Int. J. Chem. Sci.: 12(4), 2014, 1161-1168
ISSN 0972-768X
www.sadgurupublications.com

CLASSIFICATION OF FLUIDS FED BY DISPLACEMENT PUMPS

A. A. KOZHEVNYKOV[a], B. T. RATOV[*,b] and N. T. FILIMONENKO[c]

[a]State Higher Educational Institution National Mining University, DNEPROPETROVSK, UKRAINE
[b]Kazakh National Technical University After Name of K. I. Satpayev,
ALMATY, REPUBLIC OF KAZAKHSTAN
[c]State Higher Educational Institution Donetsk National Technical University,
DONETSK, UKRAINE

ABSTRACT

Classification of fluids to be fed by pumps with mechanical and air displacers is provided. It is shown that such pumps may feed with variable, pulsing and intermittent flow. Each type of feed characterizes parameters having discrete value or change spectrum that are specific for certain type of the feed. The article may be interesting for specialists engaged in drilling technology issues.

Key words: Pumps, Frequency, Well, Flush, Fluid.

INTRODUCTION

Problem statement and its connections with the most essential scientific challenges, due to the global economic and energy crisis a shortage of energy sources for supplying to energy-intensive industries and household needs, is being observed. The objective information on re-estimation of old and forecast of new stocks of energy sources can be obtained after performing drilling operations only. Therefore, the increase of drilling scales in this event is inevitable. One of the common factors complicating drilling operations is loss of circulation. Without new, efficient well drilling technologies this will adversely influence on technical and economical performances of drilling organization.

In the article, it is scientifically justified the possibility of developing progressive well flushing technologies using submersible displacement pumps that decrease the cost of drilling operations in terms of circulation loss. One of the reasons constraining their application is unsteadiness of the flushing fluid's stream, since until recently it was believed

---

[*]Author for correspondence; E-mail: boranbairatov@yahoo.com

that only steady flow of the flushing fluid calculated to be applied to certain drilling conditions, creates favourable conditions for cleaning function of the flushing fluid to be effectively carried out.

Unsteady flow to be created by displacement pumps is explained as follows: when they operate the volume of the functioning chamber (plate type, impeller, peristaltic) or velocity of the displacer's motion (piston, plunger) changes cyclically. The latter is widely used in drilling operations, but as the rule, they require presence of compensators, which are necessary for smoothing the feed in the pump's discharge line. As for submersible displacement pumps, reason of the feed's unevenness is caused by the peculiarity of its work cycle, which is concluded in feeding the fluid not at the whole part of working cycle[1,2]. Feed impulses of the displacement pumps have different amplitude-frequency characteristics. Thus the concept of unsteady flow has a common feature as long as parameters (ratios) having a discrete value or certain spectrum of variance inherent to specific types of fluid supply only, have not been established. Hence, a challenge for developing a classification of fluids to be fed by displacement pumps is quite up-to-date, since it not only allows specifying unsteady stream fluid feeding types, but also to name certain type of pumps capable to create specific types of the feed, and show a place of these pumps in this classification.

Classification of feed types by SDP allows setting up a change within the feed impulse time, which is inherent to it only. With respect to downhole flushing; this is quite essential, since the change of feed within operating cycle of the SDP will influence on to the solid phase (drill cuttings) motion law, which is in ascending unsteady stream of the fluid, and form its localization in oil circuit of the well.

Until now the feed unsteadiness degree performance showing relation of the maximum and medium feed within the work cycle, is used to characterize unsteadiness feed of the displacement pump. However this performance is more characterized by the pump then by the stream, so long as it has a specific value for the specific pump.

Qualitative characteristics of the fluid stream may not differentiate the types of feeds of the fluid. Quantitative parameters, specific value are required for this purpose, the specific value or specific spectrum of their variance on the feed impulse would have defined its type.

Fluid feed impulse form shows the regularity of its change upon time $Q = f(t)$ within the feed impulse (Fig. 1). Duration of the feed impulse T_u – time for displacing the fluid from chamber. At one working cycle of the displacement pump, duration of which is $T_ц$ generated one (Fig. 1, a) (Fig. 1, b) or several feed impulses (Fig. c) (Fig. d). Feed impulse duration may coincide with work cycle by the time (Fig. 1, a) or be less than the duration of work cycle (Fig. 1, b) if there are several such chambers.[3]

On the Figure 1, г *ΔQ* – amplitude of the feed's variable component at multi-chamber, piston or plunger pumps.

Theoretically feed impulses may be symmetric or asymetric. In first case, the common factor $Q = f(t)$ on the feed impulses following each other, coincides. In the second case, does not. The displacers' motion law within the feed impulse is invariable, and due to the constant frequency of the rotor's (plate type, impeller, peristaltic) or shaft's (piston, plunger) rotation frequency. It does not allow obtaining asymmetric feed impulses.

