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METHOD OF MINING BITUMINOUS TAR SANDS

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ABSTRACT OF THE DISCLOSURE

This specification discloses a method of reducing frost penetration into exposed deposits of bituminous tar sands which comprises depositing a cover of artificially produced snow of initial density greater than 15 pounds per cubic foot onto the exposed deposit, and maintaining the cover of deposited snow until the tar sands are removed from the deposit.

This invention relates to a method for reducing frost penetration into exposed deposits of earth material particularly deposits of bituminous tar sands. The invention also relates to a method of mining tar sands.

Numerous deposits of tar sands exist throughout the world. The most extensive deposits are found in northern Alberta, Canada. The sands are composed of a siliceous material, generally having a size greater than that passing a 325 mesh screen, saturated with a relatively heavy, viscous bitumen in quantities of from 5 to 21 weight percent of the total composition. More typically, the bitumen content of the sands is about 8 to 15 percent. This bitumen is quite viscous and contains typically 4.5 percent sulfur and 38 percent aromatics. Its specific gravity at 60° F. ranges typically from about 1.00 to about 1.06. The sands also contain clay and silt in quantities of from 1 to 50 weight percent of the total composition. Silt is normally defined as material which will pass a 325 mesh screen but which is larger than 2 microns. Clay is material smaller than 2 microns including some siliceous material of that size.

There are several well-known processes for effecting the separation of bitumen from the tar sands. In the hot water method, the bituminous sands are jetted with steam and mulled with a minor amount of hot water at temperatures in the range of 140° to 210° F. The resulting pulp is dropped into a stream of circulating hot water and carried to a separation cell maintained at a temperature of about 150° to 200° F. In the separation cell, sand settles to the bottom as tailings and bitumen rises to the top in the form of an oil froth. An aqueous middlings layer containing some mineral and bitumen is formed between these layers. A scavenger step may be conducted on the middlings layer from the primary separation step to recover additional amounts of bitumen therefrom. This step usually comprises aerating the middlings as taught by K. A. Clark, "The Hot Water Washing Method," Canadian Oil and Gas Industries 3, 46 (1950). These froths can be combined, diluted with naphtha and centrifuged to remove more water and residual mineral. The hot water process is described in detail by Floyd et al., United States patent application 509,589, now Patent No. 3,401,110 issued Sept. 10, 1968.

Mining of tar sands for charge into a hot water process or into any other treating process is often conducted under extreme conditions of weather and climate. For example, mining operations in northern Alberta are often conducted in extreme cold. Most of the tar sands deposits there are covered with an overburden. When the

overburden is removed and the tar sands laid bare and exposed to the cold, deep frost penetration occurs. This frost hardens the tar sands deposits and slows down the mining operation. It has been found in one operation that production by bucketwheel excavator is reduced to about ⅕ of summer production and that the effects of frost penetration are evident to a depth of 10 feet below exposed tar sands surfaces.

The present invention is directed to a method of reducing frost penetration into exposed deposits of bituminous tar sands and to a method of mining tar sands under climatic conditions as described above. In its most specific and preferred embodiment the invention covers a method of preventing frost penetration into bituminous tar sands deposits which are to be mined for feed into a bituminous tar sands treating process. Such processes include the hot water process, the cold water method, and pyrolytic or retorting processes as well as others. The invention comprises depositing a cover of artificially produced snow of initial density greater than 10 pounds per cubic foot on to an exposed deposit of tar sands and maintaining this cover until the tar sands are removed from the deposit. The invention can also be described as a method of mining bituminous tar sands for charging into a process for separating bitumen from tar sands which comprises removing over-burden to expose the tar sands, depositing a cover of artificially produced snow of initial density greater than 10 pounds per cubic foot onto the exposed tar sands, maintaining the cover of snow to substantially reduce frost penetration into the sands, and removing the tar sands for charge into a tar sands separation process.

