Introduction

In a well completion, screens are used for a number of reasons, the foremost of which is to control sand production. The primary function of screens in sand control applications is to retain gravel in the annular region within the wellbore. Screens are also used to prevent borehole collapse and provide, in a passive manner, the ability to control the production rate along the length of the producing interval. A variety of screens are available in the industry with different performance characteristics [1-3]. Those commonly used in well completion are spiral filters with continuos slot obtained by helically wrapping a V-shaped wire on a support made of rods, which are usually known under the name of wire-wrap screens or “Johnson screens” (JS). The main characteristic of the JS presented in figure 1 is that the filtering slot opening is variable, being formed by wrapping on the cage made of support rods placed on the equidistant generator of a wire with a section shaped in such a way that the slot opening should become bigger in the direction of fluid flow. A wire-wrap screen will not plug like slotted casing, since the slot opening in the screen is V-shaped inwards and will only have two contact points with near slot size particles from the formation sands, whereas the parallel slots in a slotted liner will gradually plug up, by having near particle size sands wedge in the slots, restricting the in-flow of fluids, increasing the drawdown and gradually the fluids yield will drop off (fig. 2).

![Fig. 1 General details of screen](image1)

![Fig. 2 Advantages of the wire wrap screen as compared to slotted casing](image2)

<table>
<thead>
<tr>
<th>Size</th>
<th>b, mm</th>
<th>h, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>45*</td>
<td>1,14</td>
<td>3,15</td>
</tr>
<tr>
<td>60**</td>
<td>1,52</td>
<td>2,54</td>
</tr>
<tr>
<td>63*</td>
<td>1,52</td>
<td>4,32</td>
</tr>
<tr>
<td>69*</td>
<td>1,75</td>
<td>4,32</td>
</tr>
<tr>
<td>90**</td>
<td>1,75</td>
<td>4,32</td>
</tr>
<tr>
<td>93*</td>
<td>2,29</td>
<td>3,56</td>
</tr>
<tr>
<td>120*</td>
<td>3,05</td>
<td>3,91</td>
</tr>
</tbody>
</table>

* shaped wire
** support rod

![Fig. 3 Some profiles and dimensions of wires and support rods](image3)

<table>
<thead>
<tr>
<th>Size</th>
<th>b, mm</th>
<th>h, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>125**</td>
<td>3,17</td>
<td>4,67</td>
</tr>
<tr>
<td>156**</td>
<td>3,85</td>
<td>5,46</td>
</tr>
</tbody>
</table>
The slot opening \( f \) (see fig.1) is commonly between 0.075 mm and 2.5 mm. With the notations from figure 1, the open area factor \( S_r \) can be determined by the following equation [3]:

\[
S_r = \frac{f}{b + f} \cdot 100 \quad [\%]
\]  

(1)

The percentage of open area as well as the strength of the screen are affected by the type of surface wire and rods used. A balanced combination of surface profiles and support rods can be determined to suit particular system requirements. The most common choices of wire and rod shapes used are shown in figure 3.

The variation of the open area factor \( S_r \) obtained with (1) for the shapes is presented in figure 4, which can be used to choose the appropriate screen type.

Each intersection of rod and shaped wire in a JS is welded because it is important to maintain slot opening within the limits required by the filtering process and ensuring the filtering element rigidity.

Standard materials used for fabricating JS are 304, 304L, 316, 316L and 321 stainless steels. Other materials such as 410 stainless steel, Alloy 400, Alloy 600 Alloy C-276 are used for special applications. When additional strength is required, it can easily increase collapse, beam, or burst strength by changing diameters, changing wire or rods shapes, or changing number of rods.

The equipment

The research whose results the paper presents generated an equipment with the scheme presented in figure 5 able to carry out simultaneously shaped wire helically wrapping and welding. The equipment design represents the object of a patent [4]. The main parts of the equipment are the wrapping-up gear (WG), the welding machine by pressure with electrical heating (WM) and the controller (C).

The main functions of this machine are:

- placement of support rods in such a way that they constitute the equidistant generators of the filtering element and in case they are shaped, they should be maintained in a correct position in cross section;
- winding the shaped wire with constant pitch; in order to do this the support rods must be rotated and drawn simultaneously so that they could advance with for a rotation;
- welding the wire to a longitudinal rod, while winding.
- The winding unit mounted on frame 1 is made of driving bearing 2 and support bearing 3, connected by shaft 7, made of a threaded part with pitch \( p \) and a smooth part, both with grooved wedge for its total length and joined by collar 8.

The shaft drive in rotation motion is carried out by a motoreducer by means of a chain wheel 6 mounted on tubular shaft 5 and by wedge 9, which slides in the slot in shaft 7 which advances because of the fact that it rotates in nut 10, connected to bearing cage 2. The nut 10 is made of two halves and mounted in such a way that it can be opened to enable bringing the shaft to the initial position without being necessary to rotate it (the idle gear is eliminated and the shaft wear is reduced). By wedge 12, the rotation motion is transmitted to the system on which disks 11 and 13 are fixed; disk 11 which rotates in the support bearing cage 3 has the role to ensure the equidistant position of longitudinal rods by the corresponding positioning of the openings through which they pass, and disk 13 ensures the support on which each point is welded (its diameter is equal to the inner diameter of the filter). To the end of the shaft of flange 14 is fixed and it is provided with a...
fixing system of the longitudinal rods of the filter, so that the cage will rotate and advance together with the shaft and the executed filter.

