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ARTICLE OF PROFESSIONAL INTEREST

A Low-Cost Indigenous Intervention which has Revolutionized the Drilling Technology and Changed the Life of Millions of Farmers in the State of Uttar Pradesh, India

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Abstract An unknown indigenous driller combined the percussion and circulation drilling principles, resulting in the development of low cost, low weight manual boring set in the year 1990–1991/1991–1992, which revolutionized the shallow well drilling technology and made possible to drill about 4.5 million shallow bore wells in the State. This has changed the landscape of irrigated agriculture, changing the life of millions of small and marginal farmers and contributed a lot in increasing crop production and crop productivity. The developed drilling equipment locally known as "Pressure Boring Set" is manually operated, low cost and can be transported on bicycles. Drilling cost is also less. This low cost and simple technology made it possible to drill large number of shallow bore wells in comparatively short time span and less cost, consequently enhancing the rate of increase in irrigated area and in turn crop production and productivity. Cost of the boring set is also low, as compared to traditional sand pump hand boring set and suitable for alluvial areas.

Keywords Shallow well drilling · Drilling technology · Percussion and circulatory drilling · Manual boring set · Irrigated area

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Introduction

Irrigation is the spirit of agriculture and it is one of the most important engineering interventions and inputs, which increases agricultural productivity and production. Assured irrigation practices encourage the farmers to invest more on inputs like fertilizers, high yielding seeds, pesticides, etc. Moreover, an own water source increases the confidence of a farmer as he can irrigate the land as and when required. In this context, bore well irrigation is an important intervention in increasing agricultural productivity.

Uttar Pradesh, the most populous and one of the largest State of India, has potential groundwater resource. The use of this resource was perceived way back in early eighties to benefit millions of small and marginal farmers of the state. Presently, there are 23.325 million land holdings in the state, out of which 90% are small and marginal with an area of less than 2 hectares [1]. One of the innovative approaches to benefit these small and marginal farmers was the adaption of any low-cost technology for drilling bore well. In this context, the Minor Irrigation Department of Uttar Pradesh, India had started the free boring scheme in alluvial formations of the state in the year 1984. The mandate of the scheme was to drill shallow bores up to an average depth of 20 m with a financial assistance of INR 3000/- per boring [2]. The prevalent drilling technology at that time was sand pump boring set which was very slow, heavy and costly to operate. The invention of an indigenous boring technology (locally named as "Pressure Boring Set") in year 1990 revolutionized the shallow well drilling technology in alluvial formations. The state has witnessed the drilling of about 4.5 million shallow bore wells in the last three and half decades after adapting this indigenous technology [3]. The mass adaption of this technology further refined it and presently, is the most widely used technique to drill shallow bores in the state.

Invented Technology

The three essential bore well drilling functions are: (1) smooth penetration through subsurface formations: (2) removal of drill cuttings: and (3) preventing the cave-in of the bore until the lowering of well assembly. In order to fulfill these three core functions, percussion and rotary drilling technologies have been developed [4, 5]. An unknown indigenous driller innovatively combined the principles of these two technologies to develop a low-cost and light manual boring set through which drilling has become very fast compared to the traditional sand pump boring set. The weight of the equipment is so low that it can be transported even on a bicycle.

Principle and Components of Drilling Equipment

The mechanism to penetrate the subsurface formation is based on shearing and cutting action as employed in percussion drilling. On the other hand, the mechanism to remove the formation cuttings and to control the borehole from cave-in during drilling is based on the principles of rotary drilling, where formation cuttings are removed by the circulation of drilling fluid through drill pipe/borehole while the bore is protected from collapsing by hydrostatic pressure maintained during drilling [6]. This drilling equipment includes

a. Two wooden logs as columns of the frame (each 1500 mm long) to support operating arm.
b. One iron rod to act as beam of the frame (1500 mm long).
c. One wooden log to act as operating shaft/arm (3000–4000 mm long).
d. GI pipes of size 50/65 mm (no. depends on the depth of drilling).
e. GI socket of size 75 mm (with a provision to attach with drill stem or pipe) to function as cutting shoe.
f. L-shape clamp to hinge the operating arm with drill stem/pipe.
g. Labor for operating the set up (no. depends on the depth of drilling).

