TESTING OF SEALING ELEMENTS FOR FIB-1 APPARATUS DESIGNED TO LIQUIDATE OPEN ERUPTION BY DRILLING TOOLS

BUJOK Petr, KLEMPA Martin, RYBA Jakub, PORZER Michal, ŠANCER Jindřich
Institute of Clean Technologies for Mining and Utilization of Raw Materials for Energy Use, Faculty of Mining and Geology, VSB – Technical University of Ostrava, 17. listopadu 15, 708 00 Ostrava Poruba, Czech Republic
petr.bujok@vsb.cz; martin.klempa@vsb.cz; jakub.ryba@vsb.cz; michal.porzer@vsb.cz; jindrich.sancer@vsb.cz

Abstract

Petroleum and natural gas still have their place among the most important resources in many industrial areas. Their global consumption influences an increasing demand on the quality of drilling works and the efficiency of extraction. Nonetheless, even in this field of human activity, we can encounter exceptional events and accidents. One of the most serious kinds of accidents during exploration is the so called open eruption of extracted medium. The specific case of this accident is an open eruption caused by drilling tools when a working crew is not capable of securing drilling workplace. In order to solve this emergency situation, Main Mining Rescue Station Hodonin (HBZS Hodonin), in cooperation with researchers from Faculty of Mining and Geology at VSB - Technical University of Ostrava, designed and developed specialised apparatus DPRP (Drill Pipe Rescue Press), working designation FIB-1. This apparatus enables the liquidation of eruption by pressing the drilling pipe. The residual crack, which remains following the pressing, must be eliminated by sealing materials. This paper reviews the testing of sealing elements (materials), designed by our team, in residual crack of circle shape with help of hydraulic press MTS 816 Rock Test System.

Keywords: pressure signs; eruption; liquidation apparatus; sealing elements

1 INTRODUCTION

By the term pressure signs, we understand a spontaneous outflow of formation fluids from the well. This effect generally takes place because of disturbing the existing pressure layers in a borehole.

The changes of pressure ratios occur both during the process of drilling and during the extraction or hoisting operation, but even in the cases of e.g. measuring inside the well when the formation fluids do not circulate inside a well. Outflow must be understood as a chain reaction because the mud that has entered the well is generally lighter than the formation fluids and it lightens the column of formation fluids. This leads to further increase of inflow into the well and the overall volume of overflow is steadily rising and thus the difference between the reservoir and hydrostatic pressure increases. Overflow can eventually break out into an open eruption. [4,5,6]

2 FORMULATION OF A PROBLEM

The liquidation of an outflow or even eruption can be achieved by various procedures, depending on the actual situation inside the well. The prerequisite of outflow (or eruption) liquidation is a complete closing of the well and consequent regulation of its opening during the pumping of heavy mud. The special case is the pressure sign in the course of extraction and hoisting operation when the drilling string is open. In order to close the inner diameter of mud pipes during this event, the so-called inside preventer (BOP) is used, especially abroad. If the drilling is done by kelly, it is possible to use the so called kelly cock. [5,7,8]

However, in some cases, it is not possible to use some of these tools. This entails especially a deadlocking of the drilling string inside the well, the so-called anchoring, and therefore the inability to drag or lower it to the level of drill floor.

If the situation on site is such that it is possible to operate at the drill floor, it is possible to liquidate the eruption by the means of the so-called killing spear. The eruption is consequently stopped by closing of top valve and the well can be snubbed after the connection of pressure piping and cementing truck or pumps. [7,8,9]

3 METHODOLOGY

In order to employ this solution of aforementioned emergency situations, the specialised service would have to be called which means foreign service in the case of the Czech Republic. This would lead to the increase of financial burden and it would prolonged the time needed for the whole task.

This has lead HBZS Hodonin in cooperation with researches from VSB - Technical University of Ostrava to initiate the designing and developing of specialized apparatus enabling the liquidation by pressing the drill pipe, creating entry point to the pipe below the level of pressure, and insertion of sealing elements together with killing fluids in any possible position of drilling equipment. This apparatus consists of three basic parts: drilling device, pressing device, and sealing elements. The scheme of apparatus application is shown in the figure 1.

