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DEVELOPMENT OF PVC WELL SCREENS FOR
LOCAL FABRICATION IN DEVELOPING COUNTRIES

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ABSTRACT

In rural areas of developing countries, the cheapest and safest source of water is usually groundwater. Pipe suitable for PVC well casings is manufactured in a number of developing countries, but high-efficiency PVC well screens have to be imported. This paper describes the development of a well screen that can be made in most developing countries: PVC is extruded through a special die to form a pipe with internal stiffening ribs. Short sections of pipe are then mounted on a standard lathe and a helical spiral slot cut in the pipe wall, using a small circular saw. The resulting screen has a large open area and appears highly competitive with screens available commercially. It allows screen characteristics to be readily adapted to the actual field conditions. Field trials of the new product are being arranged.

Prepared by: Yaron Sternberg
Robert Knight
International Rural Water Research Development Laboratory
University of Maryland

Introduction

1. In many regions throughout the world, alluvial aquifers of great extent are used for water supply. These aquifers are composed of unconsolidated alluvial materials that range from silts, clays, and fine sand to gravel and boulders. In aquifers where fine sand is the predominant constituent, screens must be provided to prevent the sand from entering the pump. Rapid wear of the internal components of mechanical pumps or the leather seals of hand pumps can be expected if fine sand particles are allowed to enter the pump.
2. Well screen is a recognized and accepted technique to control the migration of soil particles carried by the water from the aquifer, through the various well and pump components, and into the discharge side of the pump. Water will pass more freely through a screen with a large total open area than one with a small open area. A large open area also insures low inlet velocities which results in smaller head loss and lower drawdown.
3. Commercial screens are manufactured from either metal or plastics. Metal screens have a range of openings from 0.008 inches to 0.25 inches, exhibit a large open area (20%-35%), and are rugged. Commercial metal screens are expensive, particularly when fabricated from stainless steel to withstand the corrosive conditions in a well, and therefore are suitable only for high capacity deep wells. For low capacity shallow wells (up to 200 feet) a less expensive screen of medium strength is desirable.
4. Plastic screens are less expensive than metal ones but also have a smaller open area (1-10%). Commercially available plastic screens are produced either by perforating a standard plastic pipe by cutting slots or drilling holes into it, or by winding and spot-welding a continuous filament of plastic material around a set of fixed stiffeners. The former is used by a number of small manufacturers and required relatively simple production machinery. The latter requires sophisticated equipment and is produced by only a few manufacturers. One problem with its use is that the material has to be imported into developing countries; because of the long lead time, screen characteristics often have to be specified before the actual characteristics are firmly established.
5. Perforated or slotted plastic screens are inexpensive but in general have low open area (1-5%). Because of difficulties encountered in sawing the plastic pipe to produce the slots, the minimum common slot size is about 0.05 inches. The slots are not uniform, and attempts to increase the open area by providing additional slots results in a weak screen. Perforated screens are produced by drilling a standard plastic pipe. This type of screen has limitations on the minimum size hole, strength, and total open area. Spirally wound plastic screens are strong but their high cost, coupled with their relatively low open area (8-10%), limits their widespread use in developing countries.

6. The purpose of this investigation was to develop an inexpensive plastic screen that is rugged, provides an open area of 20-25%, and can be produced in most developing countries. Such screens could be used in wells equipped with handpumps and in shallow (up to 200 feet) wells equipped with electro-mechanical pumps. Another application would be in infiltration galleries. These are horizontal drainage galleries designed to intercept the groundwater emerging as a spring, or to draw on the water in river gravels (thus greatly reducing the risk of contamination and minimizing the treatment necessary).

Development Work

7. After some initial laboratory work it was concluded that a continuous helical cut in a standard pipe will provide the maximum open area. To restore the strength lost by the helical cut, webs and stiffeners are necessary. Figure 1 shows the combination of stiffeners used in the initial trial. Slotting was done on a lathe equipped with a grinding head, with a small (2-3/4 inch dia.) circular saw substituted for the grinding wheel (see Figure 7). The results showed promise, but the cemented interfaces were weak and created machining problems. The need for a different stiffener configuration was evident.