As shown in Fig. 1, about 4–6 laborers move the operating arm up and down; giving reciprocating motion to the drill pipe; which is hinged to the operating arm at the end by L-shape iron clamp. One man stands on two columns of the frame and keeps his palm on drill pipe/stem and moves his palm up and down with the motion of operating arm to function as a suction valve. Here, the principle of reciprocating pump comes into action that lifts the drilling fluid

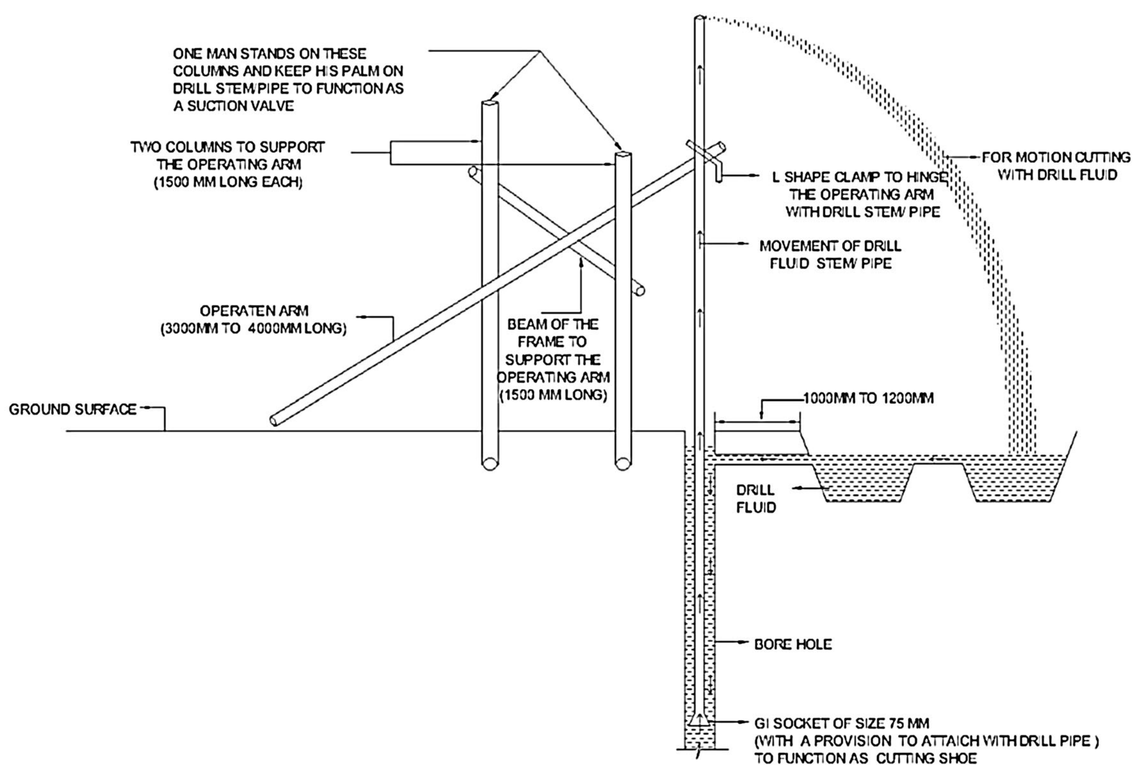

Fig. 1 Operational diagram of the drilling equipment

Table 1 Cost of boring for strainer well using indigenous technology [7] (financial year 2016–2017)