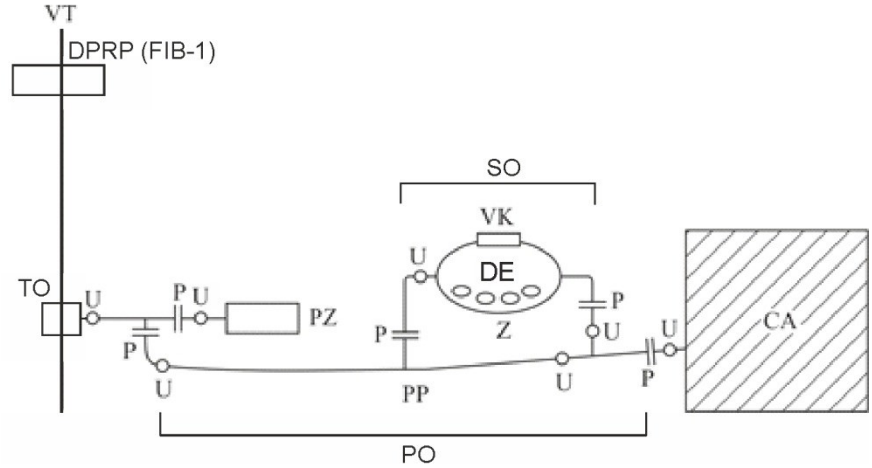


Figure 1. Scheme of designed apparatus applied to elimination of open eruption by drill rod. VT – drill pipe; U -seals; VK – cover; Z – stack; DE – sealing elements; CA – cementing aggregate; PZ – special drilling machine; PP – pipes; Drilling Pipe Rescue Press (FIB-1); TO – sealing sleeve; P – flanges; SO – secondary pressure circuit (by-pass); PO – primary pressure circuit.

4 SUBSEQUENT RESEARCH

In the first phase of research, the device called Drilling Pipe Rescue Presss (DPRP), work designation (FIB-1), with properly dimensioned hydraulic cylinder was developed. The second stage focused on inspecting the suitable shapes of pressure elements [1], see figure 2.

Figure 2. The view of special elimination apparatus FIB-1, fitted on drill pipe. The test in pilot work conditions, area of HBZS Hodonin.

The third stage of research inquired into the most suitable sealing material, since the original dural or rubber balls did not manage to seal the residual crack. [2,10]

5 SEALING OF PRESSED DRILL PIPES

Based on subsequent laboratory tests of various types of balls (polyester, wood, ballotini), accompanied by the findings about the sealing of pressed pipe achieved during the test in pilot work conditions at the premises of HBZS Hodonin [2,3], four types of working gloves with varying surface treatment, designed as RA, RB, RC, and RD were used for consequent experiments. The gloves RA and RB (material soaked in latex and nitrile) proved the most successful. See figure 3.

The sealing elements themselves, designated as "fingers" (cylinders), were made from the fingers of these gloves. The fabric of gloves serves as a container for the filling which consists of sawdust, plastic, and wooden (beech) balls. All listed elements are connected by plastic glue. Composition of materials secures appropriate density that does not allow sinking of sealing materials in the column of pressured formation fluids. Beech ball ensures sufficient toughness which prevents an "extrusion" of cylinders through incidental residual crack. Sawdust, glue, and gloves material ensure a "plasticity" of cylinder and thus mutual sealing. The size and shape of cylinders allow easy passage through supply pressure piping. All materials used are available on the market and cost-effective.

The stability of "filling" materials of "fingers" (cylinders) is ensured by gluing - it proved to be the most advantageous of the tested methods.

6 TOUGHNESS TESTING OF SEALING ELEMENTS

The inquiry into the "toughness" of sealing elements was focused on the most advantageous elements, designated as type RA, RB (see figure 3). Their working designations were "yellow finger" (RA, RB) and "blue finger" (RB, MP). Testing was done in the laboratories of Institute of Clean Technologies (ICT), using the press machine MTS 816 Rock Test System (see figure 4).

Figure 3. Sealing elements – fingers, Machine type RA, RB.

