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Well Trajectory Survey of a Directional well

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Abstract - *Directional drilling has become a very important tool in the development of oil and gas deposits. Current expenditures for hydrocarbon production have dictated the necessity of controlled directional drilling to a much larger extent than previously. For a successful drilling operation to be carried out surveys, planning and calculations needs to be carried out at the start before the operation commences. The paper focusses on the design of well trajectory. In well trajectory the well profile is plotted with the help of given Target and Surface Coordinates, Build-Up Rate, KOP. The document has included the methods and formulas used for calculation of Well Trajectory*

Key Words: **KOP, Build Up Rate, Azimuth, Inclination**

1.INTRODUCTION

Directional drilling has become a very important tool in the development of oil and gas deposits. For a successful drilling operation to be carried out surveys, planning and calculations needs to be carried out at the start before the operation commences. To design the trajectory the surface co-ordinate, target co-ordinate, TVD, KOP and build up rate are required. KOP and Build up rate is decided by the type of formation suitable for kicking of the well, maximum inclination required for intersecting the target, the angle at which the bore should penetrate the formation. In my paper work a shallow kick of point below 100m is used as the bore hole is beneath the soft and sticky formation and a downhole motor with bent sub assembly is used as the deflection tool along with a tri-cone roller bit as it gives bit walk towards the right side. A fulcrum assembly (near bit stabilizer) is used to give the desired build up rate and direct the bore in desired direction.

2. TYPES OF DIRECTIONAL PATTERNS

2.1 Build and hold profile (Type 1)

It is the most common and simplest. The well is vertical until the KOP where it is kicked off and an angle is built. When the desired inclination is reached, the well path is kept tangent or straight until the target is.

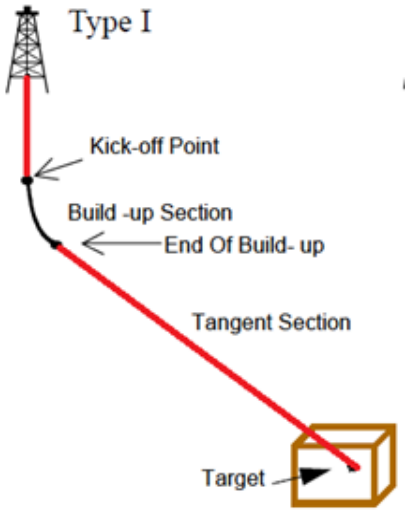

Fig-1- Type I Directional Well

2.2 Build, hold and drop profile (S Type)

It also called shaped wells. The well is kept vertical until KOP and an inclination is built and the tangent section is drilled. After the tangent section, a drop-off section is drilled where the inclination is reduced and the well path is almost vertical as it hits the target.

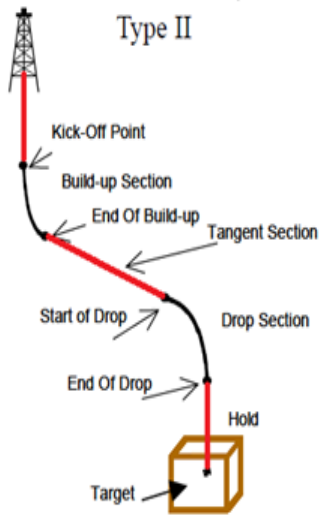

Fig-2- Type II Directional Well

2.3 Deep build/kick-off (J Type)

These types of well profiles are normally used in Appraisal wells to assess the extent of a newly discovered reservoir. It is a type of wellbore drilled when there is a hindrance, such as a salt dome, or when the well has to be side-tracked The well is drilled vertically to a deep KOP and then inclination is built quickly to the target.

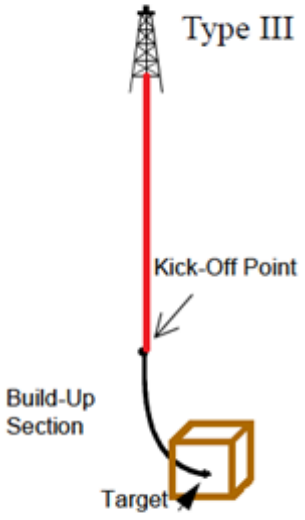

Fig-3- Type III Directional Well

3. BASIC TERMINOLOGY

Azimuth: The azimuth of a well bore at any point is defined as the direction of the wellbore on a horizontal plane measured clockwise from a north reference.

