherein during the preheating step, the wall of the upper injection well is preheated to a temperature in the range from 90°C to 300°C.
 6. A process according to any one of claims 1 to 5, wherein the hydrocarbon comprises bitumen and/or EHO.

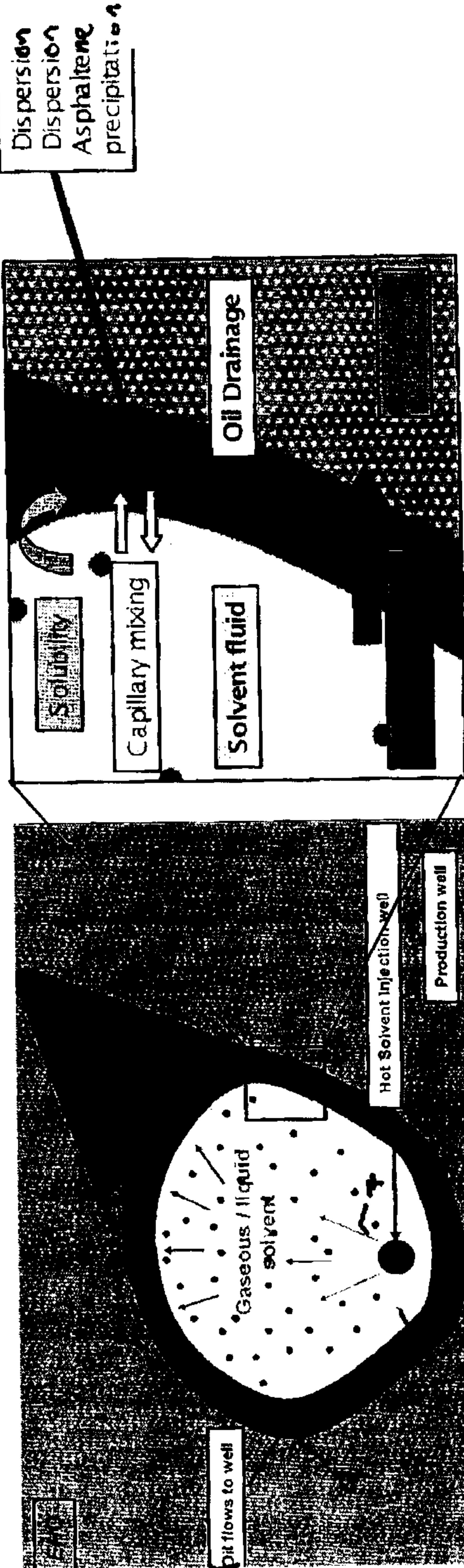
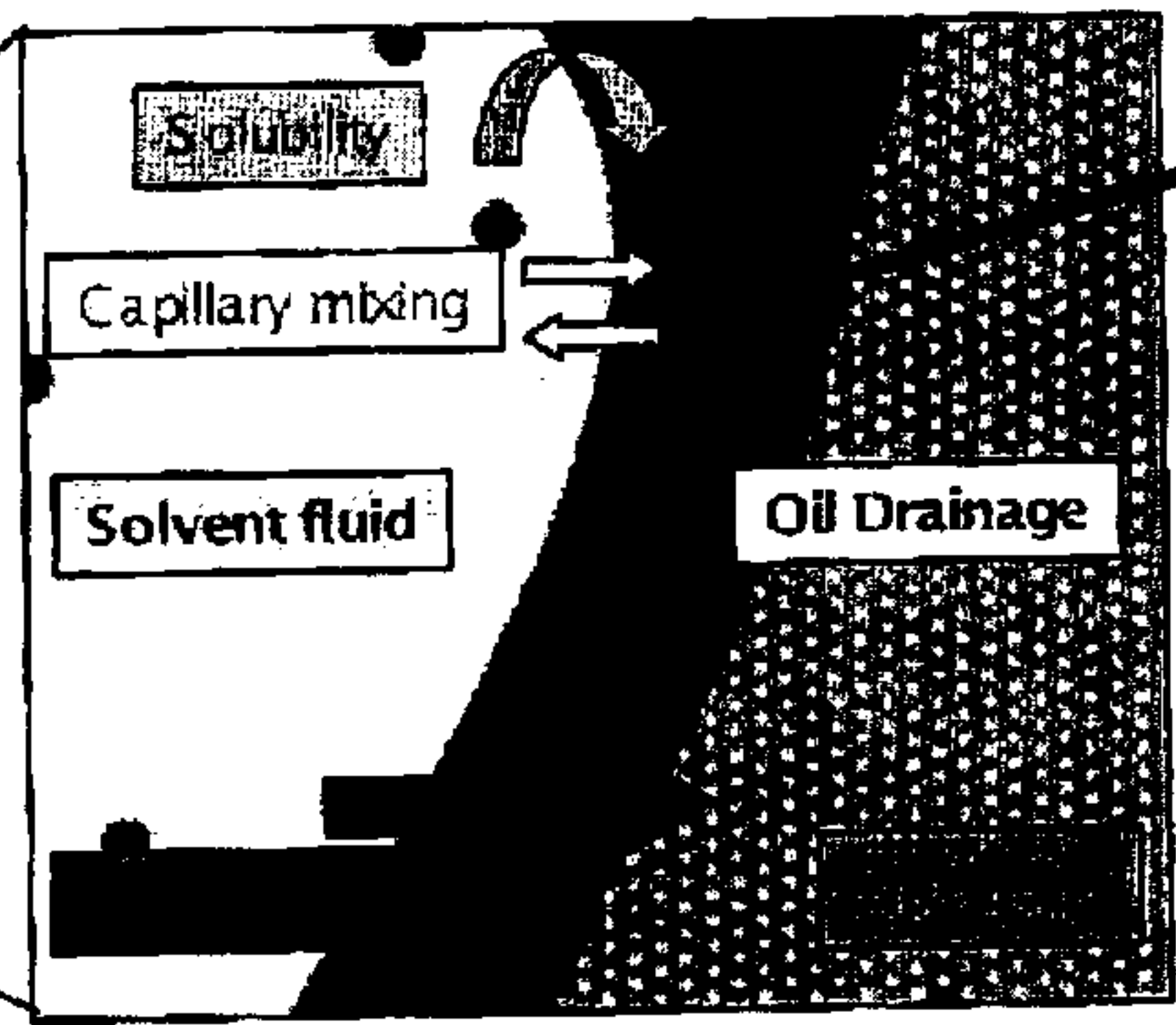
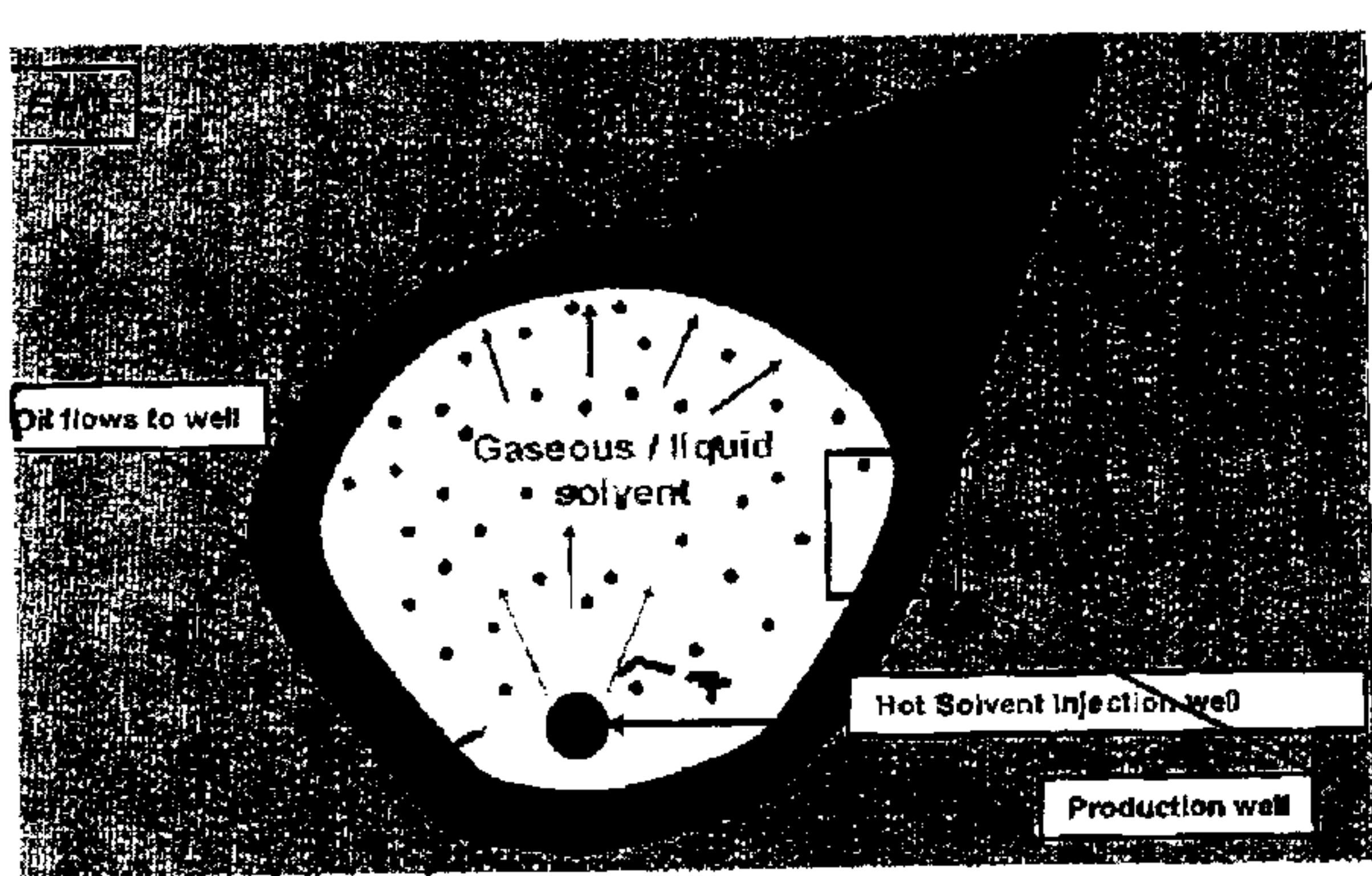


FIG 1B

FIG 1A

3 1



Dispersion
Dispersion
Asphaltene
precipitation

3

1

A

B