A new tunneling machine is described in this article. It works based on the gravity-control technology, and can reach high velocities through rocky means; possibly few tens of meters per hour, moreover it can move itself in any directions below the ground. This machine can be highly useful for urban tunneling, drainage, exploration, water supply, water diversion and accessing the mines of diamonds, coal, oil, and several others types of minerals existent in the Earth’s crust.

Key words: Gravity-control technology, tunneling technology, Subterranean Space Forming, Mining Equipment.

1. Introduction

The drilling of tunnels through rocky means is a very hard work to be performed without the use of appropriate drilling machines. Several researchers in many countries had been making attempts to developing tunneling machines [1, 2, 3].

In the decade of 70 of the last century a group of scientists created the geowinchester technology for underground workings. At the same time the first experimental prototype of the drilling machine called geohod (ELANG-3) was created.

Pneumatic punchers were developed and are widely used in several countries. These machines include their underground movement control, telecommanding as well underground location and position control [4, 5, 6].

In the early 2000s, a team of Russian scientists led by Professor Vladimir Aksionov started building a new generation of geohods with improved geowinchester technology.

Tunnel boring isn’t an easy job. The world’s largest tunnel boring machine (called Bertha) consumes 18,600 kWh and moves at a speed of about 10 m per day [7].

Currently a new model of geohod is being developed [8]. It will have a diameter of 3.2 meters and a length of 4.5 meters (without additional modules). It will be able to reach a speed of 6 m/h. This device has no similar in the world.

Creation of a tunneling machine that can rapidly move itself in any directions below the ground is highly relevant for urban tunneling, drainage, exploration, water supply, water diversion and accessing the mines of diamonds, coal, oil, and several others types of minerals existent in the Earth’s crust.

In this article we show how gravity-control technology (BR Patent Number: PI0805046-5, July 31, 2008 [9]) can be used for the development this machine, here called of Gravitational Tunneling Machine (GTM).

2. Theory

The quantization of gravity shows that the gravitational mass \( m_g \) and inertial mass \( m_i \) are not equivalents, but correlated by means of a factor \( \chi \), which, under certain circumstances can be negative. The correlation equation is [10]

\[
m_g = \chi m_{i0}
\]

where \( m_{i0} \) is the rest inertial mass of the particle.

The expression of \( \chi \) can be put in the following forms [10]:

\[
\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2 \left[ \sqrt{1 + \left( \frac{W}{\rho c^2 n_r} \right)} - 1 \right]\right\}
\]
\[
\chi = \frac{m_g}{m_{i0}} = \left\{ \begin{array}{l}
1 - 2 \sqrt{1 + \left( \frac{D n_r^2}{\rho c^3} \right)^2} - 1 \\
\end{array} \right. 
\]

where \( W \) is the density of electromagnetic energy on the particle \((J/kg)\); \( D \) is the radiation power density; \( \rho \) is the matter density of the particle \((kg/m^3)\); \( n_r \) is the index of refraction, and \( c \) is the speed of light.

Equations (2) and (3) show that only for \( W = 0 \) or \( D = 0 \) the gravitational mass is equivalent to the inertial mass \((\chi = 1)\). Also, these equations show that the gravitational mass of a particle can be significantly reduced or made strongly negative when the particle is subjected to high-densities of electromagnetic energy.

Also, it was shown that, if the weight of a particle in a side of a lamina is \( \vec{P} = m_g \vec{g} \) (\( \vec{g} \) perpendicular to the lamina) then the weight of the same particle, in the other side of the lamina is \( \vec{P'} = \chi m_g \vec{g} \), where \( \chi = m_g/m_{i0} \) \((m_g \) and \( m_{i0} \) are respectively, the gravitational mass and the inertial mass of the lamina). Only when \( \chi = 1 \), the weight is equal in both sides of the lamina. The lamina works as a Gravitational Shielding. This is the Gravitational Shielding effect. Since \( \vec{P'} = \chi \vec{P} = \chi \vec{m}_g \vec{g} = \chi m_g \vec{g} \), we can consider that \( m'_{i} = \chi m_{i} \) or that \( \vec{g}' = \chi \vec{g} \).