Build-up rate: The angle from the kick-off point is steadily built up. This is the build-up phase. The build-up rate (°/30 m) is the rate at which the angle is built.

Displacement: The horizontal distance between the vertical lines passing through the target and the wellhead.

Inclination: Angle (°) made by the tangential section of the hole with the vertical.

Kick-off point (KOP): The depth at which the well is first deviated from the vertical.

Measured depth (MD): Depth (length) of the well along the well path

Maximum Inclination Angle: It is the maximum angle to which the well is deviated to reach the target.

Tangent section: Section of a well where the well path is maintained at a certain inclination, with the intent of advancing in both TVD and vertical section.

True-vertical depth (TVD): Vertical distance between Kelly bushing (KB) and survey point

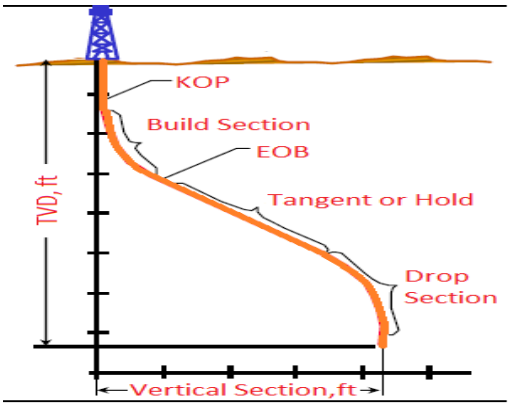

Fig 4 -S type Directional Well

4. SURVEY CALCULATION METHODS

4.1 Radius of curvature method

The radius of curvature method assumes that the wellbore has the shape of a smooth arc when viewed in both the horizontal and vertical planes. The arc is tangent to the inclination and azimuth at each survey station. The well path can be described as a circular arc in vertical plain which is wrapped around a right cylinder

4.2 Minimum curvature

As the balanced tangential method gives errors in wellbore position, the minimum curvature method is an extension of this method. This method projects the well path as a circular arc between the two survey points, by applying a ratio factor. This ratio factor is based on the overall bending between the survey sections, defined as; dog leg angel ϕ. The minimum curvature method assumes that the circular arc is wrapped around a sphere with radius

5 PROBLEM STATEMENT

To design a **L Shape/Type 1** trajectory profile for well E** *** D2 using the data given below

Design Data	
KOP (m)	100
Build up Rate (BUR) 3deg/30m	0.052359878
TVD	1269.18
Surface Co-ordinates(m)	
Northing	2610042.99
Easting	533638.09
Target Co-ordinates (m)	
Northing	2610138.06
Easting	534273.05

