Hydro-slotting perforation technology is the cutting of continuous slots ("windows") along the wellbore. The main idea of the technology is unloading of the annular compressive stress conditions (stress-strain states) around the wellbore zone. Hydro-slotting perforation refers to the basic methods of opening the casing, cement and productive formation.

- ecologically safe, environmentally friendly (produced water and an abrasive filler)
- penetration depth is up to 1.5 m (5 feet)
- opening area per one linear meter is up to 6 m² (2 nozzles), and 12 m² (4 nozzles)
- opening area per one linear foot is up to 20 ft² (2 nozzles), and 40 ft² (4 nozzles)
- cutting speed is one linear foot per 60 min (cased wells) and one linear foot per 30 min (open hole)
- simultaneous cutting 2, 3, and 4 slots along the wellbore
- no detonation impact, no casing damage, no cement cracks, no clog-up the formation borders
- unloading of the annular compressive stress conditions in the near wellbore zone up to 50-100%

Accordingly the increase in the useful inflow up to 5-10 times
- can be used in oil, gas, and injection wells
- can be used in newly drilled and low productivity, low debit wells
- can be used in vertical and horizontal wells, with tubing and coiled tubing
- can be used in any formation (sandstone, carbonates, shale’s, thinly interbedded, quicksand, etc.)
- can be used near the water reservoirs (impossible to make a hydraulic fracturing)
- extract more than 20% of additional oil from the layers with higher productivity
- duration of the effect over 10 years
- make an excellent geometry for subsequent fracturing (if necessary)

The efficiency and duration of effect of all additional stimulation’s methods depends on the size (area) of opening the casing, cement and productive formation.

- accordingly the increase of permeability up to 30-50%
It is known that during the drilling in any well (any perforation hole) in and around the wellbore annular (tangential) compressive stress conditions (stress strain states) are created. The deeper the well, the more compressive stress conditions. Under this action and high overburden pressure occurs a significant reduction of permeability in the near wellbore zone, and in some cases close to near zero. Oil or gas flow can not penetrate to the well.

Deterioration of the rock’s permeability in the near-wellbore directly from the borehole wall is one of the main causes of the declining production rate of oil and gas wells. This occurs both during drilling and during their operation (figure on the left).

On the rocks lying at depths of 3–5 km the compressive stresses may reach up to 75–125 MPa. In the near wellbore zone, as a result of concentration these stresses increase and sometimes become equal to or double 150–250 MPa. If the tectonic stress is several times higher than stress from the weight of rocks, the stress in the near-well zone may be even greater.

How is it possible to offload the rocks from its existing shear stresses?

How to unload annular compressive stress conditions in the near wellbore zone and thereby improve the permeability and accordingly increase the production rate of oil and gas wells?

The idea came from the coal industry (coal mines). Since ancient times, when there were the first coal mines, it was observed, that increasing the depth of the development the coal tunnel, under the action of overburden pressure, surrounding rocks become harder and little-permeable. To solve this problem they developed a cavern of a certain form in the rock.

The only possible solution in this situation, in relation to oil and gas wells, is to offload the rocks from its existing shear stress. In particular, the current decrease in near wellbore zone, the hoop stress.

In practice, this can be achieved by cutting continuous slots (“windows”) in the vertical section of the wellbore.
The first figure below shows that the borehole is surrounded by low permeable "cork" thickness which is approximately 50% of the well's radius. From figures 2 and 3 shows that two or four diametrically opposite vertical continuous slots is almost twice lower operating on the circuit hole shear stresses, and reduced permeability areas are significantly reduced in size and are pushed into the interior of the reservoir. Thus, the presence of vertical slots significantly improves the situation, and generally retains rock permeability.

CONTINUOUS SLOTS (“WINDOWS”) ALONG THE WELLBORE

When cutting of continuous slots ("windows") along the wellbore occurs the redistribution of the annular stress conditions to the ends of these slots ("windows"), further from wellbore zone. As a result, the stress in the near wellbore zone is reduced. Occurs the unloading of stress state. Accordingly, the permeability in this zone is increase. Accordingly, the productive inflow to the well also is increase. The effect of stress state’s discharge occurs at a depth of continuous slots from ~ 30 cm (1 foot) to 100 cm (3.3 feet).

