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A new integrated method for comprehensive performance of mechanical sand control screens testing and evaluation

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ABSTRACT

The comprehensive performance of mechanical screens is extremely important for sand control and well completion and to the screen's service life. Screen sand retaining media are analyzed and divided into several classifications. The concepts of sand retaining ability, anti-plugging ability, and flow capacity are put forward to describe screen comprehensive performance. A new experimental method is set up to test the comprehensive performance of mechanical screens. During the test, formation sand is carried by fluid that flows radially against the screen to simulate the real process of sand retaining. The variation of flow rate, pressure difference through screen media, and permeability with time reflect the screen's dynamic characteristics. Based on test data, a set of evaluation indexes is proposed to describe the conductivity, sand retaining, anti-plugging ability, and relevant comprehensive performance of screens. The calculation method is also developed. This new integrated methodology for comprehensive performance evaluation was successfully applied in the selection of optimum screen type for a given reservoir. This method needs only a small number of tests and provides an effective means for evaluating and selecting an optimum screen type for reservoirs.

1. Introduction

Sand production is a big issue for unconsolidated sandstone reservoir (Morita and Boyd, 1991; Bianco, 1999; Saurabh and Keka, 2016). Sand control is significant for the hydrocarbon production in the unconsolidated formations because of the serious problems caused by sand production, and it includes many techniques (Abass et al., 2002; Dong, 2011). For the mechanical sand control method, mechanical screens are key equipment for easily sanding reservoirs for both initial and later sand control completion. Their main function is to support the well wall and prevent the formation from sanding (Dong et al., 2011). Evaluating the comprehensive performance of mechanical screens is very important for sand control and service life. The comprehensive performance depends on whether the mechanical screens can effectively stop formation sanding and whether the well can be kept stable with high efficiency productivity for a long period of time (Wang et al., 2014; Somnath et al., 2014; Ehimhen and Erome, 2014). At present, a variety of mechanical screen products are available with different characteristics. For a specific sanding reservoir, proper evaluation and selection of the existing screens are crucial.

Experimental testing is the most direct method for evaluating sand control screen performance, but the majority of them provide only a primary evaluation with single factor. A systematic evaluation method and specification for comprehensive performance of sand control screens has not yet been established. A simple experimental apparatus was established to evaluate the performance of a sand control screen by measuring the pressure difference crossing the screen (Underdown et al., 2001; Jin et al., 2012). The indexes of “sand control efficiency” and “sand retaining efficiency” were calculated according to test data, in which just the sand retaining performance of the screen was considered. Another experimental study focused on evaluation of the sand-retaining effect and the impact on well production for screens and gravel-packing (Hodge et al., 2002). The test data were used to analyze the difference between the sand-retaining performance of a stand-alone screen and that of gravel-packing. A series of different linear or radial flow apparatuses were also developed to simulate sand-blocking by the screen and packed gravel and to evaluate the sand-retaining performance (Chen et al., 2006; Tang et al., 2007; Zhu et al., 2011; Ma et al., 2011; Wang et al., 2011; Wang, 2013; Yi et al., 2013; Shi et al., 2013). The sand production flow was achieved in most of these models with pre-packing formation sand in

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the annular region between the screen (or gravel) and the apparatus container. These models essentially formed a stable "sand bridge" in advance of the test beginning and could not really simulate the process of crashing, invading, and blocking for a sand–fluid mixture flowing to the screens. Furthermore, in these experimental studies, only qualitative analyses could be done for screen performance evaluation by testing the flow rate, pressure change, and produced sand size. A systematic quantitative evaluation method and indexes have not yet been formed based on experimental testing data. The impact of hydrate separation on the sand control screen has been evaluated during the process of pressure reduction through laboratory testing; however, evaluation of the comprehensive performance of the screens has not been addressed (Lee et al., 2013). Another group study of screen performance evaluation mainly involved screen media plugging and the effect of mesh hole size on sand-retaining results through experimental and numerical studies (Ranjith et al., 2013; Rajesh et al., 2012; Kuang et al., 2013), but these studies were also limited to only sand retaining.

In summary, present research on evaluation and analysis of screen performance mainly focuses on the development of experimental apparatuses. In most tests, prepacked formation sand is usually applied to form a stable sand bridge in advance, and then the displacement is measured. This kind of test cannot simulate actual sand production and blocking in oil and gas wells. More importantly, only a qualitative evaluation of screen performance has been made according to the test data; systematic test specifications and a quantitative evaluation methodology for screen comprehensive performance have not been established.