If we take two parallel gravitational shieldings, with \( \chi_1 \) and \( \chi_2 \) respectively, then the gravitational masses become: \( m_{g1} = \chi_1 m_g \), \( m_{g2} = \chi_2 m_g \), \( m_{g1} = \chi_1 \chi_2 m_g \), and the gravity will be given by \( g_1 = \chi_1 g \), \( g_2 = \chi_2 g_1 = \chi_1 \chi_2 g \). In the case of multiples gravitational shieldings, with \( \chi_1, \chi_2, ..., \chi_n \), we can write that, after the \( n^{th} \) gravitational shielding the gravitational mass, \( m_{g_{n}} \), and the gravity, \( g_{n} \), will be given by

\[
m_{g_{n}} = \chi_1 \chi_2 \chi_3 ... \chi_n m_g \quad \text{and} \quad \chi_1 \chi_2 \chi_3 ... \chi_n g \]

This means that, \( n \) superposed gravitational shieldings with different \( \chi_1, \chi_2, \chi_3, ..., \chi_n \) are equivalent to a single gravitational shielding with \( \chi = \chi_1 \chi_2 \chi_3 ... \chi_n \).

The extension of the shielding effect, i.e., the distance at which the gravitational shielding effect reach, beyond the gravitational shielding, depends basically of the magnitude of the shielding’s surface. Experiments show that, when
the shielding’s surface is large (a disk with radius \( a \)) the action of the gravitational shielding extends up to a distance \( d \cong 20a \) [11]. When the shielding’s surface is very small the extension of the shielding effect becomes experimentally undetectable.

If we make \( (\chi_1, \chi_2, \ldots, \chi_n) \) negative (\( n \) odd) the gravity \( g' \) becomes repulsive, producing a pressure \( p \) upon the matter around the sphere. This pressure can be expressed by means of the following equation

\[
p = F = \frac{m_{10}(\text{matter})g'}{S} = \frac{\rho_i(\text{matter})S\Delta g'}{S} = \rho_i(\text{matter})\Delta g'
\]

Substitution of Eq. (5) into Eq. (6), gives

\[
p = -(\chi_1x_2\ldots x_n)\rho_i(\text{matter})\Delta x(Gm_{10s}/r^2)
\]

If the matter around the sphere is only the atmospheric air \( (p_a = 1.013 \times 10^5 \text{ N} \cdot \text{m}^{-2}) \), then, in order to expel all the atmospheric air from the inside the belt with \( \Delta x \) - thickness (See Fig. 5), we must have \( p > p_a \). This requires that

\[
(\chi_1x_2\ldots x_n) > \frac{p_a r^2}{\rho_i(\text{matter})\Delta x Gm_{10s}}
\]

Satisfied this condition, all the matter is expelled from this region, except the Continuous Universal Fluid (CUF), which density is \( \rho_{\text{CUF}} \approx 10^{-27} \text{ kg} \cdot \text{m}^{-3} \) [12].

The density of the Universal Quantum Fluid is clearly not uniform along the Universe. At supercompressed state, it gives origin to the known matter (quarks, electrons, protons, neutrons, etc). Thus, the gravitational mass arises with the supercompression state. At the normal state (free space, far from matter), the local inertial mass of Universal Quantum Fluid does not generate gravitational mass, i.e., \( \chi = 0 \). However, if some bodies are placed in the neighborhoods, then this value will become greater than zero, due to proximity effect, and the gravitational mass will have a non-null value. This is the case of the region with \( \Delta x \) - thickness, i.e., in spite of all the matter be expelled from the region, remaining in place just the Universal Quantum Fluid, the proximity of neighboring matter makes non-null the gravitational mass of this region, but extremely close to zero, in such way that, the value of \( x = m_i/m_{10} \) is also extremely close to zero \( (m_{10} \) is the inertial mass of the Universal Quantum Fluid in the mentioned region).

Since in the region with \( \Delta x \) - thickness, the value of \( \chi \) is extremely close to zero, we can
conclude that the gravitational mass of the sphere, which is given by \( m_i = \chi r_{x_1} \cdots r_{x_n} m_{0} \), becomes very close to zero.

Now consider Fig. 6, where we show a Gravitational Tunneling Machine, which works based on the principles above described. Encrusted inside the tungsten tip of the tunneling machine there is a set of \( n \) plane gravitational shieldings, with \( \chi_1, \chi_2, \cdots, \chi_n \), respectively. Just before the gravitational shielding \( \chi_1 \) there is a cube of tungsten, which produces a gravity acceleration \( g_i \) on its surface (See Fig.6). When the set of gravitational shielding is activated the gravity \( g_i \) is increased to \( (\chi_1 \cdots \chi_n)g_i \). Thus, if \( n \) is odd, the rock in front of the tunneling machine will be attracted to it with a gravitational force given by \( F_{e} = M_{ge}(\chi_1 \cdots \chi_n)g_i \), where \( M_{ge} \) is the gravitational mass of the rock. Similarly, the tunneling machine will be attracted to the rock with a gravitational force \( F_{i} = M_{gi}(\chi_1 \cdots \chi_n)g_e \), where \( g_e \) is the gravity produced by \( M_{ge} \) on the surface of the rock (See Fig.6). Thus, by increasing the values of \( (\chi_1 \cdots \chi_n) \) the pressure upon the rock can surpass its compressive strength, and the tunneling machine progresses. The compressive strength of the tungsten is about 100GPa while the maximum compressive strength of the rocks is about 1GPa. Consequently, the strong compression does not affect the tungsten tip of the tunneling machine. In order to support this enormous compression, it is necessary to use, between the tungsten plates of the gravity control cells, Silicon Carbide (SiC) (or similar), whose compressive strength is about 10GPa (See Fig.6).