How to cut a continuous deep slot along the wellbore section through the casing, cement and further into the productive formation?
**HOW TO CUT CONTINUOUS SLOTS (“WINDOWS”) ALONG THE WELLBORE**

How to cut a continuous deep slot along the wellbore section through the casing, cement and further into the productive formation?

**MINING GEO-MECHANIC’S REQUIREMENTS**

- Large opening area of a casing, cement ring and productive formation - it provides a good hydro-dynamic connection between productive layer and the well.
- The depth of penetration into the productive formation - it provides the unloading the stress conditions in the near wellbore zone and accordingly increases the permeability.
- Preventing the formation of crusts on the border of opening zone - this prevents the inflow of useful product and requires additional actions.
- Preventing cracked of cement ring - it provokes the flows of water and increases the risk of well’s flooding.

All currently known main methods of opening the casing, cement sheath and productive formation (mechanical and jet, shock-explosive and sparing, stressed and unstrained, etc.) have their own drawbacks:

- Detonation impact
- Casing damage
- Cement crack
- Borders clog-up
- Formation damage
- Uncontrolled direction
- Affects the other layers and zones
- Low efficiency
- Unwanted flows generating
- Short duration effect
- Shallow penetration depth
- Increase of annular stress conditions in the near wellbore zone
- Permeability decreasing
- Well life's reducing

None of these methods does not create the real continuous, geometrically correct and deep slots (“windows”) along the wellbore, and correspondingly does not discharged stress-strain states in the near wellbore zone. Opening area of casing in all cases is small enough.

- In addition the efficacy and duration of effect of all currently known additional stimulation’s methods (as acoustic, cavitation, chemical treatment, electric, frequency, impact, impulse, laser, magnetic, oscillations, plasma, pneumatic, temperature, ultrasound, vacuum, vibrations, voltage, warming-up, wave, etc.) is directly depends on the size (area) of opening the casing, cement and productive formation.

**DIMENSION’S COMPARISON OF DIFFERENT OPENING’S METHODS**

<table>
<thead>
<tr>
<th>Method</th>
<th>Depth (inches)</th>
<th>Depth (feet)</th>
<th>Drainage/Fracturation</th>
<th>Square inches</th>
<th>Square feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun perforation</td>
<td>3.9</td>
<td>0.3</td>
<td></td>
<td>13.0</td>
<td>0.15</td>
</tr>
<tr>
<td>Jet perforation</td>
<td>3.9</td>
<td>0.3</td>
<td></td>
<td>13.0</td>
<td>0.15</td>
</tr>
<tr>
<td>Shooting perforation</td>
<td>4.72</td>
<td>0.39</td>
<td></td>
<td>3.8</td>
<td>0.034</td>
</tr>
<tr>
<td>Abrasive perforation</td>
<td>1.67</td>
<td>0.05</td>
<td></td>
<td>10.9</td>
<td>0.13</td>
</tr>
<tr>
<td>Mechanical hydro-slootting perforation</td>
<td>16.9</td>
<td>1.33</td>
<td></td>
<td>10.0</td>
<td>0.13</td>
</tr>
</tbody>
</table>

The depth of the slots is limited.
The movement from the tubing.
Slots along the wellbore is possible to cut using abrasive jet perforation or mechanically. But in mechanical methods (circular saw, for example) it is impossible to use abrasive filler, we will not get the deep slots. Consider in more detail an abrasive jet perforation (or point jet perforation).

Abrasive jet (hydro-jetting) perforation relates to the main methods of opening the casing, cement sheath and productive formation. AJP is widely used in oil and gas industry as a main opening method, and an auxiliary, for subsequent hydraulic fracture.

Abrasive jet perforation does not damage the casing, not crack the cement sheath, and not damage the formation. This is environmentally friendly method (produced water and an abrasive filler). Point jet perforation does not unload the annular compressive stress conditions in the near wellbore zone (profile is the hole D=2.5 cm (1 inch) and L=30 cm (1 foot), and it regardless of the number of holes.

**The depth of holes does not depend on time application and not becomes deeper.** This happens because the reverse jets from the holes hinder direct jets from the nozzles, and perforated rock can not freely go out from the holes (excavation effect does not occur).

Increasing the number of nozzles does not create continuous slots too, and only creates additional annular stressful conditions around the perforation holes.