Figure 4. View of used press (type MTS 816 Rock Test System)

Due to the material filling of "fingers", beech balls, which should ensure appropriate toughness of sealing elements, were chosen for extensive testing. It is known, that wooden carrier elements endure the load according to the relation of load and their growth rings. Further, it depends on a shape of carrier element and on a type of load (spot and area) it must carry. Used beech balls are not oriented in any direction inside the sealing elements as well as the sealing elements are not oriented in any direction in the course of transportation to a residual crack. Therefore, the load can act perpendicularly to growth rings, diagonally to growth rings, or even parallelly to them. Predominant diagonal pressure action is considered to be the most probable case. The so-called circular model of residual crack, which most commonly occurs after pressing of drill rods by designed apparatus, was manufactured for the testing itself. The model was created from two short, thick-walled pipes Ø 4.9 cm

Volume LXIV (2018), No. 3
p. 1-7, ISSN 1802-5420

connected by stabilizing screws, where the distance between outer walls of pipes (the width of residual crack) is adjusted by using spacer pads of 1 and 2 mm thickness (see figure 5).

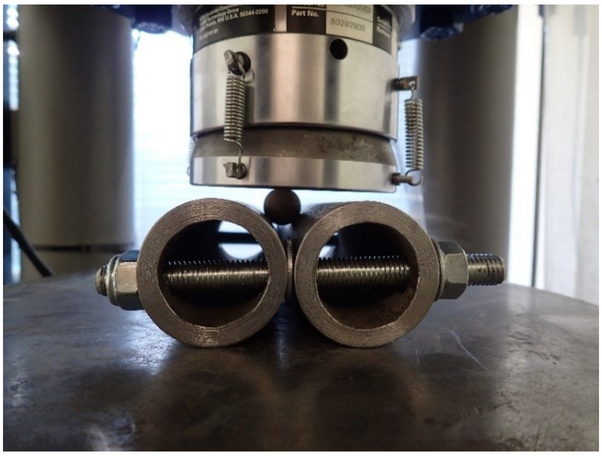
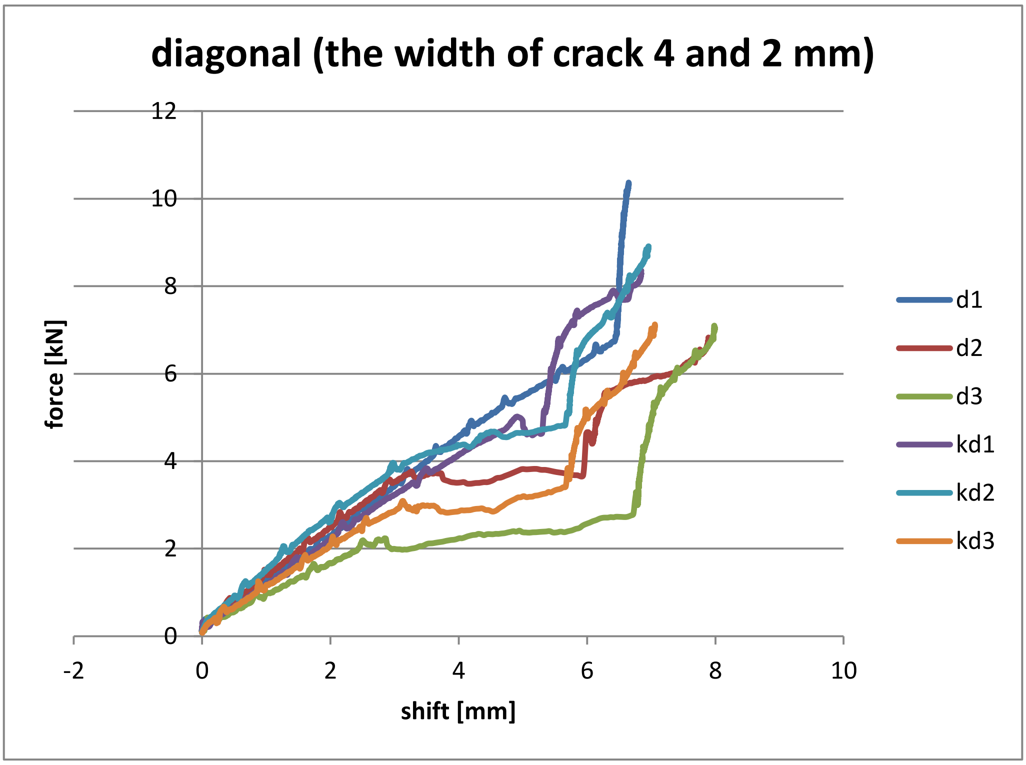


Figure 5. Beech ball (B) during the pressing in the circular type of residual crack of 2 mm width. Used press machine MTS 816 Rock Test System.