Based on the analysis of the structure and characteristics of screen sand-retaining media, a set of individual and comprehensive evaluation indexes for screen performance is proposed here. The corresponding experimental evaluation methodology and specification are also established. The integrated test and evaluation method can be used to conduct comprehensive evaluation for screen performance effectively, providing an effective procedure for screen evaluation and optimization for a given well or reservoir.

2. Sand retaining media structures and performance

2.1. Structure analysis of screen media

Various types of mechanical screens have been applied in sand control and well completion in oil and gas wells. Typical mechanical sand control screen tends to involve an interior base pipe, intermediate sand retaining media, and an exterior protecting tube. Normally, the base pipe is a perforated pipe as the load-bearing body of the screen. The outside tube acts as a protecting shield for alleviating impact and erosion. The key part of the screen is the sand retaining medium. The medium acts as a sand-retaining element and determines the comprehensive sand control performance of a screen.

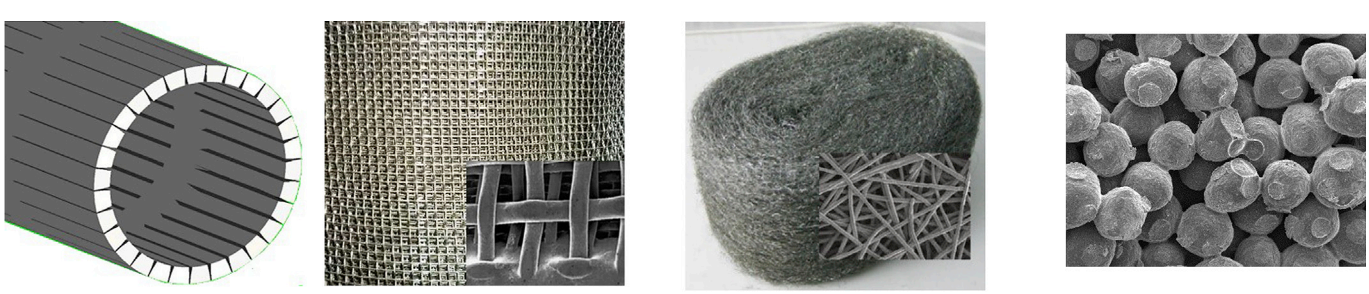
The sand retaining medium is required not only for better sand control ability but also for better fluid flow capacity. These two conflicting aspects have led to manufacturers offering multiple choices for both sand-retaining materials and processing techniques. Based on the characteristics of the sand-retaining media they can be classified into four types (see Fig. 1) as follows: (1) Regular slits (Fig. 1a) can be processed with wires wrapped on the base pipe or by cutting the casing with a laser or plasma; typical products are slotted liner or wire-wrapped screens. (2) Regular mesh filters (Fig. 1b) are composed of a monolayer or multilayer mesh knitted by metal wire; the resultant throats are relatively regular rectangles, with typical products being CMS and MGC screens. (3) Irregular metal wool (Fig. 1c) is made of irregular wires or fibers wrapped around themselves, with permeability and sand-retaining precision grade controllable by adjusting the pressed fiber body volume; the typical product is a metal-fiber sand filter. (4) Packed grains (Fig. 1d) are formed by packing grains such as quartz sand, resin-coated sand, or ceramsite, with typical products being dual pre-pack screens and resin-coated sand screens.

At present, the available sand screens are all quite different in sand control performance and applicable conditions because of the variety of materials used, different structures, and different processing techniques. Therefore, unifying and specifying the evaluation methodology of sand control screen performance are the key for optimizing and evaluating screen types for sand control completion in a specific reservoir.

2.2. Basic performance of sand control screens

For a sand control well with a screen, when the screen cannot effectively block the formation-produced sand or becomes plugged, reducing well productivity, the screen has failed to work. Excellent screen performance means not only very good sand-retaining ability but also the ability to maintain a high fluid flow capacity throughout the whole production life. From the viewpoint of comprehensive sand control, three individual basic abilities are put forward to describe the screen performance:

(1) Sand retaining ability. This is the sand-retaining performance of the screen. Sand retaining ability can be indicated by the minimum size of fines the screen could block and the amount of sand passing through the screen being less than the specified screen precision for a given period.
(2) Anti-plugging ability. This is the ability of the screen to resist being plugged by formation sand and other fines. A screen with a high anti-plugging ability is less prone to be invaded and plugged by fines and tends to maintain high conductivity and well productivity during the whole production process.
(3) Flow capacity. This is the general permeability the screen can achieve or maintain during the whole production life. Screen flow capacity can be expressed as its general permeability in the whole life. It depends on the initial permeability of the clean screen and the final permeability after the sand retaining medium plugging stops.



a. Regular slits   b. Regular mesh filter   c. Irregular metal wool   d. Packed grains

Fig. 1. Classification of sand retaining mediums of screens.