**To create the continuous and deep slots needed, the interference must be prevented by eliminating the streams from competing.** A free exit of perforated rock from the holes must be created, and this is accomplished through MOVING the jets (nozzles) continuously along the wellbore. But such a move is impossible to get by moving the tubing or coiled tubing from the surface. Both tubing and coil tubing have their own frequency and stretch. The working jets will jump (figures on the right) causing a scissor cut. In the best case, a cavern will be formed. The movement of cutting jets (nozzles) shall be applied directly at the cutting place (cutting interval) within the borehole and not depend on the movement of the tubing or coiled tubing.
CONTINUOUS MOVING JET (HYDRO-JETTING) PERFORATION

- The movement of cutting jets (nozzles) shall be applied directly at the cutting place (cutting interval) within the borehole and not depend on the movement of the tubing or coiled tubing.

The movement of cutting jets (nozzles) shall be constant and rectilinear, with a speed, enough for cutting casing, cement and deeper into the productive formation. Working jets (nozzles) all the time are moving to lower from the formed holes, reverse jets from the holes do not interfere direct jets from the nozzles, and perforated rock freely go out from the holes to the surface, together with the flow of fluid. The slots in the formation becomes deeper and deeper. Any angles of the nozzles are not necessary.

In this case along the wellbore it will be formed continuous and depth slots, with a good enough geometry. Accordingly, will occur unloading of annular stress conditions in the near wellbore zone, and consequently permeability in this area will be increased, which will lead to an increase in the productive flow to the wellbore.

- Such a movement can be created by a special device with electrical, mechanical or hydraulic / pneumatic principle.

HYDRAULIC SLOT-PERFORATION TOOL

- Hydraulic slot-perforation tool is not only iron. This is research, design, tests and mistakes, manufacture and tests again, continuous improvements and creating of new models. This is geological analysis and determination of the most promising cutting intervals, calculation of the technological parameters for slotting perforation process and “cut program” instructions. This is special computer programs, skills and knowledge, operational experience and “know-how”. Finally, it is the intellectual property.
The principle of operation are the following. When applying working fluid (produced water and an abrasive filler) pressure, the working rod with perforator starts to make rectilinear motion with constant slow velocity. Jets (2, 3, or 4) of working fluid with abrasive filler start cutting the casing (if the well is cased), cement and further into the productive formation. Since the perforator with working nozzles are constantly moving, forward and reverse jets (from the formed slots) they do not interfere with each other, cut (slot) becomes deeper and deeper, spent abrasive filler and rock freely escapes with the stream of working fluid to the surface. At the stop pressure supply operating rod with perforator is set up to the starting (initial) position, and the tool can be moved to the next cutting interval. Thus it is possible to cut the long continuous slots, or via specified interstices.

**HYDRAULIC SLOT-PERFORATION TOOL - IT IS VERY EASY**

**PATENT US 8863823**

**Patent US 8863823 from October 21, 2014** is the latest invention of hydraulic slot-perforation tool “Universal underground hydro-slotting perforation system, controlled by working fluid pressure, for activation and intensification of gas, oil and hydro-geological wells”. This patent includes design and operation of hydraulic unit (slotting perforation engine), return unit (spring block), perforator, nozzles, nozzle-holders and adapter.

**Hydraulic unit** (slotting perforation engine), it is a main part of the tool for performing of slotting perforation process. This unit provides the constant rectilinear motion of the working rod with the perforator and working nozzles at a certain speed (speed determines the depth of cut), depending on the operating pressure and temperature of the working fluid. The unit is sealed and autonomous. The valve and the floating pistons provides a change of internal volume, depending on the hydrostatic pressure. The flow controller sets a constant speed of the working rod, depending on temperature and pressure of the working fluid (produced water and an abrasive filler).
Return unit (spring block), it is a part of the slotting perforation tool. This unit provides return of the operating rod of hydraulic slotting perforation engine into the initial (start-up) position after stop supply the pressure at the end of the next cutting interval. The block becomes sealed when the pressure supply. Exists spring blocks of direct action (direct slots) and spiral action (spiral slots for use in the case with two nozzles in the perforator, and when the direction of the highest fracturing of the deposit-field is unknown). It consists of housing, rod, springs, regulating devices, airtight lids and seals.

