The effects of top drive misalignment with the well center - a case study

Os efeitos do desalinhamento do Top Drive com o centro do poço - um estudo de caso

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ABSTRACT
The petroleum industry is still to this date one of the most important sectors in the energy segment and it has expectations to grow in the following years with the development of new technologies to explore newer and deeper wells. During well drilling, some procedures must be applied to assure good operation of the components and prevent further accidents. One of the main causes of component malfunction is rather related to errors during installation than materials issues. A misalignment of the Top Drive to the center of the well, for instance, can create unexpected bending stresses that can reduce the lifespan of a component and lead to failure. Therefore, this work aims to provide detailed information on the methodology of how to correctly conduct the alignment of the Top Drive to the center of the well to improve the lifetime of the components, avoid accidents and save money.

Keyword: maintenance, alignment, petroleum industry.

ABSTRACT
A indústria petrolífera é ainda até esta data um dos sectores mais importantes no segmento energético e tem expectativas de crescer nos próximos anos com o desenvolvimento de novas tecnologias para explorar poços mais novos e profundos. Durante a perfuração de poços, alguns procedimentos devem ser aplicados para assegurar o bom funcionamento dos componentes e prevenir novos acidentes. Uma das principais causas de mau funcionamento dos componentes está mais relacionada com erros durante a instalação do

que com questões de materiais. Um desalinhamento do Top Drive para o centro do poço, por exemplo, pode criar tensões de flexão inesperadas que podem reduzir a vida útil de um componente e levar a falhas. Portanto, este trabalho visa fornecer informação detalhada sobre a metodologia de como conduzir correctamente o alinhamento da Top Drive ao centro do poço para melhorar a vida útil dos componentes, evitar acidentes e poupar dinheiro.

Palavra-chave: manutenção, alinhamento, indústria petrolífera.

1 INTRODUCTION

The world is currently living the oil age. It is difficult to find a product that neither uses compounds derived from petroleum nor is produced directly or indirectly from this natural mineral oil. Its importance has been crucial for developing and studying new oil exploration technologies in Brazil and across the globe (MORAIS, 2013).

Top Drive HPS-03 1000 is an equipment manufactured by the NOV, an international oilfield supplier, and it can be seen at most drilling platforms or drillships. The Top Drive is responsible for drilling oil wells. It has two electric motors of 1150 HP each, which rotate the shaft to which the drill string is connected, thus rotating the drill bit.

The oil well drilling process occurs as follows: the drill string is formed by several pipes; they are interconnected to increase the length of the column. The drilling process occurs until the bit reaches the ground. Upon reaching the ground, the entire drill string is supported by the slip (Figure 1) and then the Top Drive shaft is connected to the drill pipe.

Figure 1 - Detail of the drill string being supported by the wedges

Source: MHTWIRTH

Figure 2 - Top Drive detail during the well drilling operation.

Source: NOV, 2021.

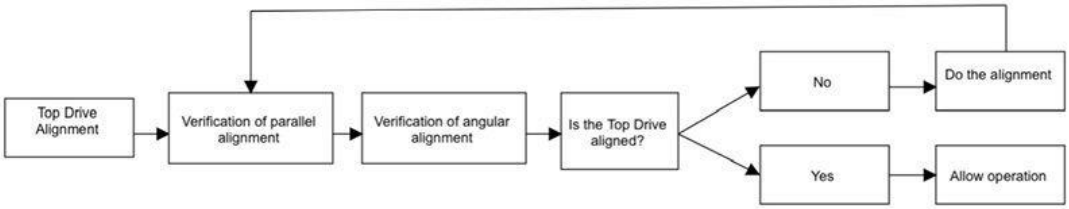
The alignment between the Top Drive and the center of the well is crucial to avoid accidents and improve the lifespan of the machine and its components. This is the reason why the alignment procedure is recommended in its maintenance plan.

Thus, this work aims to describe an effective method for performing the alignment of the Top Drive with the center of the well by analyzing a case study reported in the product information bulletin 1000011765-PIB issued by NOV, besides highlighting how much the lifespan of a Top Drive shaft and its components can be reduced due to misalignment.

2 METHODOLOGY FOR TOP DRIVE ALIGNMENT

The proposed methodology for aligning the Top Drive with the well center is based on the misalignment tolerance recommendations provided by NOV, which is the manufacturer of the HPS-03 1000. The method for performing the alignment is organized according to the flowchart shown in figure 3.

Figure 3 - Flowchart of Top Drive alignment method.



