STATIC STRUCTURAL AND BUCKLING ANALYSIS OF SURFACE DRILLING DTH DRILL BIT

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Abstract - Th*e oil exploration sector, blasting a hole on rocks and drilling hole on heat exchanger pumps is a challenging task for the engineers Hence engineers are using DTH drilling method to minimize the cost of operation and time, DTH method is a reverse of drilling process where drilling is generally carried out upwards instead of downwards. Toughness of the material used on drill bits indicate its reliability. Hence in the present investigation an attempt has been made to use three different material drill bits made out of Structural steel, Titanium carbide, and Tungsten carbide respectively. FEM concepts have been applied by using ANSYS 15.0 software to know the static structural and buckling effects different patterns has been generated for different materials. It has been found that the titanium carbide material has exhibited 0.000184mm deformation in comparison with 0.0034mm and 0.0021mm for tungsten carbide and structural steel respectively. As a deformation decreases reliability of the component increases. Increasing reliability minimizes the tool down time and increases the productivity an account of increase in wear resistance of the drill bit.*

Key Words: Modal analysis , button bit drilling ,DTH(DOWN-TO-HOLE)etc…

1.INTRODUCTION

The DTH boring strategy being developing in prevalence, with expansions altogether application portions, as well as impact opening, water well, establishment, oil and gas, cooling frameworks and boring for warmth trade siphons. Applications were subsequently found for the DTH strategy underground, wherever the bearing of penetrating is for the foremost half upwards instead of downwards. In DTH boring, the musical instrument frequently known as the sledge is found straightforwardly behind the boring tool. The drill pipes communicate the essential feed power and revolution to mallet and spot additionally to packed air for the sledge and flushing of cuttings. The drill pipes are put together to the drill string increasingly behind the mallet because the opening gets further. The cylinder strikes the impact surface of the piece straightforwardly, whereas the sledge packaging offers straight and stable direction of the bore. this means that the effect energy doesn't got to bear any joints whatever Boring is that the manner toward making a gap into a tough surface wherever the length of the opening is exceptionally huge contrasted with the measurement. With regards to mining coming up with boring alludes to creating openings into a stone mass. Surface excavation needs penetrating for varied functions that include: Creation boring for example for making openings for position of explosives for impacting. The target of boring and impacting is to get ready very much divided free stone amiable to unearthing with better usefulness from the uncovering apparatus. The openings bored for this reason for existing are characterized as impact opening.

1. Investigation boring for test assortments to assess the quality and amount of a mineral hold. The examples are gathered as center and the penetrating for such designs are alluded as Core boring. As jewel pieces are utilized for such penetrating, center boring is regularly called precious stone boring.
2. Specialized penetrating during advancement of a dig for seepage, incline soundness and establishment testing purposes. Opencast mining includes evacuation of waste stone and resulting winning of the mineral. If there should arise an occurrence of stores hidden hard and reduced waste stone called overburden extricating of the stone mass is fundamental preceding removal. In this way boring and impacting is the significant ground arrangement work. Except if the stone mass is exceptionally endured and especially unconsolidated boring of openings for position of explosives and exploding them for impacting is needed for any mining activity. Present day machines like constant surface excavator can anyway wipe out the need of boring and impacting in certain surface mining activities. Fruitful penetrating under explicit site conditions requires mixing numerous advancements and administrations into an intelligent effective group, especially in case it is for profound investigation boring. Impact opening boring is nearly easier. In any case, to limit costs and upgrade the exhibition and post penetrating activities specialized administrators and choice chiefs should comprehend the language and innovation of boring tasks.