Compensators using for stimulation of the slotting perforation process in vertical oil, gas, injection or hydro-geological wells (open/cased). Compensators can work with regular tubing only.

Perforators it is an integral part of any slotting perforation process (hydro-slotting, jet slotting, or jet point perforation). Perforator it is the unit of turbulent’s zone, where the working fluid it changes the directory of movement from the working rod direction into the cutting's nozzles. Requirements for perforators: long period of operation (made from one piece of solid metal), ergonomics (low pressure loss), streamlined shape (not scratch the casing), the ability to direct and back flushing even when lowering the tool on the ground. There are many types of perforators varying according to design, type, form, destination, number of nozzles and stiffened ribs, for different type of wells, diameter, tasks, etc. Exist ergonomic, streamlined, multiple use, for vertical and horizontal wells, self-oriented, swiveling, etc.

Nozzles for perforators are made from high quality tungsten mixture of carbide, tungsten, corundum, technical diamond grit and special additives in a definite proportion. Nozzles must to meet all the technological process requirements of the slot perforation process: lasting of work, resistance to high temperature, high pressure, impacts, crumbling and have a hardness of more quartz. Nozzles have a different design and size depending on the shape of the nozzle-holders and perforators, where they are used.

Adapters it is a connecting elements between tubing or coiled tubing and slotting perforation tool. Adapters also can perform other important functions, for example, saddle for a valve ball for testing of tubing or coiled tubing may be located in the shank of slotting perforation tool, or within adapter. Adapters are made from special nonmagnetic material, that is visible in the emissions of radioactive logging during the correlation and installation of the first cutting interval. In this case, adapter also serves as a marker. Exists elongated adapters, smoothing fluctuations of the supply pressure of the working fluid. In this case the adapter partially function as compensator.

SECURITY AND SAFETY OF THE TOOL
- This equipment is environmentally safe (using produced water and an abrasive filler)
- This equipment is not used any hazards materials (chemical, thermal, radiological, etc.)
- Hydraulic unit is a closed sealed self-regulating system for prevent explosion under the action of hydrostatic pressure in a water-filled borehole.
- Perforator is designed so stiffness ribs did not scratch the casing.
- Perforator does not burrow into the sand completely.
- If accidentally lowering the tool on the ground remained the possibility of reverse (and direct) flushing.
- Almost all threaded connections involve the use of Teflon (oil) tape.
- Rod with the perforator starts to move at a pressure 800 psi (5.5 Mpa).
- Maximum pressure of the hydraulic fluid 6500 psi (45 Mpa) (taking into account losses in the pipes).
- With further increase in pressure dosing device in the main piston (hydraulic block) snap on, hydraulic oil will flow through the gap between the main piston and the rod, the rod stops moving.
- When the pressure drops below 800 psi (5.5 Mpa) or pressure is cut (at the end of cutting, e.g.) rod with a working perforator will be immediately recharged (set-up) to the starting (initial) position, and will be ready for use again (on the next cutting interval, for example)
- Spring in the return block no operative in a free state.
- Spring is limited by special washers and nuts on the rod. In addition returning unit is limited by the protective cover from the perforator side
- If the spring breaks during the slotting perforation process, the rod with perforator still recharged (set-up) to the starting (initial) position.
- If perforator will break (even with a base spring rod) then the spring will not pops out from the return block because it will be hold the bottom with the protective cover.
HYDRO-SLOTTING PERFORATION PROCESS

Surface equipment for slotting perforation process is absolutely standard as for the jet perforation or hydraulic fracturing, only proppant (sticky sand) is not needed (wide vertical slots does not collapse). Instead abrasive quartz sand is needed.

- rig with crew (or coiled tubing service)
- tubing (or coiled tubing)
- wellhead and surface piping
- tank with formation water
- cutting tank and abrasive filler mixer (shaker, blender)
- frac service (pump service) with monitoring
- high pressure line with Manifold block
- abrasive filler (abrasive quartz sand)
- lowering the tool
- correlation log
- position correction
- tubing pressure test
- reverse flushing
- cutting first interval
- direct flushing
- lifting tool for the next cutting interval
- cutting next interval
- direct flushing
- reverse flushing
- lifting tool
- swabbing water