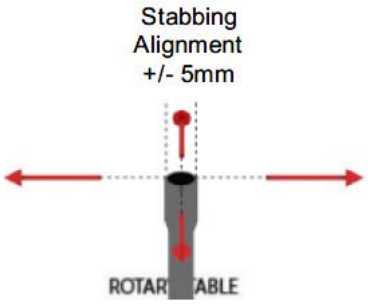
2.1 PARALLEL ALIGNMENT VERIFICATION

Firstly, a drill pipe section is inserted into the center of the well, using slips on the rotary table to support the pipes, as previously illustrated in Figure 1. The height of the connection must be 5.5 +/- 1.0 feet above the drill floor.

Then, it is necessary to rotate the rotary table and ensure the drill pipe is vertical. The Top Drive should be lowered as close to the drill pipe as possible to verify that the axis of the Top Drive is concentric to the drill pipe tool joint.

The misalignment tolerance is +/- 5 mm along the X-Y direction according to the installation procedure V3409-Z-KA-003 (Figure 4). The measurement can be performed using a caliper, and its calibration must be within its validity period.

Figure 4 - Parallel Misalignment Tolerance



Source: V3409-Z-KA-003, 2010.

2.2 VERIFICATION OF ANGULAR ALIGNMENT

The first step to verify the degree of misalignment is to remove the section of the tube positioned on the rotary table to check the parallel alignment. Soon after, it is important to put the protective cover and clean the rotary table so that the proper markings can be made on the table to check the degree of misalignment.

It is important to find the center of the well on the rotary table to check the alignment. To do so, two pieces of string can be used, and the lifting points of the Power Slip should be used as a reference point. The strings must be positioned as illustrated in Figure 5. The point where the strings meet is the center of the well. At this point, a mark must be made on the rotary table protection cover to indicate the position.

Based on the guidelines described in the document PIB 16569188 issued by NOV, the laser P/N 11412491-001 should be used to verify the angular alignment of the Top Drive shaft with the center of the well. Before positioning the laser, the face of the Top Drive shaft end must be cleaned to fix the laser's magnetic base as can be seen in Figure 6.

Figure 5 - Detail of the laser attached to the Top Drive shaft.

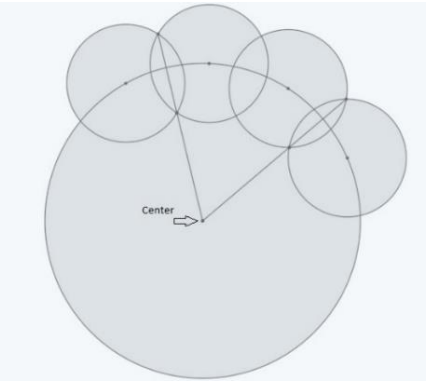
A dial indicator must be used afterward to center the laser to the axis, as shown in figure 6. It is worth mentioning that the visualization of alignment becomes easier after centering the laser.

Figure 6 - Detail of the dial indicator in the laser centering.

Checking the Top Drive alignment should be conducted at 5 ft, 25 ft, and 45 ft from the drill floor to the tip of the Top Drive shaft. At 5 ft, the Top Drive shaft should be rotated slowly as the laser light traces a circle on the rotary table protection cover. Markings should be made according to the circle created by the laser.

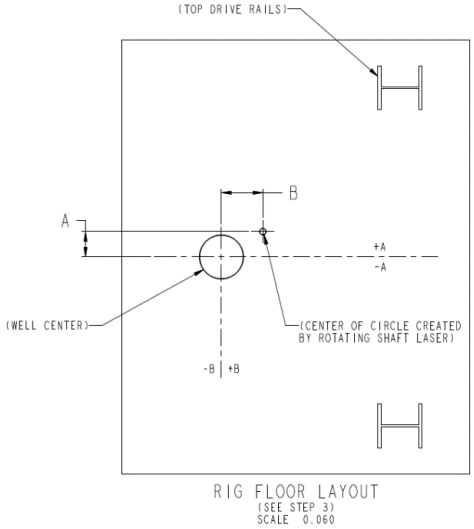
As it is not possible to guarantee the laser is perfectly centered, it is necessary to perform the step of rotating the axis and verify the formation of the circle. At each position, a circle will be generated by the laser and with the use of a compass, the center can be found. This geometric method is shown in Figure 7. A good alignment generates smaller circles making it easier to find the center of the circles. As previously mentioned, this operation must be repeated at 25 ft and 45 ft to check the alignment at other heights.

Figure 7 - Geometric method to detect the center of a circle.