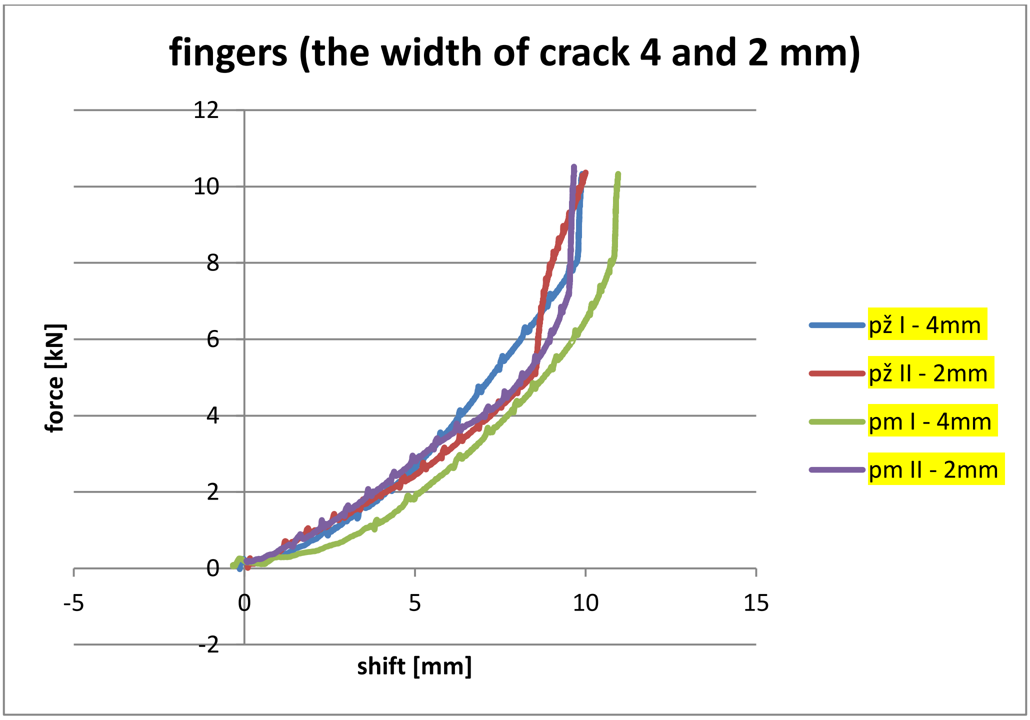
Figure 6. The set of beech balls (KR 1 – 3) after pressing in direction parallel to growth rings.

For own research, we chose (according to the results of preceding research) two types of residual crack of 2 and 4 mm width. For each size of residual crack, three sets of three beech balls were tested and further we tested yellow and blue "finger" (cylinder) in sets consisting of three pieces.

On figure 6, the set of beech balls is presented after the pressing in direction parallel to growth rings. The pressing process of sealing elements is represented in graphs 1 and 2.



Graph 1. The testing process of pushing sole sealing elements (beech balls) into the residual crack (shift in mm), the width of crack 2 mm (d1, d2, d3) and 4 mm (kd1, kd2, kd3). The force acting diagonally to growth rings.



Graph 2. The testing process of pushing sole sealing elements ("fingers") into the residual crack (shift in mm), the width of crack 2 mm and 4 mm. Orientation of beech ball, located in the body of "finger" is not known; PZ-yellow finger, PM-blue finger.

"Averaged" values of sealing elements deformation extent (of sole balls and fingers) depending on the pressure (max. and min. courses were eliminated) are listed in table 1.

Table 1. The results of toughness testing of sealing elements (used press machine MTS 816 Rock Test System).

	Shift in mm (for crack 2 mm)				
	2	4	6	8	10
	Force of pushing [kN]				
Ball "perpendicularly" *1	2.2	4.7	6.5	6.2	7.7
Ball "parallelly" *2	2.3	5.1	5.7	6.4	7.5
Ball "diagonally" *3	1.5	6.0	7.3	-	-
Finger "blue" *4	3.7	7.9	8.8	9.4	9.5
Finger "yellow" *5	4.1	7.2	8.5	9.0	9.9
	Shift in mm (for crack 4 mm)				
	2	4	6	8	10
	Force of pushing [kN]				
Ball "perpendicularly" *1	2.0	4.3	5,6	6,7	7.7
Ball "parallelly" *2	1,3	3,2	4,7	5,8	6,1
Ball "diagonally" *3	1,8	3,8	5,4	6,6	-
Finger "blue" *4	5,0	5,7	9,5	10,8	-
Finger "yellow" *5	4,3	6,2	8,2	9,8	9,9

Caption:

*1 "perpendicular" – the ball was oriented in the crack in such way, that pressure force acted perpendicularly to growth rings.