The artificially produced snow cover insulates the exposed tar sands and reduces frost penetration thus facilitating mining of the deposits. Naturally occuring snow when distributed on the ground generally has a density of about 8 to 9 pounds per cubic foot up to 10 pounds per cubic foot for wet snow. It has been observed as per the present invention that artificially produced snow of initial deposited density greater than that of natural snow provides increased protection against frost penetration over that provided by the natural snow. It has also been observed that artificial snow of initial deposited density between about 15 to 27 pounds per cubic foot gives best frost protection.

After a layer of snow is deposited, pressure and lack of fresh air at the bottom of the layer causes the snow flake to withdraw its dendritic fingers and to form what is commonly known as corn snow. This snow is in the form of a small pellet, and its thermal insulation qualities are poor compared to the snowflake. However, this ripening process of the snow crystal involves a change of densities and the bottom of the snow layer tends to shrink, creating more air space, thus improving the thermal insulation qualities of the snow layer as a whole.

Snow of increased density contains increased proportion of water. As the snow is laid down, this water freezes. It appears that this freezing aids the ripening of the snow layer and results in a snow cover of superior insulating properties. Interestingly, it has been observed that the presence of ice in the snow as it is laid on the ground results in a poor insulating cover while the presence of water which later freezes results in an excellent insulating cover.

Thus although it is known that natural snow coverage acts as an insulation against frost penetration into the ground, it has been found by the present invention, that snow cover of density greater than that of natural snow provides greater insulation than natural snow. Generally, natural snow has a density of about 10 pounds per cubic

foot. Increased insulation is provided by the process of the present invention by the application of snow cover of density of greater than about 15 pounds per cubic foot.

The invention is an improvement to any known process for mining bituminous tar sands. Preferably the invention is applied to open pit mining of the sands with bucket-wheel excavators. Such processes are numerous and detailed descriptions of both the processes and apparatus used in the processes can be found inter alia in United States Patents 1,763,769; 2,291,669; 2,757,463; 2,834,127; 3,020,656; 3,258,865; 3,298,117; and 3,304,634.

The initial step in the preferred mining process is the removal of overburden preceded by cleaning of the ground surface. The surface of tar sands mining areas is often characterized by swamps and muskeg with poor drainage. Initial removal of trees and plant cover helps the surface to dry naturally. After removal of trees and roots, etc., the overburden can be removed with conventional earth-moving equipment such as electrical shovels and trucks. In order to produce synthetic crude from the tar sands at an economic rate, the mining step must be capable of removing and transporting large quantities of material. The preferred method of mining utilizes large bucketwheel excavators and high speed conveyors. The excavators offer a maximum capacity of 9,000 tons per hour. The material discharging from the excavators is picked up by crawler-mounted conveyors for transfer to the conveyor system. The conveyor system consists of a face conveyor and a trunk conveyor for each excavator discharging into a single plant feed conveyor. The face conveyors and trunk conveyors are shiftable and extendable to follow the progress of the excavation.

As noted above, one of the greatest difficulties encountered in maintaining mining production in the described process is frost penetration in exposed, undisturbed tar sands. Through a winter this penetration can reach as deep as ten feet, sometimes greater. By supplementing natural snow cover with artificial snow per the process of the present invention, the tar sands are substantially protected from frost penetration. Furthermore, it has been found by the present invention that artificially produced snow cover of a density greater than natural snow cover provides better protection against frost penetration than naturally-occurring snow cover.

Although any method of depositing the snow cover may be used, the preferred method is disclosed in Canadian Patent 513,432. An apparatus disclosed in that patent injects into the atmosphere a mist of fog formed from water. The particles of water in the mist or fog are cooled by the projection of rapidly expended air supplied by a compressed air source so that snowflakes are formed which precipitate onto the tar sands. The spray can be directed onto the sands or beside the sands to form a pile which can thereafter be spread over the sands. Although any depth of snow will suffice to protect the sands a depth of at least 2 feet works best.