Note that before the tungsten cube there is a cell with air. When the set of gravitational shielding is activated the gravity acceleration upon the air molecules becomes equal to \( (\chi_1 \cdots \chi_n)g_e \), then if condition (8) is satisfied, all the matter will be expelled from this cell, except the Continuous Universal Fluid (CUF), which density is \( \rho_{\text{CUF}} \approx 10^{-27} \text{kg.m}^{-3} \). As we have already seen, the consequence is that the gravitational mass of the air in this region becomes extremely close to zero, and consequently, the value of \( \chi \) in this region (\( \chi_0 \)) is also extremely close to zero. This works as a strong attenuator of gravity, reducing the enormous gravity \( (\chi_1 \cdots \chi_n)g_e \) down to \( \chi_0(\chi_1 \cdots \chi_n)g_e \). Thus, the value of the gravity acceleration \( (\chi_1 \cdots \chi_n)g_e \) before the air cell is practically nullified (See Fig. 6).

Note that the axis of the tunneling machine can be easily displaced. This makes possible the machine move itself in any directions below the ground.

Obviously, this machine can include systems to control its underground movement, as well underground location and position, etc. Also additional modules can be included for others specific uses.

In order to drill the rock, the pressure, \( p = F/S \), exerted by the tunneling machine on the rock must be proportional to compressive strength of the rock, \( \sigma_r \), i.e.,

\[
p = k \sigma_r
\]

where \( k \) is the factor of proportionality. For \( k \leq 1 \) the force \( F \) does not carry out work. The work just occurs for \( k > 1 \). In this case we can write that

\[
dW = (k - 1)Fdr \quad \text{for} \quad k > 1
\]

Then the potential energy \( U(r) \) is given by

\[
U(r) = \int_{r_{\text{e}}}^{r} dW = \int_{r_{\text{e}}}^{r} (k - 1)Fdr = \\
= \int_{r_{\text{e}}}^{r} (k - 1)(\chi_1 \chi_2 \cdots \chi_n)GM_{gi}M_{ge}\left(\frac{1}{r} - \frac{1}{r_0}\right)dr = \\
= -(k - 1)(\chi_1 \chi_2 \cdots \chi_n)GM_{gi}M_{ge}
\]

(11)

On the other hand, the kinetic energy of the tunneling machine is

\[
E_k = F \cdot r = M_{gi}(\chi_1 \chi_2 \cdots \chi_n)v_{e}r = \\
= M_{gi}(\chi_1 \chi_2 \cdots \chi_n)\left(\frac{v^2}{2}\right)
\]

(12)

By comparing equations (11) and (12), we obtain

\[
v = \sqrt{\frac{2(k - 1)GM_{ge}}{r}}
\]

(13)

For \( p = 10 \text{GPa} \) (maximum pressure supported by the tungsten) and \( \sigma_r = 0.2 \text{GPa} \) (compressive strength of granite), we get \( k = p/\sigma_r = 50 \). Considering just a granite block in front of the tunneling...
machine, whose center of mass is at a distance \( r \approx 10m \) of the center of mass of the tunneling tip, then we can assume \( M_{ge} \approx 100 \) tons. Thus, for \( k = 50 \) Eq. (13), gives

\[ v \approx 10 \text{ m} / \text{h} \] \hspace{1cm} (14)

This is therefore the order of magnitude of the velocity of the tunneling through the granite. Note that this velocity is greater than the velocity of the new model of geohod mentioned at the introduction of this work.

Through soft soil \( \sigma_r \approx 50\text{kPa} \) the velocity of the tunneling increases to \( h \text{ km} / \text{10} \approx \). The pressure exerted upon the rock heats the tip of the tunneling machine. In order to calculate the temperature due to this pressure we start considering that the thermal energy \( T_E \) produced by the frictional force, \( F_\mu \), is given by

\[ E_T = F_\mu d = \mu m d = \mu m \left( \frac{v^2}{2} \right) = \mu E_k \] \hspace{1cm} (15)

where \( \mu \) coefficient of friction.