*2 "parallel" – the ball was oriented in the crack in such way, that pressure force acted parallelly to growth rings.

*3 "diagonally" – the ball was oriented in the crack in such way, that pressure force acted diagonally to growth rings.

*4 “blue finger” – the designation of sealing material according to the colour of used materials (gloves).

*5 “yellow finger” – the designation of sealing material according to the colour of used materials (gloves).

It follows from the results of loading the sole beech balls that in order to seal the residual crack of 2 mm width the most advantageous arrangement of balls in “fingers” was the perpendicular arrangement. However, during the testing of “fingers” the damaging of filling occurred only at much higher values of pressure (see table 1). The same holds for the crack of 4 mm width.

7 DISCUSSION

Therefore, it is possible to state that the specific orientation of balls inside the sealing elements is not necessary, that tested “fingers” appear to be an appropriate sealing material, and that their sealing ability is not dependent on their orientation during the accumulation in the residual crack of pressed pipe.

8 CONCLUSIONS

The designed sealing elements (fingers) were successfully tested in “working” conditions at the premises of HBZS Hodonin in April 2018 during the simulated liquidation of pressure eruption using drill rods Ø 5“ (127 mm), see figure 7. However, the designed stack was not used for inserting during the test (see figure 1). Elements were inserted directly into the pipe of unscrewed secondary pressure circuit (SB). This method necessitates consequent adjustment of sealing elements, which is going to be the goal of subsequent research stage. Fingers are going to be measured by pressure on the straight-shaped residual crack. The newly designed elements are going to be tested in working conditions during the team exercise of HBZS in June 2018 at training polygon in Lozorno (Slovakia).

Figure 7. The premises of HBZS Hodonin. The elimination of open eruption by drilling tools with help of apparatus FIB-1 and designed sealing elements.

ACKNOWLEDGEMENT

This article was written in connection with project Institute of clean technologies for mining and utilization of raw materials for energy use - Sustainability program. Identification code: LO1406. Project is supported by the National Programme for Sustainability I (2013-2020) financed by the state budget of the Czech Republic.

REFERENCES

[1] BUJOK P.; FIBINGR J.; KLEMPA M.; PORZER M.; KALUS D.; RADO R. 2014. The problem of liquidation of the open eruption by drilling tools. AGH Drilling, Oil, Gas. Volume 31, Number 2. ISSN: 2299-4157.

[2] BUJOK P.; KLEMPA M.; PORZER M.; RYBA J.; SELZER L.; WEIPER M. 2016. Řešení dílčích problémů zmáhání otevřené erupce vrtným nářadím. Závěrečná zpráva k HS 511 17 03. Ostrava.

[3] BUJOK P.; KLEMPA M.; PORZER M.; RYBA J.; BLÁHA M.; SELZER L.; WEIPER M. 2017. Řešení dílčích problémů zmáhání otevřené erupce vrtným nářadím. Závěrečná zpráva k HS 511 17 03. Ostrava, 2017.

[4] De GEARE J.; HAUGHTON D.; McGURK M. 2003. The Guide to Oilwell Fishing Operations – Tools, Techniques, and Rules of Thumb. Gulf Professional Publishing. ISBN: 978-0-7506-7702-2.

[5] RENPU W. 2008. Advanced Well Completion Engineering. Third edition, Elsevier, Oxford, UK. ISBN: 978-0-12-385868-9.

[6] SCHNEIDERWIND J. 1988. Hloubení vrtů na ropu a zemní plyn. Třetí díl. Nakladatelství technické literatury. Praha.

[7] ŠŤASTNÝ L. 2016. Současný stav a perspektivy metod likvidací erupcí na vrtech. Bakalářská práce, VŠB-TU Ostrava.

[8] WATSON D., BRITTENHAM T., MOORE P. L. 2003. Advanced Well Control. SPE Textbook series vol. 10. Texas. ISBN: 1-55563-101-0.

[9] Materiály firmy Wild Well Control. USA.

[10] Catalog of the Nonstardardized Equipment GAZOBEZOPASNOST firmy VEYA Investments ltd. Moskva, 2009.