In order to differentiate fluid feed types by unsteady stream, the impulse ratio $k_{им}$ (1), steadiness ratio k_{st} (2) and discontinuity ratio k_{pr} (3) are recommended.

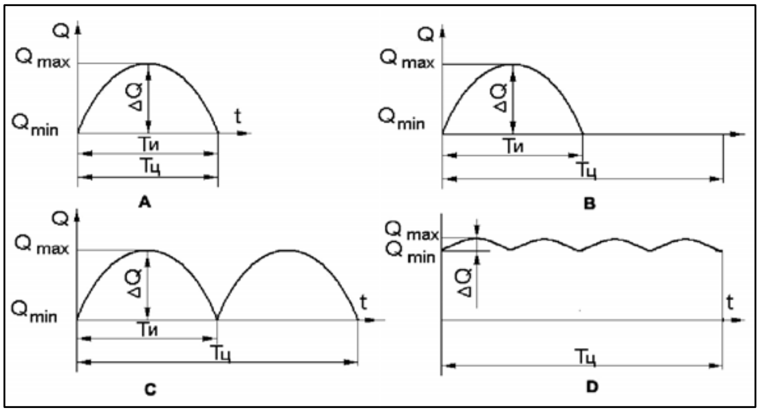


Fig. 1: Possible shapes of feed impulses of the displacement pumps

$$k_{im} = \frac{\Delta Q}{Q_{max}} \quad \ldots(1)$$

Where ΔQ –feed variable component's amplitude; Q_{max} maximum feed.

$$k_{st} = \frac{Q_{min}}{Q_{max}} \quad \ldots(2)$$

Where Q_{min} – Pump feed part's minimum variable component.

$$k_{pr} = \frac{t_{pause}}{T_i} \quad \ldots(3)$$

Where t_{pause} – Duration of pause between the feed impulse; T_i – duration of the impulse feed.

Values of the ratios $k_{им}$ and k_{cm} unlike the feed unevenness degree parameter shows not constant, but current values of these ratios on the feed impulse.

When there is a pause between the fluid feed impulses, the intermittency ratio k_{pr} shows a relation value, duration of pause between the feed impulse $t_{паузы}$ toward the duration of feed impulse T_i.

Thus k_{im} and k_{st} quantitatively characterize feed variance, but the k_{pr} – feed intermittency degree.

These parameters are variable, value or variance spectrum of which may differentiate the fluid feed type. Besides, impulse ratio and steadiness ratio are connected between each other since

$$k_{im} = \frac{\Delta Q}{Q_{max}} = \frac{Q_{max} - Q_{min}}{Q_{max}} = 1 - \frac{Q_{min}}{Q_{max}} = 1 - k_{st} \quad \ldots(4)$$

Hence

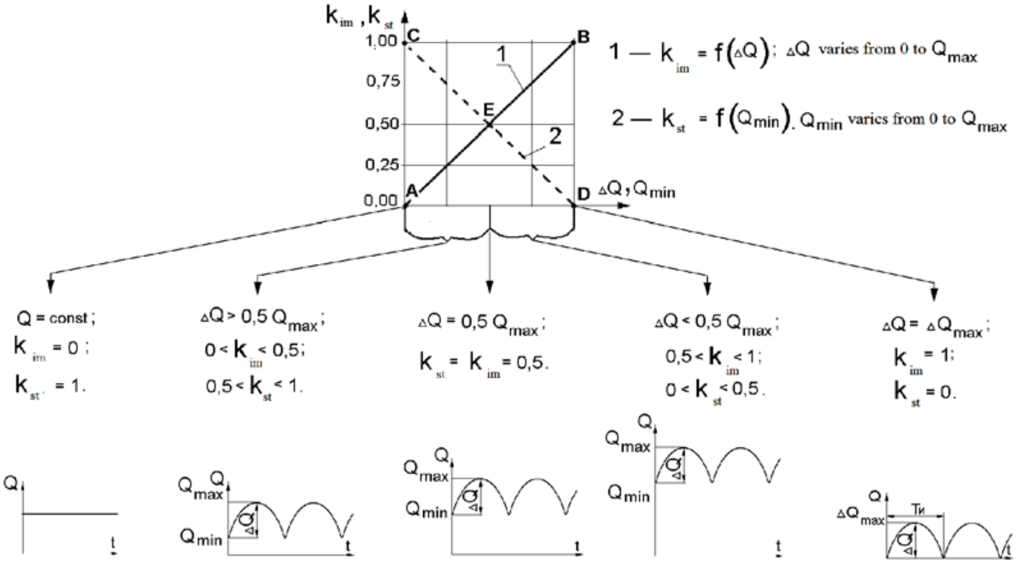
$$k_{im} + k_{st} = 1 \quad \ldots(5)$$

Fig. 2 illustrates transition of the fluid feed from steady in to pulsing depending upon the specific value k_{im} and k_{st} provided that there is no pause between the impulses, i.e. $k_{pr} = 0$. K_{im} values in specific points of **A**, **E** and **B** on the constraint 1 ($k_{im}=f(\Delta Q)$) and the value k_{st} in the points of **C**, **E** and **D** on the constraint 2 ($k_{st}=f(\Delta Q)$), as well as between the specific points, define a specific type of the feed.