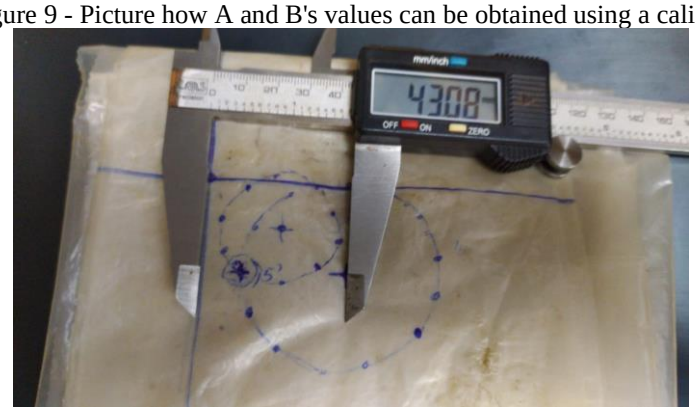
As can be seen in Figure 8, the dimensional values of A and B must be taken using a calibrated caliper (Figure 9).

Figure 8 - Reference to measure A and B.



Source: TDX1250 MYLOS, 2014.

Figure 9 - Picture how A and B's values can be obtained using a caliper.



The misalignment tolerance is 0.1° for angle A (forward tilt) and angle B (side tilt), according to NOV document V3409-Z-KA-003. The values of A and B are then applied to Eq.1 and Eq.2 to calculate the angle and verify if they are within the tolerance recommended by the manufacturer. The equations are:

$$tan^{-1}\frac{A}{L} \qquad \text{Eq. 1}$$

$$tan^{-1}\frac{B}{L} \qquad \text{Eq. 2}$$

Where the letter L is the height at which the Top Drive is positioned, i.e., 5ft, 25ft, or 45ft.

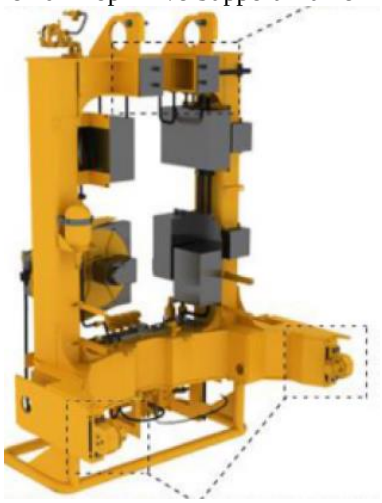
2.3 PERFORMANCE OF ALIGNMENT

Since it is necessary to perform the alignment of the Top Drive with the center of the well, the methods described in items 2.3.1 and 2.3.2 must be conducted.

2.3.1 Correction of angle A and front parallel

After analyzing the results acquired in the verification of the Top Drive alignment and considering the need to correct angle A (forward / backward tilt) or frontal parallel (forward / backward), shims must be added or removed from the Support Frame of the Top Drive. The amount of shim used depends on the level of misalignment detected. Figure 10 illustrates the Support Frame and the location where the shims must be inserted or removed.

Figure 10 - Top Drive Support Frame Detail.



Source: V3409-Z-KA-003, 2010.

2.3.2 Correction of angle B and side parallel

After analyzing the results obtained in the verification of the Top Drive alignment and considering the necessity to correct angle B (leaning to the left / to the right) or lateral parallel (to the left / to the right), shims must be added or removed from the side rollers of the Dolly. The amount of shim depends on the misalignment displayed. Figure 11 illustrates the Dolly and the location where the shims should be inserted or removed.

Figure 11 - Detail of the Top Drive Dolly.

Source: V3409-Z-KA-003, 2010.

During shim adjustment, it is important to notice that the clearance between the side rollers and the guide rail must be 3 mm +/- 1.5 mm and the total clearance is 6 mm +/- 3 mm, as reported in the document V3409-Z-KA-003 provided by NOV.

3 RESULTS & DISCUSSION

As published by NOV in PIB (Product Information Bulletin) 1000011765-PIB, the misalignment of the Top Drive with the center of the well reduces the lifespan of the shaft and drill string components.

NOV has received multiple reports of Top Drive shaft components such as upper and lower IBOP valves, Saver Sub, and Mainshaft information body cracking and failure caused by bending stresses during operation.

For instance, several failed IBOP valves were carefully examined to detect the main cause of the failures. Material analysis was performed to rule out any material issues that could contribute to premature failures. A finite element analysis (FEA) was performed and later confirmed that there were many degrees of bending in drill stem components which resulted in the exponential reduction of component lifespan.

The Top Drive alignment must be periodically checked and, if necessary, the procedure must be carried out. Figure 12 illustrates an ideal alignment between axes.

Figure 12 - Top Drive shaft aligned with drill pipe.

4 FINAL CONSIDERATIONS

The Top Drive aligned with the center of the well provides agility in action, minimizes damage to the drill pipe threads, avoids premature wear of the drill rod components, and mainly, prevents accidents. Therefore, the PIB (Product Information Bulletin) 1000011765-PIB must be considered for a good operation of the equipment. To effectively achieve the alignment of the Top Drive with the center of the well, the methodology presented in this study must be followed.

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