1.1 DOWN TO HOLE (DTH) BUTTON DRILL BIT

The DTH button bit is that the multi-point slicing equipment that cut the stones and surface and facilitate to create gaps or holes in to the laborious rock surfaces of the world and to breaking the stones and also the sturdy lots of land in its manner .it is the very important piece of whole apparatus. The down-the opening piece relies upon extreme pressure from the putting cylinder even as from the grating cuttings passing the piece at high speed.It gets blows from cylinder so it need to be prepared to ingest shock loads. Also, for the foremost half any piece ought to be wear safe. Any low steel is ready to assimilate the shock burdens and it's wear safe. getting to the instance of high carbon steel it is solid nonetheless can't get shock burdens and it isn't we have a tendency toar safe. thus, our low steel is carburized to urge all of the characteristics we require. The items are accessible in several setups, shapes and plans to ensure most extreme infiltration rates, Same as high mallet button bits, DTH button bits have distinctive face plan, numerous catch shapes, diverse flushing gaps plan, distinctive opening openers plans. In Sino drills, no matter level face, arched face, sunken face, drop focus face, circular catches, trajectory catches, spike catches, tapered catches, any arrange is accessible as indicated by client' solicitation. the gap across is from 60mm to 700mm. The knifes is Cop series. All DTH drill button items are planned along to figure in terrific harmony, long facilitate life and low expenses. they're for the foremost half hot squeezed and superb heat treatment, that guarantee our quality are systematically sure and dependable. items will are available in varied kinds: Flat-confronted, Convex, Concave, and drop enter trajectory pieces and arch pieces

1.2 PRINCIPLE OF ROCK TOOL INTERACTION IN DRILLING

The guideline of rock boring includes the stone device connections to make an entrance in rock. In the ordinary boring interaction mechanical energy is scattered through a piece to a stone. In view of the practices of boring framework and rocks the piece reacts in an unexpected way. The rule of rock penetrating is worried about giving a logical premise of such reactions, so that for a given occupation the right technique can be chosen. Arrangement crumbling in boring is for the most part because of mechanical energy. Nonetheless, there are boring procedures in which heat energy or synthetic energy is utilized. Water fly energy is additionally utilized in specific cases for rock deterioration. The mechanical energy can crumble rock mass by pounding,

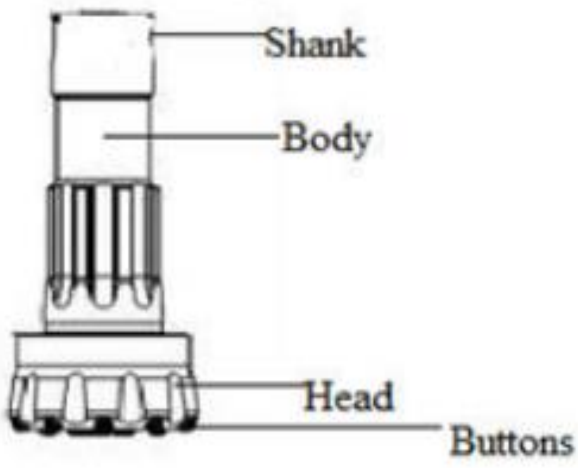

Figure 1.1: -Schematic diagram of DTH Drill Bit

sway smashing or scratching. Squashing happens when weighty and consistent power is applied on the stone mass through hard penetrating piece. The protection from entrance of rock is called penetrating strength or drill capacity of rock. This is not the same as other stone properties as it is identified with number of controllable and wild boundaries.

Rock Penetration in Percussion Drilling In percussion boring an etch type or catch type bit sledges or blows the stone mass while handing the device over between two progressive blows called blow ordering. A pivotal push is applied to keep the piece in touch with the stone when the blow is applied. The stone entrance happens due to arrangement of a pit under the activity of the blow.

1.3 OBJECTIVE OF THE WORK

In this project evaluation of the static and dynamic response of DTH drilling assembly to detect weak sections is carried out.

Modal Analysis of DTH drill bit: Carried out to identify the natural frequency of the system and different mode shapes.

Static Structural Analysis: To find the stress and deformation of the system.

Buckling Analysis of drill bit: To find the Eigen buckling value of the drill string.