The welding machine is made of the electric transformer 4 together with its supply and command system and the ensemble 16 of the welding roller which permits the roller rotation and movement on the vertical. One of the terminals of the transformer second is connected to the roller cage 16, and the other is connected to the bearing cage 3, the contact with the mobile part being achieved by means of the front surface of disk 11.

![Diagram of the equipment for shaped wire filters](image)

**Fig. 5 Scheme of the equipment for shaped wire filters**

The electronic system (The Controller 19) commands the current impulse when a rod is in the vertical plan which contains the roller axis, so that local heating is obtained by maximum controlled pressure and the wire welding to the respective rod takes place in optimum conditions. The synchronizing of the current impulse with a rod position is ensured by microswitch 18 driven by the pins mounted on disk 17 connected either to driving gear 6, or to the disk unit 11, 13, depending on the adopted constructional variant (the number of pins is the same as the number of longitudinal rods of the filter).

Obtaining a continuous slot and a quality wire welding imposes its directioning and guiding until it comes near the contact with the welding roller. For this reason a directioning – guiding device is used, which is connected to support bearing.

**Establishing the technological parameters**

The main problems to be solved by Johnson screen manufacturing technology on this machine are: the correct winding of the wire and welding to each longitudinal support rod.

The correct wire winding depends mainly on the winding system quality considered from the following points of view: the system rigidity; the precision of the shaft thread; the deviations from coaxiality of bearing elements; the deviation from the parallelism of shaft axis with welding roller axis; the axial deviation of support disk 13; the axial deviation of welding roller; the free length of the wire (from its getting out of the straightening device guide to the contact with the welding roller). Given the complexity of the effects of these deviations, the elements involved are provided with position control possibilities. The corrections are made after manufacturing some test filters, depending on the precision obtained at slot opening.

Once the machine control is carried out, the slot opening variation is due to the deviations at pitch p of shaft thread and width variation b of wire shape, which for this reason is subjected to a calibration operation by drawing.

The welding by pressure with electrical heating by Joule effect of austenitic steels presents
the following characteristics related to physical-mechanical properties and their chemical composition: formation of an adherent film of difficulty fusible oxides in the heated area; increased strength to heat distortion (especially of those allied with molibden too); difficult dissipation of heat due to their low heat conductivity.

Establishing the parameters of the technology of welding the wire to support rods must take into account these characteristics to obtain quality welded joints.

The formation of oxide film between the elements to be welded diminishes the joint mechanical strength. The elimination of this shortcoming is done by limiting the heating time and the application of high specific pressures, that is by using some “hard” welding regimes.

The duration and intensity of welding current impulse must be high enough to ensure local welding of the material, but low enough to avoid further heating.

The specific pressure must be adjusted to be high enough to produce local deformation in the moment of welding and to avoid oxide film formation, without reaching a too high interpenetration between wire and support rod.

The experimental research carried out have shown that the best results in winding wire welding to support rods have been obtained by current impulses of 8…10 kA and duration’s of 0,06…0,12 s, for roller pressure forces of 700…900 N.

Metallographic research in welding area (figure 6) reveal a structure made of austenitic, delta ferritic and carbides. Increased finishing of grain can be noticed, one to localized plastic deformation, during welding. Not observing optimum pressure on welding roller or oxide presence in the contact area of wire with support rod produces discontinuities, as shown by figure 7.

Specific pressure in the contact area in the moment of welding depends both on the force developed by the roller action system and the wire position to roller axis; the pressure will be maximum only when the wire is placed vertically in the plane containing the welding roller.
axis. The current impulse must be started the same moment to obtain a correct welding as shown in figure 8; thus the joint will be inappropriate as shown in figure 9 which presents the microphotograph of a welded joint in which the current impulse was started earlier.

The lack of correlation between the wire position and the impulse starting moment also causes the instability of the welding regime because current intensity depend on the contact strength between the wire and the longitudinal support rods. The synchronizing precision depends on the precision of pin positioning on disk 17 (fig. 5) and the precision of microswitch position control.

The low heat conductivity of austenitic steels imposes the cooling of water welding area to avoid the overheating of the welding roller which is made on chrome-copper alloy (1% Cr) deformed by cold flow. By overheating, roller strength is reduced and the excessive deformation of the contact surface with the wire takes place, being necessary to stop the process and correct the roller, operation which cannot be carried out during a screen winding because when stopped, the whole system is elastically relaxed, and when the process is started these occur excessive deviations at slot opening.

Conclusions

The analysis of screen manufacturing led to the elaboration of a machine functional scheme, which ensure simultaneous welding and winding by coupling a wrapping-up gear with a electrical welding machine by pressure. The machine assures the synchronizing of current impulses with wire position.

The research concerning the characteristics of welding by pressure with electrical heating of stainless steels shows the following:

- the welding regime must (8%-10 kA) and short duration of impulse (0.06^-0.125);
- increased specific pressure in wire-rod contact areas at welding (1000^-1200 N/mm^2) which corresponds to pressure forces of 700^-900 N, the contact between electrode rollers and wires should be very good to avoid local heating of the roller;
- the contact areas between the curse and the rods must be devoid of oxides or impurities.

The research has been finalized by licensing the machine, the prototype making and organizing a microproduction of filtering elements with slot opening f = 0.15^-2.5 mm, diameter D_i = 50^-250 mm and lengths L = 250^-1500 mm, used in oil production industry, in chemical and petrochemical industry, in production industry.

References

2. Penberthy, W.L. and Shaugnessy, C.M. Sand Control, SPE 1992