5.1 Calculations using Excel (Refer Fig- 5 and Fig-6)

A. Easting Offset

ΔE=Target Easting Co-ordinate-Surface Easing Co-ordinate

= 534273.05-533638.09

=634.96m

B.Northing Offset

ΔN =Target Northing Co-ordinate-Surface Northing Co-ordinate

=2610138.06-2610042.99

=95.07m

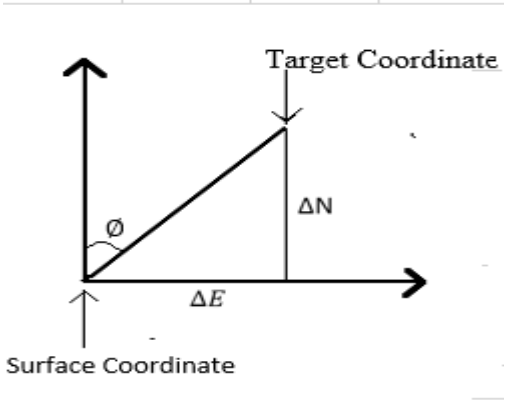

Fig 5- Plan View of a Well Trajectory

C. Azimuth

Azimuth=$tan^{-1}(\frac{\Delta E}{\Delta N})$

$=tan^{-1}(\frac{634.96}{95.07})$

=81.52°

D. Radius of Build up (R)

R= $\frac{MD*360}{BUR*2\pi}$

R=$\frac{30*360}{3*2\pi}$

R=573.24m

E. Departure (d)

$d = \sqrt{\Delta N^2 + \Delta E^2}$

d =$\sqrt{95.07^2 + 634.96^2}$

d=642.03m

F. Inclination

α=x+y

X=$\tan^{-1}(\frac{d-R}{D})$

X=$\tan^{-1}(\frac{642.03-573.24}{1169.18})$

X=3.36°

$$Y = \sin^{-1}(\frac{K}{OT})$$

OT= $(\frac{d-R}{SINX})$

OT= $(\frac{642.03-573.24}{Sin(3.36)})$

$$Y = \sin^{-1}(\frac{573.24}{1171.20})$$

Y=29.30°

α=X+Y

α=32.67°

Calculate Total Measured Depth

$TMD=MD_{1+}MD_{2+}MD_3$

MD_1=Measured depth until KOP

MD_2=Measured depth of build up

MD_3=Measured depth along the tangent section

MD_1=100m

To calculate MD_2

$$\frac{MD_2}{2\pi R} = \frac{\alpha}{360}$$

$MD_2 = \frac{32.65*2\pi*572.95}{360}$

MD_2=326.33m

To calculate MD_3

$MD_3 = \frac{R}{tany}$

$MD_3 = \frac{572.95}{tany}$

MD_3=1022.23

TMD=100+326.33+1022.23

TMD=1448.5m

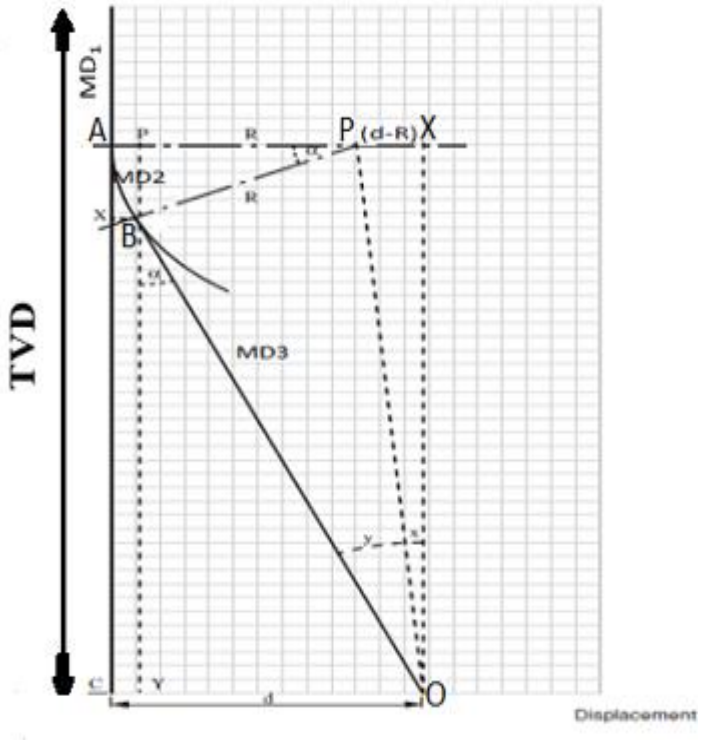

Fig 6- Radius of Curvature(section View**)**

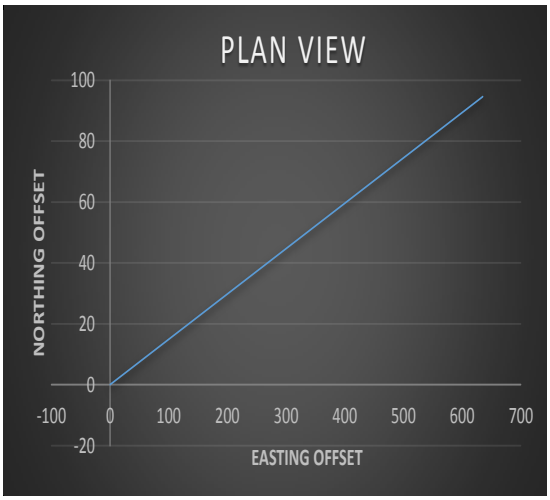

Chart 1- Well Trajectory in Excel (plan view**)**

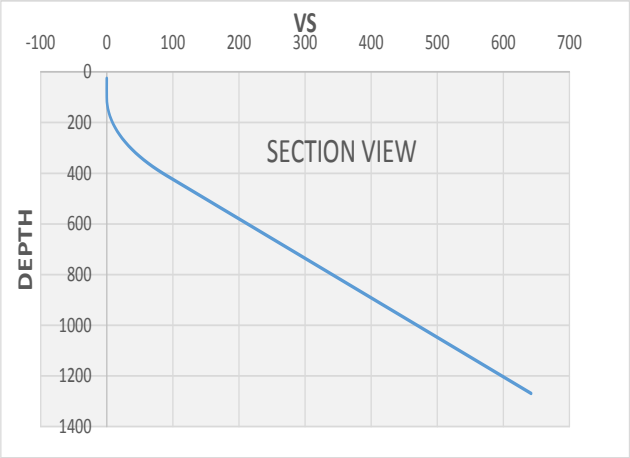

Chart 2- Well Trajectory in Excel (section view**)**

5.2 Calculations in Landmark (Compass)