The tool is connected to the tubing or coiled tubing through the adapter with standard connections and lowered into the well on a predetermined depth of the first cutting interval. Hydraulic camera will set the volume itself, depending on the hydrostatic pressure. Tubing connections can be checked by the pressure with the valve ball in the adapter. After flushing out a test ball from the adapter to the surface, can be make flushing directly through the tool. After lowering through the tubing the service valve ball in the perforator, tool ready for cutting. When working pressure fluid (produced water and an abrasive filler) is supplied, rod with perforator and nozzles starts to make slow down the linear motion with constant velocity, enough for cutting casing, cement and further into the productive formation. The speed and depth of the cutting slots is regulated by pressure, concentration of abrasive filler and temperature of the working fluid. When stop applying pressure the rod with perforator and nozzles returns to the initial (set-up) position. The tool moves to the next cutting interval and the operation is repeated. After flushing out the service valve ball from the perforator to the surface, can be make flushing directly through the tool.
HYDRO-SLOTTING PERFORATION PROCESS

Some technical parameters of the slotting perforation process. The figure on the left shows a diagram of pressure, slurry rate and abrasive concentration. The figure on the right shows the cutting speed dependence on temperature and pressure (installed in the lab).

Maximum cutting depth with slotting perforation does not exceed 1.5 meters (or 5 feet). Greater depth of cut can not be done in connection with the physical and structural features of nozzles. With increasing pressure, increases only conicity of jets behind the nozzles (increases spraying zone), but increasing the depth of the jets does not occur. For a real increase in the cutting jets it is necessary to extend the body of nozzles, that is impossible to make - the length of the nozzles must be greater than the diameter of the well. Diameter of the tubing or coiled tubing is not very important, slot-perforation tool is connected to the tubing or coiled tubing through the standard adapters (varying diameters). The size of the tubing can be limited only by design of the internal diameter of the working rod in the slot-perforation tool and is equal to 30 mm (1.2 inches). But in such a small diameter, pressure losses in the pipes will be quite large. Therefore, with respect to the diameter of tubing or coiled tubing is possible to say: the more - the better.

Pressure increase leads to the simulation of hydraulic fracturing, and an increase in the concentration of an abrasive additive causes early erosion nozzles and perforator, but does not affect the depth. Much more important design parameter is the internal diameter of casing in vertical wells (or open hole for horizontal wells). Currently the design of slotting perforation equipment allows to operate in the wells with casing OD=100 mm (4 inches) for vertical wells, and OD= 120 mm (4.5 inches) for horizontal wells. In the nearest future it is planned to create slotting perforation equipment for operate in the wells with OD= 75 mm (3 inches) and OD=89 mm (3.5 inches).

Tool orientation in horizontal wells. Currently there is only a self-oriented (self-aligning) perforator for horizontal wells (figure on the right). Perforator can create vertical slot in the upper direction or vertical slot in the down direction in the horizontal wellbore.
Cutting depth is an adjustable parameter. Cutting length depends on the length of the working rod. The number of slots depends on the number of nozzles in the perforator.

GEOMETRY OF CUTTING SLOTS ("WINDOWS")

- Cutting depth is adjustable parameter. Cutting length depends on the length of the working rod. The number of slots depends on the number of nozzles in the perforator.

WHAT CAN BE DONE WITH SLOTTING PERFORATION TOOL

- Thin interbedded layers
- Shale’s near the water
- Few casings
- Mini fracturing
- Bypass couplings
- Chemical treatment
- Direct/reverse flush
RESULTS AFTER THE WORK OF A HYDRAULIC SLOT-PERFORATION TOOL
BENEFITS FROM HYDRO-SLOTTING PERFORATION

- Ecologically safe, environmentally friendly (produced water and an abrasive filler)
- Penetration depth is up to **1.5 m (5 feet)**
- Opening area per one linear meter up to **6 m² (2 nozzles), and 12 m² (4 nozzles)**
- Opening area per one linear foot up to **20 ft² (2 nozzles), and 40 ft² (4 nozzles)**
- Cutting speed is one linear foot per **60 min** (cased wells) and one linear foot per **30 min** (open hole)
- Simultaneous cutting **2, 3, and 4 slots** along the wellbore
- No detonation impact, no casing damage, no cement cracks, no clog-up the formation borders
- Unloading of the annular compressive stress conditions in the near wellbore zone up to **50-100 %**
- Accordingly increase of permeability up to **30-50 %**
- Accordingly increase the useful inflow up to **5-10 times**
- Can be used in oil, gas, and injection wells
- Can be used in newly drilled and low productivity, low debit wells
- Can be used in vertical and horizontal wells, with tubing and coiled tubing
- Can be used in any formation (sandstone, carbonates, shale’s, thinly interbedded, quicksand, etc.)
- Can be used near the water reservoirs (impossible to make a hydraulic fracturing)
- Extract more than **20 %** of additional oil from the layers with higher productivity
- Duration of the effect over **10 years**
- Make an excellent geometry for subsequent fracturing (if necessary)
WHERE IS HYDRO-SLOTTING POSSIBLE TO USE?