8. Other samples, shown in Figures 2, 3, and 4 were manufactured with different stiffener and web combinations. As in the first case, the stiffeners were glued to the inner circumference of a standard 3-inch PVC pipe. The rigidity of these samples was excellent, and it was therefore decided to contract with plastic manufacturers to extrude a pipe with stiffeners according to the design shown in Figure 3.

9. Considerable difficulties were encountered in trying to obtain the above extruded samples. Many manufacturers were not interested in the small quantities required for research, while others indicated that the cross-stiffeners or the Y-stiffeners could not be extruded according to the specifications because of the different cooling rates of the stiffeners and of the main pipe wall.

10. A number of other stiffener and web combinations were manufactured in the laboratory. The final design, shown in Figure 5, by using internal strengthening ribs, eliminated the need for heavy inner stiffeners and therefore could be extruded. A plastic manufacturer was contracted who produced the special extrusion die and the samples shown in Figure 6. The completed Roboscreen is shown in Figure 8.

11. The extrusion of this modified section appears to present no particular technical difficulties. Many developing countries have their own industry manufacturing PVC pipe (usually from imported polymer). If these industries were to produce this product, it would be necessary to fabricate a special die for each diameter of well screen required; extrusion should then be routine. The cost of the special pipe section might be about twice that of standard pipe of the same nominal diameter, depending very much on the quantities of screen required (in the examples tested, 3-inch internal diameter, the addition of the ribs increases the raw material requirements by about 30%, whereas the die cost could add 10% to over 100% depending on the production run).

Screen Slotting

12. The technique for slotting the screen has been developed by trial and error during the laboratory work, but is undoubtedly still capable of improvement. Paragraph 13 describes the general procedure developed to date. Particular points of interest are:

Equipment Needs - The lathe and grinding head are unsophisticated and commonly available in developing countries. The expanding mandrel is available or can be easily fabricated. Only the slitting saws need to be imported.

Cooling Methods - PVC has a low melting point (about 275-300°F) and the work piece needs to be cooled. Air-cooling (by means of an air hose attached to a household vacuum cleaner) was found to be as satisfactory, and far less messy, than water-or oil-cooling.

Slitting Saws - The saw blades used were high speed steel, 2 3/4 inch dia., with thicknesses varying from 0.018" to 0.032". It was found that high speed sawing or the use of blades with too many teeth, were unsatisfactory. A maximum cutting speed of 2000 RPM was adopted, and the saws had no more than 32 teeth. Care must be taken to align the blade exactly with the helix angle, to prevent frictional heating against the side of the slot. Investigations are continuing into carbide-tipped saws or diamond-faced discs in place of plain saws.

Workpiece Feed Rate - The workpiece feed rate should not exceed 6 to 8 surface feet per minute. On many lathes, which are not geared down to this speed, this means that the workpiece will have to be advanced manually. This presents no problems.

13. Equipment Required

- One engine lathe (a 9" South Bend is currently being used).
- One grinding head compatible with the lathe.
- A selection of slitting saws to match the desired slot widths.
- One 3" dia. expanding mandrel, 12" long.

Lathe Preparation - Remove tool post and install the grinding head. Substitute a slitting saw of the correct thickness for the grinding wheel. Select the required pitch and pre-set the leadscrew accordingly.

Operation - The workpiece, which is a 12" length of the extruded PVC pipe, is mounted on the mandrel. Location is at the crowns of the stiffening beads. This ensures concentricity and provides ample clearance for the slit saw to break through inner surface of the pipe. The workpiece and mandrel is now supported between the lathe centers ready for slotting. The grinding head complete with slitting saw is now set at the starting position. Engage the leadscrew half-nuts. Now switch on the grinding head and feed the cutter into full depth. Start the lathe and the air cooling system. As the spindle revolves, the grinding head will traverse the length of the workpiece and shut off. Now withdraw the cutter and remove the mandrel. Separate the workpiece from the mandrel. This completes the slotting operation.