When the fluid is fed by steady stream $k_{im} = 0$, a $k_{st} = 1$ (Fig. 2, a). With the increase of k_{im} and decrease of k_{st} the steady stream feed from the pump transits into qualitatively other type of the feed. Let us call it variable stream feed. The unevenness degree of such a stream characterizes correlation of the values ΔQ and Q_{max}, i.e. a numerical value k_{im}.

When k_{im} grows from 0 up to 0.5 (area between the points A and E on the constraint *1* and when k_{st} decreases from 1 down to 0.5 (area between the points C and E on the constraint *2* the fluid fed by steady stream transits into the highly uneven variable stream of fluid feeding (Fig. 2, b). Thus $\Delta Q > 0.5\ Q_{max}$.

In the point E the constraints 1 and 2 intercross. This point characterizes that the pump is feeding by variable stream with similar values of k_{im} and k_{st}, which are equal to 0.5. Thus $\Delta Q > 0.5\ Q_{max}$ (Fig. 2, b).



(a) **(b)** **(c)** **(d)** **(e)**

(a) Pumping steady flow; (b) Pumping high variable flow non-uniformity; (c) Pumping flow variables being equal to k_{im} and k_{st}; (d) Pumping variable flow low unequal; (e) Pumping pulsed

Fig. 2: Transition of fluid feed types from steady into the pulsing depending upon specific values of the $k_{им}$ and k_{cm}

When the $k_{им}$ continues increasing from 0.5 up to 1.0 (area between the points E and B on the constrain *1* and decreases from 0.5 down to 0 (are between the point E and D on the constraint 2, the fluid fed by variable stream is characterized by lower unevenness. For such feed $\Delta Q > 0.5\ \Delta Q > 0.5\ \Delta Q > 0.5\ \Delta Q > 0.5\ \Delta Q > 0.5\ Q_{max}$ is characteristic (Fig. 2, d).

In the point B on the constraint *1* the value $k_{им} = 1$. In the point **E** on the constraint 2 the value $k_{cm} = 0$. Thus the points **B** and **E** characterize a transition of the fluid fed by variable stream in to a new quality-feeding by pulsing stream (Fig. 2, e), at which $\Delta Q = Q_{max}$.

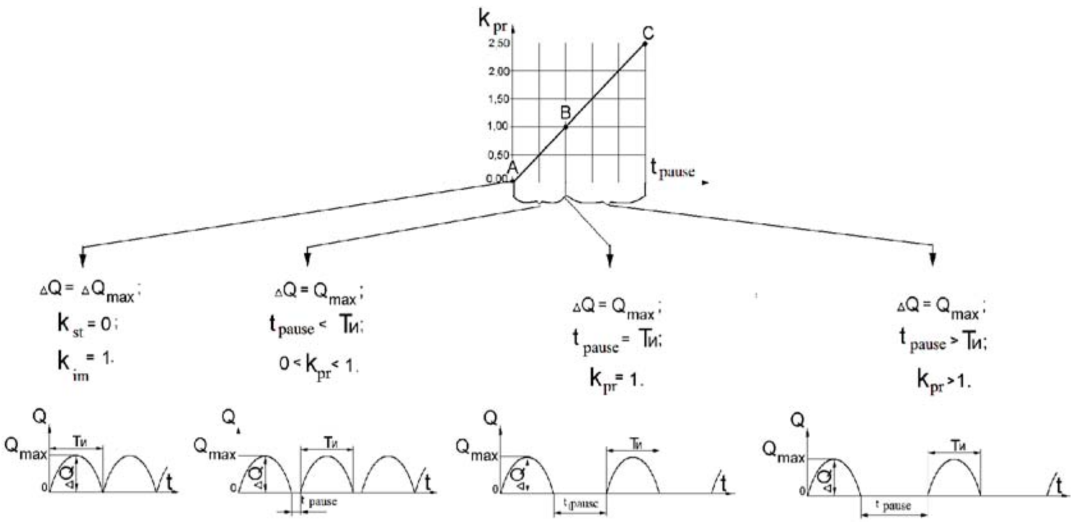
When similar by time pauses between the similar by duration feed impulses appear, the pulsing feed of the fluid transits into a new quality, becomes intermittent. Fig. 3 illustrates a transition of fluid fed by pulsing stream into the intermittent.