S. no.	Details of work	Unit	Qty	Rate (INR)	Amount (INR)
1	Excavation of 2.0 m diameter pit				
a	From ground surface to 1.5 m depth	m^3	4.71	82.00	386.22
b	From 1.5 to 3.0 m depth	m^3	4.71	95.50	449.81
Total (A)					836.03
2	Carting of boring set	Job	1	300.00	300.00
3	Drilling charges	m	30	307.15	9214.50
Total (B)					9514.50
4	Materials detail				
a	110 mm PVC pipe (6 Kgf/cm^2)	m	15	149.00	2235.00
b	110 mm PVC strainer pipe (6 Kgf/cm^2)	m	15	146.00	2190.00
c	110 mm PVC end cap	Unit	1	48.00	48.00
d	110 mm FTP with cast iron flange	Unit	3	120.00	360.00
e	Solvent cement	l	0.18	144.00	25.92
f	100 mm reflux valve non ISI	Unit	1	1140.00	1140.00
g	1.25–1.30 mm mesh size filter cloth	m	15	12.00	180.00
h	500 micron mesh size filter cloth	m	15	10.00	150.00
i	5 mm diameter nylon dori (rope)	m	100	1.32	132.00
j	100 mm cast iron bend	Unit	1	510.00	510.00
k	110 mm PVC coupler	Unit	3	43.00	129.00
Total (C)					7099.92
5	Pumping test (diesel pump set charges)	h	10	110.00	1100.00
Total (D)					1100.00
Total (A + B+C + D)					18,550.45
6	Contingency (2% of total)	371.01			
Grand total (INR)					18,921.45
SAY (INR)					18,900.00

from the bottom of bore and conveyed it to out of drill pipe. The moving column of drilling fluid through the drill pipe also lifts the drill cuttings in suspension mode to the surface. The driller guides the discharging fluid to settling pit with the help of his hands. The reciprocating motion of the drill stem/pipe cut the formation by shearing and cutting action. Formation cuttings are then move with the drill fluid and come out of the top of the drill pipe and the laborer standing on the columns with his palm on drill pipe guides the circulating fluid to the settling pit. In this technology, the percussion principle is used to cut the subsurface formations while the rotary principle is used to remove the formation cuttings and control the borehole from cave-in by hydrostatic pressure maintained during the drilling operation. Usually, clay mixed with water is used as the drilling fluid. The system is a combination of percussion and reverse circulation rotary drilling. As drilling operation proceeds another length of drill pipe is screwed and the clamp is shifted upward.

This drilling set is very light and can be transported even on a bicycle. The cost of drilling is only about INR 307.15 per meter in alluvial formation. The technique is well adapted for drilling shallow bores up to the depth of 30 m. Though, it is feasible to drill bores up to a depth of 60 m; however, to keep the drilled bore straight is a challenge for the driller. The cost of a 110 mm, 30 m deep strainer and cavity boring through this technology is presented in Tables 1 and 2 [7].

Impact of Innovative Technology

During the launch of free boring scheme in the year 1984, the major challenge was to install a large number of bore wells at low-cost as there was pressing need to increase irrigation facilities to increase agricultural production.

Initially, an assistance of only INR 3000/ per boring was provided, which has been revised many times since its inception. At present, the pattern of assistance under the scheme is as given in Table 3 [2]:

Under the scheme, the Department of Minor Irrigation of the Government of Uttar Pradesh, India constructs the

Table 2 Cost of boring for installing cavity well using indigenous technology [6] (financial year 2016–2017)

S. no.	Details of work	Unit	Qty	Rate (INR)	Amount (INR)
1	Excavation of 2.0 m diameter pit				
a	From ground surface to 1.5 m depth	m^3	4.71	82.00	386.22
b	From 1.5 to 3.0 m depth	m^3	4.71	95.50	449.81
Total (A)					836.03
2	Carting of boring set	Job	1	300.00	300.00
3	Drilling charges (lined)	m	24	307.15	7371.60
	(Unlined)	m	6	307.15	1842.90
Total (B)					9514.50
4	Materials detail				
a	110 mm PVC pipe (6 Kgf/cm^2)	m	24	149.00	3576.00
b	110 mm FTP with cast iron flange	Unit	3	120.00	360.00
c	Solvent cement	l	0.1	144.00	14.40
d	100 mm reflux valve (non ISI)	Unit	1	1140.00	1140.00
e	100 mm cast iron bend	Unit	1	510.00	510.00
Total (C)					5600.40
5	Pumping test, (diesel pump set charges)	h	20	110.00	2200.00
Total (D)					2200.00
Total (A + B+C + D)					18,150.93
6	Contingency (2% of total)				363.02
Grand total (INR)					18,513.94
SAY (INR)					18,500.00