In sandstones, carbonates, shale’s, thinly interbedded formations. In oil and gas, vertical and horizontal, newly drilled, low-debit and low productivity wells. In low-temperature and low-viscosity wells. It is certainly better to use hydro-slotting perforation for its intended purpose, as a way of opening casing, cement and productive formation with the effect of annular stress conditions unloading in newly drilled wells, than later treat problem wells. Near the water reservoirs, for subsequent hydraulic fracture and additional stimulation’s methods (acoustic, cavitation, chemical treatment, electric, frequency, impact, impulse, laser, magnetic, oscillations, plasma, pneumatic, temperature, ultrasound, vacuum, vibrations, voltage, warming-up, wave, etc.) the efficacy and duration of effect which is directly depends on the size (area) of opening the casing, cement and productive formation.

SOME EXAMPLE - THINLY INTERBEDDED FORMATION

The picture below shows example of thinly interbedded formation (top and side view), similar to shale formation. Top view shows only one limited layer. How are you going to open this information? Of course, by traditional methods - cumulative or jet perforation and, if not near aquifers, hydraulic fracturing.

- Hydro-slotting perforation just cut through all the of thinly interbedded layers entirely and without residue, plus unloaded the annular stress conditions in the near wellbore zone.
SOME EXAMPLE - CRUMBLING SAND

Let’s consider another case. Crumbling (losing) sand - a fairly common well’s problem in some regions. Is it possible to treat this problem with hydro-slotting perforation? At first glance, this is not possible. Feed an abrasive under the high pressure into the well, which is already colmatated by crumbling sand! Let’s look at it from a different perspective.

- Firstly, how to remove the sand through small holes in the casing? Yes, with water jets under high pressure, or by different methods of stimulation may clear the holes, but remove sand behind the casing and cement is impossible. It is necessary to cut casing and cement to clean sand from the entire colmatation zone.

- Second, the sand falls into the channels in the near wellbore under the action of rock pressure. Continuous slots along the wellbore allow unloading of the annular compressive stress-strain states around the wellbore zone. Rock pressure to the sand will be reduced, crumbling of sand will be weakened.

- Occurs unloading (discharging) of the stress conditions in the near wellbore zone (up to 50-100%). As a consequence the rock pressure on the sandy rocks in the near-wellbore area (in radius ~ 12-14 feet around the well) become smaller, and sand stops to crumble.

- “Breaking component” of oil flow rate is reduced. It does not mean that the flow becomes less. Example. Suppose that through a hole in casing after cumulative perforation with the maximum diameter ~ 2” and the area ~ 3.14 square feet passes 1 barrel of oil per hour (in the case of a broken casing after hydraulic fracturing the area of hole ~ 10-15 square feet). One full slot after slotting perforation has an area of hole ~ 30-40 square feet. Let the flow of oil through the hole 40 square feet will remain the same: 1 barrel of oil per hour. But the total flow rate through the large hole will be less, respectively “destructive component” will also be less, respectively, the effect will be much longer.

SOME EXAMPLE - HORIZONTAL WELL

One more example of opening the productive layer in a horizontal wellbore with hydraulic fracturing and hydro-slotting perforation. Slots after hydro-slotting perforation are within the productive formation horizon (located along the productive horizon).

Drilled well before the operation
After perforation and subsequent hydraulic fracturing
After hydro-slotting perforation
**HYDRAULIC FRACTURING AND HYDRO-SLOTTING**

**Hydraulic fracturing** (fracking) - hydraulically pressurized liquid made of water, sand, and ... chemicals.

Hydraulic Fracturing is the most powerful method, creating very long cracks and micro cracks spread in the direction of the greatest fracture.