The point A on the constraint $k_{pr} = f(t_{pause})$ (Fig. 3, a) corresponds to the fluid fed by pulsing stream. The pulsations follow each other without pauses, i.e. $t_{паузы} = 0$. Hence the k_{np} at this point = 0.

When the k_{np} increases the fluid feeding by pulsing stream transits into the intermittent feeding of different degree of intermittence. When the intermittence ratio value is in the spectrum $0 < k_{pr} < 1,0$ (the area between points A and B), a fluid feeding by low intermittent stream is observed (Fig. 3, b). Here $t_{паузы} < T_i$.

In the point B $k_{pr} = 1$. This point characterizes intermittent feeding flow with equal time value $t_{паузы}$ and T_i (Fig. 3,c).

When the k_{np} continues growing (the area from the point B till the point C) the feeding becomes highly intermittent (Fig. 3, d). At this area $t_{паузы} > T_i$.



(a) **(b)** **(c)** **(d)**

(a) Pumping pulsed; (b) Pumping malopreryvistym flow; (c) Pumping intermittent stream with equal t_{pause} and $T_{И}$; (d) Pumping vysokopreryvistym flow

Fig. 3: Transition of the fluid feeding types from pulsing into the intermittent, depending upon specific value of the k_{im}, k_{st} and k_{pr}

It is noteworthy that the point C on the constraint $k_{pr} = f(t_{pause})$ does not restrict the value of k_{pr}. Theoretically, the k_{pr} may grow endlessly. In this case, it will mean that fluid has stopped feeding.

When the fluid is fed by intermittent stream of any intermittence degree $k_{st} = 0$, $k_{im} = 1$. From the Fig. 3 it is seen, what way the fluid feeding by pulsing stream transits in the feeding by intermittent flow of any intermittence degree. Hence, specific discrete values and variance spectrum k_{pr} define variety of type of feeding the fluid by intermittence stream.

Table 1: Types of feeding the fluid and parameter values defining a specific type of feeding

Fluid feeding type		**Value of parameters defining a specific type of feeding**	**Displacement pumps creating this type of feeding**
1	2	3	4
Intermittent stream	Highly uneven	$0 < k_{im} < 0,5$ $0,5 < k_{st} < 1$ $K_{pr} = 0$	Single piston, double action
	In case of equality k_{im} и k_{st}	$K_{im} = k_{st} = 0,5$ $K_{pr} = 0$	So far unknown
Variable stream	Low unevenness	$0,5 < k_{im} < 1,0$ $0 < k_{st} < 0,5$ $K_{pr} = 0$	Double piston, double action, three plungered pumps
Pulsing stream		$K_{st} = 0$ $K_{im} = 1,0$ $K_{pr} = 0$	Plate type, single and double action, impeller, peristaltic, pulsation pumps.
Intermittent stream	Low intermittence degree	$K_{st} = 0$ $K_{im} = 1,0$ $0 < k_{pr} < 1,0$	Submersible displacement pump of single action
	At the equality of t_{pause} and T	$K_{st} = 0$ $K_{im} = 1,0$ $K_{pr} = 1.0$	Single piston hydraulic pump, submersible displacement pump of single action.
	High intermittence degree	$K_{st} = 0$ $K_{im} = 1,0$ $K_{pr} > 1,0$	Submersible displacement pumps of single action.

CONCLUSIONS

(i) Feeding the fluid by displacement pumps may be carried out by variable, pulsing, and intermittent streams. Each type of feeding characterizes parameters having a discrete value or specific variance spectrum (Table 1) inherent to specific type of feeding only.

(ii) Feeding by intermittent stream is a feature for single action submersible displacement pumps.

(iii) According to the recommended classification, it is known that well flushing using single action submersible displacement pump is absolutely incorrectly called as pulsing, also this SDP are unjustifiably called pulsation pumps.

REFERENCES

1. B. T. Ratov and N. T. Filimonenko. Development of Scientific Fundamentals of Calculating the Work Cycle of Pneumatic Displacement Pump, Geology and Natural Resources Preservation, Kazakhstani Geological Community KazGEO, **1(50)**, C. 77-82 (2014).
2. N. T. Filimonenko Pneumatic Displacement Pumps, Donetsk: Noulidge Press, (Donetsk Office) (2012) p. 296
3. A. A. Kozhevnykov, N. T. Filimonenko and N. V. Jikalyak, Impulse well Flushing, Donetsk, Noulidge Press (Donetsk Office) (2010) p. 275.

Revised : 15.09.2014 *Accepted : 18.09.2014*