2. EXPERIMENTAL SET UP AND PROCEDURE

2.1 MATERIAL SELECTION

In this work we are going to use 3 different materials to do the analysis for down to hole drill bit and the materials we used are

1. Structural steel
2. Tungsten carbide
3. Titanium carbide

2.1 PROPERTIES OF STRUCTURAL STEEL

Table 2.1 Chemical Composition of Structural Steel

Element	**Percentage**
Carbon, Max %	0.23
Manganese %	0.50-1.60
Silicon, Max %	0.40
Vanadium, Max%	0.15
Columbium, Max%	0.05
Phosphorus, Max%	0.035
Sulphur, Max%	0.045

Table 2.1(a) Material Properties of structural steel

Sl /n o	**Structural steel Material**	**Properties**
01	Density	7850 kg/m-3
02	Young's modules	2E+05
03	Passion ratio	0.33
04	Yield stress	535 Mpa

2.2 PROPERTIES OF TUNGSTEN CARBIDE

Coming up next is a rundown of Tungsten Carbide Properties. Various Grades of Tungsten Carbide will contrast in Strength, Rigidity, and different Properties, yet all Tungsten Carbide Material falls into the fundamental properties recorded beneath. For additional top to bottom data on the properties of explicit grades of Tungsten carbide, or more data on Carbide and other device Materials visit Tool Tipping Material Index.

Table 2.2 Material Properties of Tungsten carbide

Si no	Tungsten carbide	Properties
1	Density	1190 kg/m-3
2	Youngs modulus	2e+07
3	Poisson's ratio	0.29
4	Yield stress	250Mpa

2.3 PROPERTIES OF TITANIUM CARBIDE

Table 2.3 Chemical Composition of Titanium carbide

Element	Percentage
Titanium, Ti	98.9
Iron, Fe	0.30
Oxygen,O	0.25
Carbon,C	0.080
Nitrogen,N	0.030
Hydrogen,H	0.015

Table 2.3(a) Material Properties of Titanium carbide

Si no	Titanium carbide	properties
1	Tensile strength	485Mpa
2	Yield strength	345Mpa
3	Poisons ratio	0.34-0.40
4	Elastic modulus	105-120 Gpa
5	Density	4.51g/cm3
6	Melting Point	1660 C

3. MODELING AND ANALYSIS OF BUTTON BIT

The piecemeal procedure for static structural problem will be declared as follows:
Step-1: - Modelling
Step 2: - Dividing the Modelling
Step 3: - Choosing the appropriate interpolation structure
Step 4: - Assembly of element calculations to obtain the equilibrium calculations.
Step-5: -Enforcing the boundary conditions
Step 6: - Resolution of system calculation to identify the nodal values of dislocation
Step 8: - Calculate the deformation and stress of the element.