14. Using these techniques, it has been found possible to slot the screen satisfactorily with slots as fine as 0.018 inches, and as wide as 0.032 inches (wider slots appear to present no problem; the width shown was the maximum blade thickness readily available). The lathe is set so that the land (material remaining between the slots) is about twice the slot width; the screen therefore has a theoretical open area of 33%. At present, it is impractical to machine screen lengths longer than 12 inches; in the field these lengths would be joined by solvent-welded couplings to make up the total screen length required. Use of one 2-inch deep coupling for each 12-inch length of screen reduces the available open area to about 25 percent. This is still 2.5 to 3 times the open area available on commercial screens (but the latter have V-slots, claimed to be less susceptible to blockage).

15. The complete slotting process for each 12-inch length takes about 15-20 minutes. All the screens needed for a typical well could therefore be made in about a day. This suggests that a further advantage of the Roboscreen may be that the slot openings can be precisely tailored to the actual aquifer conditions found during well sinking, rather than relying on pre-specified material.

16. Theoretical analysis indicates that the slotted screen would withstand external loads up to 100 psi. This would be ample for most applications likely to be experienced during further field trials and evaluation.

Necessary Future Development Work

17. The Roboscreen has not been subjected to any laboratory or field testing. Before manufacturing the screen in developing countries, tests should be undertaken on the material already available:

- (a) to determine its strength in comparison to that of commercially available materials; and
- (b) to investigate in the field its hydraulic and filtering efficiency.