Fracturing relates to methods of opening the productive formation, but it can be applied only after one of the *known methods of opening the casing*:

- **Shock-explosive**: bullet (gun perforation) and cumulative perforation;
- **Unstressed**: methods of point perforation and continuous opening;

**Positive aspects**:
- Very large area of opening;
- Large productive inflow (especially in the initial stage);

**Negative aspects**:
- The process has practically no control;
- The process affects the other layers and zones;
- Cracks and micro cracks of large length extend the boundaries of producing formation and transferred to other layers;
- Coefficient of efficiency sometimes reduced up to 40% (within productive formation), the remaining 60% are harmful;
- Violation of the integrity of a producing formation;
- Combining unwanted productive and non-productive reservoirs;
- Generating unwanted flows;
- Pulling up the water with subsequent flooding of the productive layer;
- Reducing the life of the well.

Coefficient of efficiency of hydraulic fracturing in shale’s or thinly interbedded layers, for example, is very low and financially not beneficial.

**Hydro-sloTTing perforation** - continuous moving jet slotting perforation.

Hydro-sloTTing perforation is the most effective method of opening the casing, cement and productive formation. Uses a special slotting perforation tool that produces linear motion with constant velocity of abrasive cutting jets along the wellbore, and without moving the tubing from the surface.

**Positive aspects**:
- Ecologically safe, environmentally friendly (water and sand);
- Very long duration of effect (up to 15-20 years);
- Opportunity of using near the water reservoirs (impossible to make a hydraulic fracturing);
- The process is controlled (length and depth of slots);
- The process takes place within the productive formation, and not affects other layers and zones;
- Large opening area, penetration depth is up to 5 feet;
- No detonation impact, no casing damage, no cement cracks, no clog-up the formation in borders;
- Unloading the tangential circle stress conditions in the near wellbore zone up to 50-100%;
- Increases the collecting properties in the near wellbore zone;
- Increase of the drainage volume characteristics in more than 6 times;
- Increase of permeability and accordingly increase the useful inflow up to 30-50%;
- Opportunity to use in any wells and in any formations;

**Negative aspects**:
- The process is quite complicated in the performance;

Hydro-sloTTing perforation perfectly working in sandstones and carbonates, thinly interbedded formations, shale’s, etc.

Coefficient of efficiency of HSP in shale’s and thinly interbedded layers is very high.
HYDRO-SLOTTING PERFORATION IS NOT A MAGIC WAND FOR ALL OCCASIONS

According to classification the hydro-slotting perforation relates to methods of opening the productive formation. Hydro-slotting perforation it is accurate, and quite effective method, but it is not a magic wand for all occasions. Necessary to understand all the advantages of this method based on the physics of the phenomena of unloading the annular compressive stress-strain states around the wellbore zone, depth of created slots, opening area of the formation, operating principle and so on.

If in the well oil or gas is over, or productive layers have watered (or cement has cracks for water overflows), then no method will help anymore. Or if the well is working perfectly and gives productive influx of hundreds barrels per day, then no method will increase such influx in twice (except additional new drilling).

Cause of the fall of productive influx is a lot:
- Oil or gas is over
- Fall intrastate pressure
- Flooding of producing layer
- Chemical damage of the productive formation
- Incorrect grid drilling
- Incorrect development
- Incorrect exploitation
- Colmatation
- Poor hydrodynamic connection of the well with producing layer
- Low temperature, high viscosity, etc.

In which wells can slotting perforation be used?
- Oil, gas and injection wells
- Vertical and horizontal wells
- Newly drilled and old wells
- Sandstone, carbonate, shale, etc. formations
- Shallow and deep wells
- High-temperature and low-temperature wells
- Low-viscosity and high-viscosity, etc.

Is preferable:
- Newly drilled wells, or old wells with the following criteria:
- Old wells with the following criteria:
- Having no problems with the water during operation;
- Total period of operation not exceeding 10-15 years;
- Designed exclusively via gun perforation or cumulative perforation;
- Designed exclusively via hydraulic fracturing, but without water during the whole period of operation;
- The operational reservoirs one or two;
- Having a very good productive inflow in early or mid-operation;
- Currently idle or even abandonment;
- Currently inflow 0-0.5-1.0-1.5-2.0 bod;