The Computerized Planning and Analysis Survey System (COMPASS) is broadly used in industry do find the best trajectory of the well, meeting all geological and production targets as well as some technological aspects.It is a comprehensive software tool designed for use in directional well design by either oil companies or directional contractors. COMPASS for Windows is a tool that enables you to quickly and accurately plan wells and identify potential problems at the earliest possible stage. All of the features for complex well trajectory design, monitoring and analysis are included.

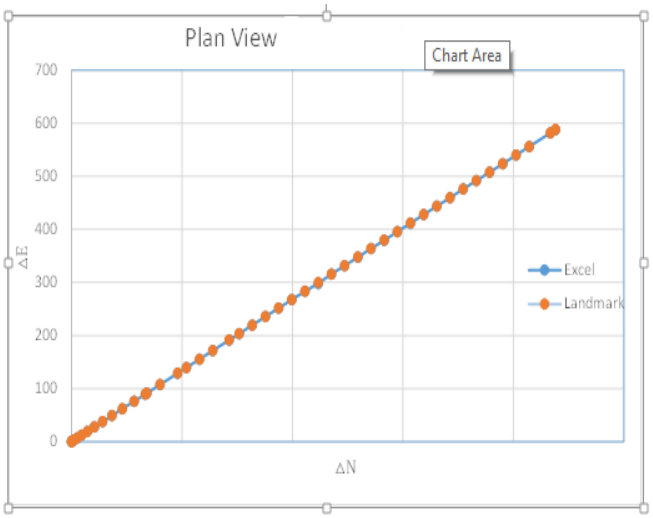

Chart 3-Comparison of Well Trajectory between landmark and Excel (plan view**)**

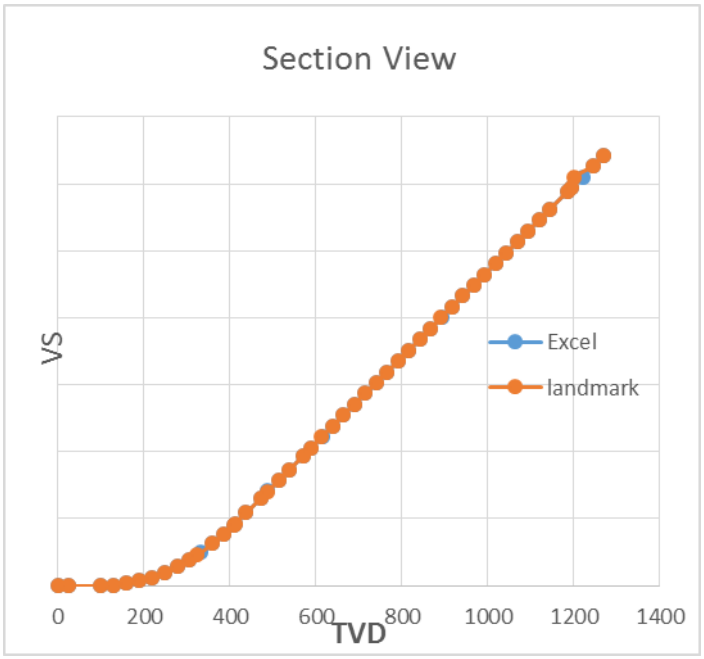

Chart 4-Comparison of Well Trajectory between landmark and Excel (section view**)**

The above graph shows comparison between the well trajectory calculations carried out manually in excel using radius of curvature method and using Compass. It was seen that the trajectory survey in Landmark was in closeness with the one calculated manually.

6. CONCLUSION

- It was seen that the trajectory survey in Landmark was in closeness with the one calculated manually.
- The Build and Hold profile is used in the Raniganj basin as there are around 6 coal seams each having a thickness of 1-10 meters, and this type of well profile helps to penetrate through all the seams.
- The Kick off point suggested is around 100 meters.
- For this particular well the maximum inclination is found to be 32.67 degree and azimuth is 81.52 degree from the well path calculation.

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