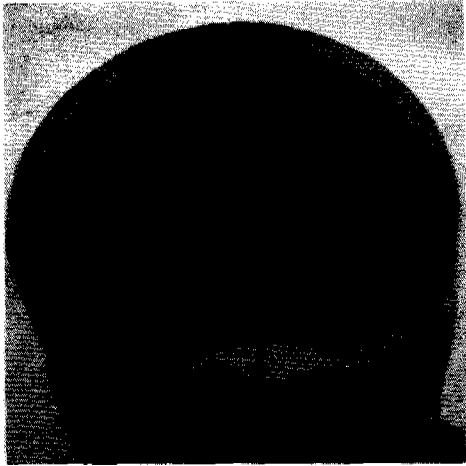


Figure 1
Initial Screen Trial with
Three Stiffeners



Figure 2
Screen with Cross-Stiffeners
(9/32" wide) and Webs

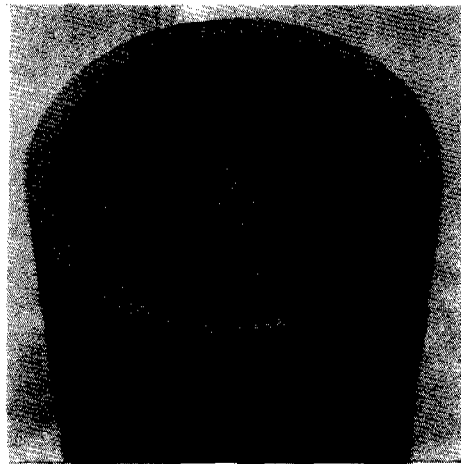


Figure 3
Screen with Cross-Stiffeners
(3/16" wide) and Webs

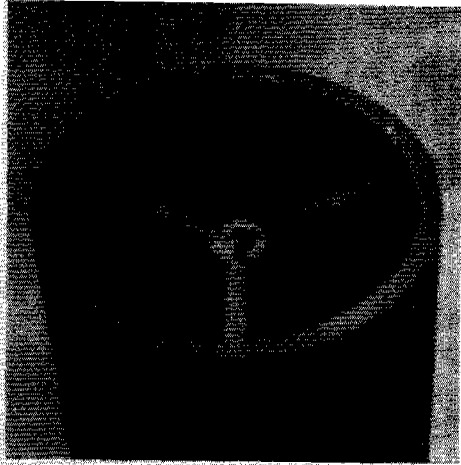


Figure 4
Screen with Y Stiffeners
(3/16" wide) and Webs

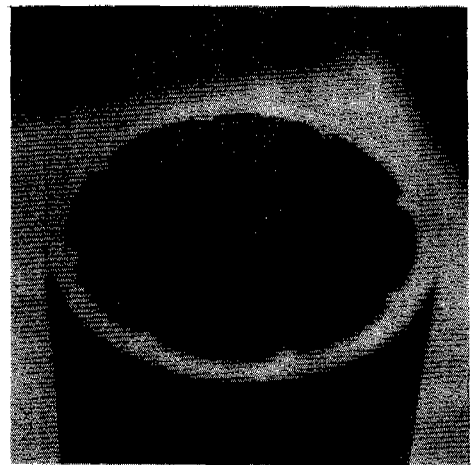


Figure 5
Roboscreen with Semicircular Stiffeners
of 1/8" Radius



Figure 6
Roboscreen Sample

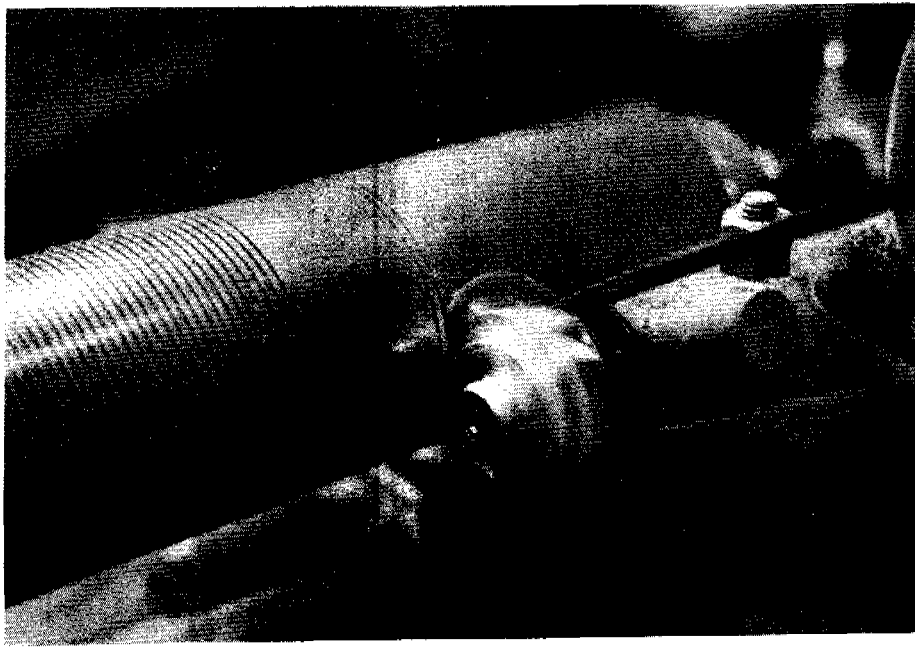


Figure 7

Circular Saw Used for Slotting

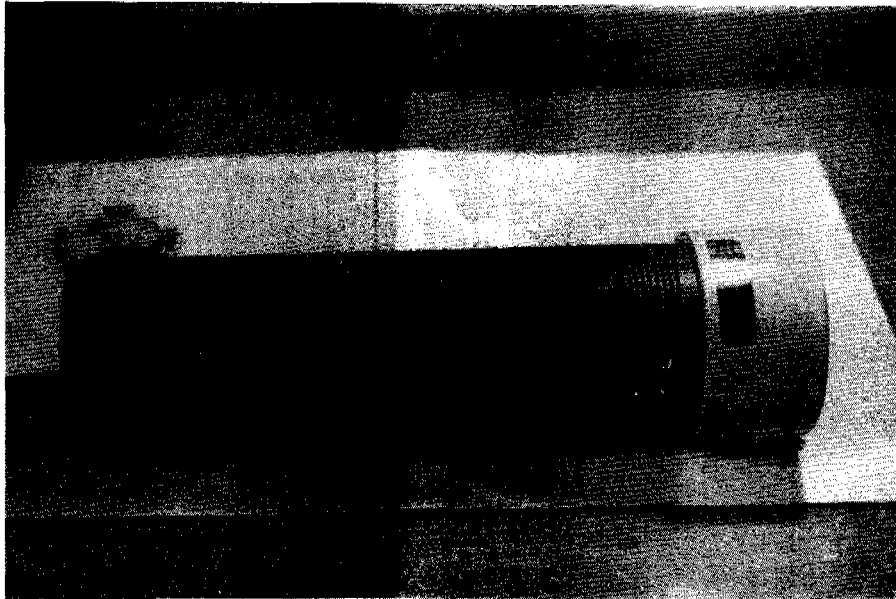


Figure 8

Roboscreen with 0.032" Slot Width