Table 3 Pattern of assistance under the scheme on the basis of caste and land holding [2]

Sl. no.	Name of scheme	Category of beneficiary	Category of land holders	Admissible subsidy
1	Free boring (shallow tube well)			
	(i) For boring	General	Small	Up to INR. 5000/-
			Marginal	Up to INR. 7000/-
		Schedule caste/schedule tribe	Small/marginal	Up to INR. 10,000/-
	(ii) For pump set	General	Small	Up to INR. 4500/-
			Marginal	Up to INR. 6000/-
		Schedule caste/schedule tribe	Small/marginal	Up to INR. 9000/-
	(iii) High density polyethylene pipe irrigation system (25% of beneficiary)	General/schedule caste/ schedule tribe	Small/marginal	Up to INR. 3000/-

bore well and hands over the bore well to the farmer for operation and maintenance. If the cost of boring is more than above assistance, the additional expenditure is borne by the farmer. Table 4 presents the increase in irrigated area with increase in the number of bore wells from the year 1984–1985 to 2013–2014 [1, 3].

The adaption of the presented indigenous drilling technique has boost up the pace of tube well construction in the

Table 4 Cumulative progress of shallow boring and irrigated area [1, 3]

Year	No. of boring	Net irrigated area (in lakh hect.)
1984–1985	5481	101.54
1985–1986	59,927	101.55
1986–1987	1,20,434	98.54
1987–1988	1,85,055	100.43
1988–1989	3,54,317	101.69
1989–1990	5,40,482	103.32
1990–1991	7,39,062	105.42
1991–1992	9,37,854	110.48
1992–1993	11,30,039	113.22
1993–1994	13,24,136	115.64
1994–1995	15,98,881	116.70
1995–1996	18,84,001	117.47
1996–1997	21,68,832	119.99
1997–1998	22,03,184	120.12
1998–1999	23,04,435	126.91
1999–2000	23,44,470	124.70
2000–2001	24,20,242	124.01
2001–2002	25,01,999	128.28
2002–2003	25,76,612	128.48
2003–2004	26,64,527	132.27
2004–2005	28,04,484	131.19
2005–2006	30,11,232	130.75
2006–2007	32,32,364	133.13
2007–2008	34,91,171	130.85
2008–2009	36,52,160	134.35
2009–2010	37,39,192	133.83
2010–2011	39,10,575	134.40
2011–2012	40,84,359	138.09
2012–2013	42,20,600	139.29
2013–2014	43,12,700	140.27

Unit: 10 lakh hectare = 1 million hectare

state. In the first 6 years from the start of scheme in year 1984–1985, only 0.54 million bore wells were constructed and the net irrigated area in the state increased by only 0.178 million hectares. However, with the introduction of new drilling technology, 1.34 million bore wells were constructed during the period 1990–1991 to 1995–1996 [3] and the net irrigated area was increased by 1.45 million hectares [1]. Thus, it can be concluded that the mass adaption of innovative drilling technology along with the subsidy have played a pivotal role in increasing the irrigated area in the state.

Conclusion

With the adaption of the innovative indigenous drilling technique, it could be possible to construct a large number of bore wells in cheaper rates and in relatively short time. The resulting increase in the irrigated area has led to increase in crop production which has changed the life of millions of small and marginal farmers of the state. This innovative technology is cost effective and can be used to rapidly drill shallow bore wells in alluvial formations.

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