3.1 GEOMETRY OF THE DRILL BIT

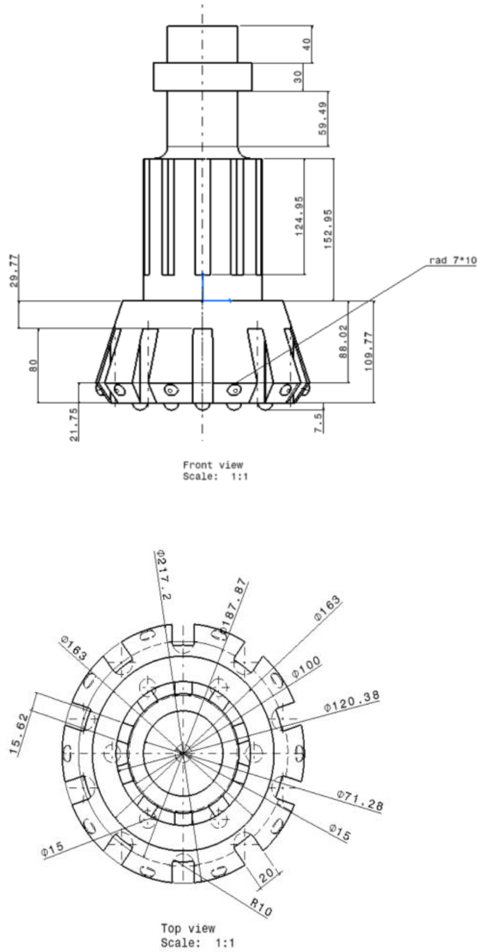

Figure 3.1 Geometry of the DTH drill bit

3.2 MODELLING AND MESHING OF THE DRILL BIT

As shown in figure 4.8.1(a) to Figure 4.8.2 (b) we have made a Model in Catia v5 programming with the given measurements in figure 4.8 and afterward the assembled - in model is imported to ANSYS workbench 15.0. furthermore, A default course lattice of 3 gestured three-sided components is created with 100 relevance.

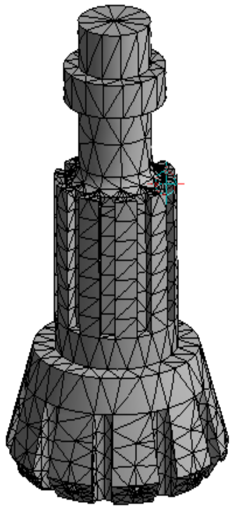

Figure 3.2 Pictorial view of meshed drill bit

3.3 BOUNDARY CONDITION FOR THE IMPORTED MODEL OF DOWN TO HOLD DRILL BIT

In the fig 4.8.2 we have applied the boundary condition to the meshed model of DTH drill bit and we can see the rotational velocity and displacement and force in the below figure.