By dividing both members of this equation by the volume, \( V \), we get \( W_T = \mu W_k = \mu \left( \frac{1}{2} \rho_l v^2 \right) \), where \( \rho_l \) is the density of the tip of the tunneling machine (tungsten), and \( v \) is its velocity. Since \( D_T = W_T(c/4) \) and \( D_T = \sigma_B T^4 \) (\( \sigma_B = 5.67 \times 10^{-8} W/m^2 K^4 \) is the Stefan-Boltzmann’s constant), we obtain

\[ T = \sqrt[4]{\frac{\mu c \rho_l v^2}{8 \sigma_B}} \] \hspace{1cm} (16)

For \( v \approx 10\text{m} / \text{h} \approx 3 \times 10^{-3} \text{ m/s} \), \( \rho_l = 19.250 \text{kg} / \text{m}^3 \), we obtain

\[ T \approx 3,271.7 \mu^{\frac{1}{2}} \] \hspace{1cm} (17)

The value of \( \mu \) for any two materials depends on system variables like temperature, velocity, pressure, as well as on geometric properties of the interface between the materials. In the particular case of the tunneling machine shown in Fig.6, due to the elliptic surface, the value of \( \mu \) should be very less than that associated with kinetic friction* and very greater than the values for the coefficient of rolling resistance, which typical values are about 0.001 [13]. Assuming that, for the tunneling machine, the value of \( \mu \) is of the order of 0.01, then Eq. (17) shows that the temperature at the tip of the tunneling machine is of the order of 1,000K (~800°C). This temperature is sufficient to melt the rock, and then the molten rock is pushed from the tip is immediately turned into a glass-like material, which coats the inner diameter of the tunnel, creating an initial tunnel liner.

Since \( k \) is expressed by

\[ k = \frac{p}{\sigma_r} = \left( \chi_1 \chi_2 \ldots \chi_n \right) \frac{M_{gi} g_{e}}{S \sigma_r} \]

we can conclude that, for \( k = 50 \), \( M_{gi} = M_{ge} = 100 \) tons, \( S = (3.2)^2 = 10.2m^2 \), \( r \approx 10m \) and \( \sigma_r = 0.2\text{GPa} \), we must have

\[ \left( \chi_1 \chi_2 \ldots \chi_n \right) = \frac{G_{M_{gi}} M_{gi}}{S \sigma_r r^2} \approx 10^{12} \] \hspace{1cm} (16)

Thus, if \( \chi_1 = \chi_2 = \ldots = \chi_n \) and \( n = 8 \), we get

\[ \chi_1 = \chi_2 = \ldots \chi_8 = \chi = 8^{1/12} \approx -31.6 \] \hspace{1cm} (17)

This is, therefore, the necessary value of \( \chi \), at each gravity control cell, in order to produce \( \left( \chi_1 \chi_2 \ldots \chi_n \right) \approx 10^{12} \).

It is important to note that the energy necessary to move this tunneling machine is just the energy used to produce the gravitational shieldings. This is a very small amount of energy, and can be supplied by a common battery only. Thus, this is the world’s most economical tunneling machine, and has no analogues in the world, and represents a completely new type of tunneling machine.

* Most dry materials in combination have friction coefficient values between 0.3 and 0.6. Values outside this range are rarer.
Fig. 6 - Gravitational Tunneling Machine

\[ \chi_0(\chi_1...\chi_n)g_e \approx 0 ; \chi_0 \approx 0 \]

\[ F_i = M_\delta(\chi_1...\chi_n)g_e \]

\[ F_e = M_\delta(\chi_1...\chi_n)g_i \]

Air

\[ n \text{ odd} \]

\[ \chi_0 \approx 0.40 \text{ m} \]

\[ \chi_1 \approx 0.40 \text{ m} \]

\[ \chi_2 \approx 0.40 \text{ m} \]

\[ \chi_3 \approx 1.00 \text{ m} \]

\[ \chi_4 \approx 1.00 \text{ m} \]

Gravitational Shieldings

Rock (\( \sigma_{\max} \approx 1 \text{ GPa} \))

\[ \sim 50 \text{ ton} \]

Tungsten (\( \sigma \approx 100 \text{ GPa} \))

Silicon Carbide (SiC) (\( \sigma \approx 10 \text{ GPa} \))
References