The following example illustrates this invention. In this example snow was made by discharging air and water as a vapor under pressure through a mixing gun into a freezing atmosphere. The water was supplied from its source at an approximate pressure of 80 pounds. The water was passed through a heat exchange to a gasoline powered pump where the pressure was raised to approximately 150 pounds per square inch. A three-inch distributor pipe fed the water supply to two-inch rubber hosing connected to the snow-making machine.

Air was supplied to the snow gun by two 600 c.f.m. rotary screw compressors through a three-inch pipe to a two-inch rubber hose connected to the snow gun.

The snow gun was constructed from a four-inch aluminum tube approximately four feet long having a bottom water inlet and air inlet on the side of its barrel. The barrel was mounted on a bipod, permitting elevation control. Discharge of the mix was through replaceable nozzles of circular cross section.

A test area 400 feet by 160 feet was divided into 10 sections, each 80 feet by 80 feet. Eight thermocouples were installed at the center of each of eight blocks. Each thermocouple had 9 probes at depths of 0, 1, 2, 3, 4, 5, 7, 9, and 12 feet. Temperatures were recorded from the thermocouples by a portable plug-in type potentiometer.

The Test Sections were covered as follows:

Sections 1 and 2 were covered with two feet of artificial snow, Sections 3 and 4 with four feet of artificial snow, and Sections 5 and 6 with six feet of articificial snow. Section 7 was retained for natural snow coverage and Section 8 was maintained exposed with no snow coverage.

The snow in the Test Sections 1 to 6 formed a hard surface. The density of the snow in these areas ranged from 20 to 25 pounds per cubic foot compared to that of the natural snow cover in Section 7 which was about 10 pounds per cubic foot.

Temperature readings in the Sections were taken over a winter period of about five months in which the ambient temperature ranged from about +55° F. to −45° F. Generally, temperature readings indicated highest temperatures and least frost penetration in Sections 5 and 6 with progressing lower temperatures and greater frost penetration in Section 3 and 4, Sections 1 and 2, and Section 7 and with lowest temperatures and greatest frost penetration in Section 8. For example, on a typical day at an ambient temperature of about −10° F. the approximate readings given in the table were recorded for probes set respectively at 2, 5 and 12 feet in the tar sands deposits.

TABLE
[Temperature readings, ° F.]

	Probe depth		
Section	2 Feet	5 Feet	12 Feet
1	28	32	36
2	27	32-33	36
3	29	33	35-36
4	29	34	36
5	31	35	37
6	31	34-35	37
7	22	28	36
8	19	27-28	34-35

The temperature readings in the table indicate that frost penetration into tar sands deposits can be decreased by maintaining a cover of artificially-produced snow on the deposits. Furthermore, a comparison of temperatures obtained from Sections 1 to 6 with the temperatures obtained from Section 7, particularly at probe depths of 2 and 5 feet indicate that artificial snow cover of density greater than that of natural snow, provides better protection from frost penetration than natural snow.

What is claimed is:

1. A method of mining bituminous tar sands for changing into a process for separating bitumen from said tar sands which comprises:
   (a) removing overburden to expose said tar sands;
   (b) depositing a cover of artificially produced snow of initial density greater than 10 pounds per cubic foot on said exposed tar sands;
   (c) maintaining said cover of snow to substantially reduce frost penetration into said sands; and
   (d) removing said tar sands for charge into a process for separating bitumen from said sands.

2. The method of claim 1 in which Step (b) comprises depositing on the said exposed tar sands a layer of relatively light, dry snow and then depositing a layer of relatively wet snow.

3. The method of claim 1 in which Step (b) comprises depositing a cover of snow at least 2 feet in depth on said exposed tar sands.

4. The method of claim 3 in which the snow cover deposited in Step (b) has a density of between about 15 to 27 pounds per cubic foot.

5. The method of claim 1 in which the snow cover deposited in Step (b) has a density of between about 15 to 27 pounds per cubic foot.

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