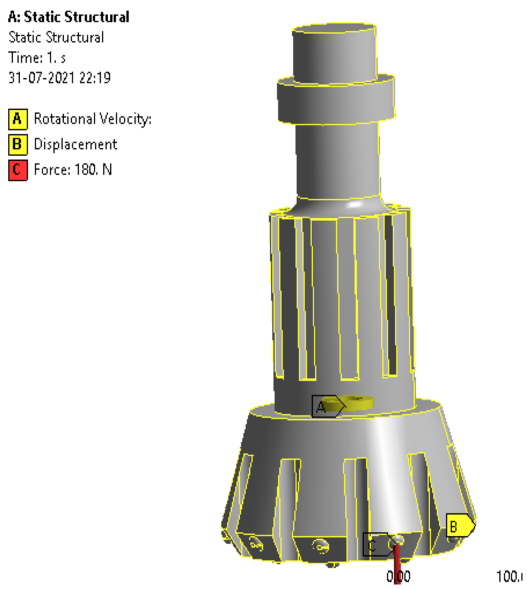

Figure 3.3 Applying boundary condition on Drill Bit

3.4 Analysis of the Structural steel in Ansys 15.0

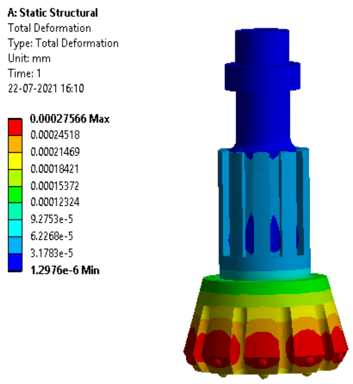

Figure 3.4 Max total deformation is 0.0021 mm for applied load condition

3.4.1 Analysis of the Tungsten carbide in Ansys 15.0.

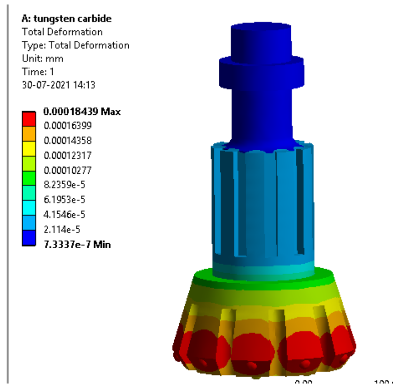

Figure 3.5 max total deformation is 0.000184 mm for applied load condition

3.4.2 ANALYSIS OF THE TITANIUM CARBIDE IN ANSYS 15.0

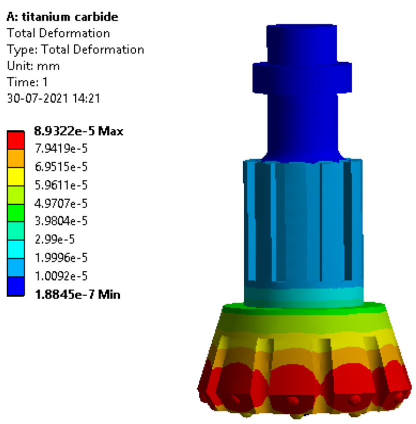

Figure 3.6 Max total deformation is 0.000184 mm for applied load condition

Si/no	Material	Equivalent stress unit Mpa	Total deformation unit mm
01	**structural steel**	2.178 Mpa	0.0021
02	**Tungsten Carbide**	2.678 Mpa	0.0034 mm
03	**titanium carbide**	0.9145 Mpa	0.000184 mm

Table 3.1 Comparison of equivalent stress and deformation

Since the Value of Deformation is less in case of Titanium Carbide in comparison with structural Steel and tungsten carbide as shown on table 3.1.

Hence the Dynamic Buckling and fatgue analysis has been shown for titanium carbide to show its reliability

3.5 DYNAMIC ANALYSIS FOR TITANIUM CARBIDE

Dynamic Analysis has spearheaded a large number of the estimation and examination methods important to foresee and mitigate primary vibration issues. We have utilized insightful models (normally utilizing Finite Element methods) to decide the unique reaction of constructions going from little individual segments to whole structures. In one such, still up in the air in the plan stage the changes needed to restrict train-incited vibrations on an upper floor of another substantial design. This cycle included characterizing the vibration affectability of the gear to be introduced, estimating the train-prompted vibration levels and soil conditions at the structure site and building a logical model of the proposed design and soil framework. This can be generally forthright for essential slices of a basic framework, and very muddled once passing a multifaceted mechanical tool or a confounded design accessible to intermittent breeze loading. These outlines require precise assurance of normal frequencies and mode shapes utilizing methods like FEA.

Table 3.5 initial modes and corresponding natural frequency

Si no	Modes	Natural frequency
01	1	8602.7
02	2	8642.8
03	3	12626
04	4	13253
05	5	13959
06	6	14266

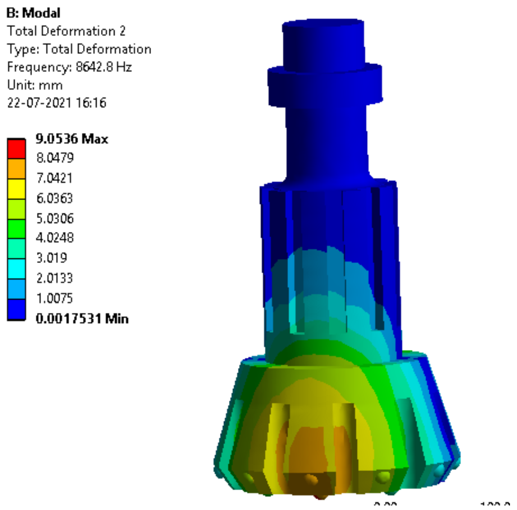

Figure 3.5 Second mode of Connecting rod and corresponding frequency

Similarly, five more modes are calculated and results are tabulated in table 4.1

3.6 Buckling analysis of titanium carbide

Buckling happens when the compressive burden in a cylindrical drill string surpasses a basic worth, past which the rounded is never again steady and misshapes hooked on a sinusoidal or helical shape, the sinusoidal buckling comparing drill string to pipe, that pictures into a sinusoidal shape. Material disappointment and auxiliary unsteadiness which is frequently called buckling or Eigen esteem buckling or straight buckling. Buckling is that method of disappointment when the structure encounters abrupt disappointment when exposed to compressive pressure.

The method used to decide buckling load for drill string or a vertical segment under the basic compressive burden at which a structure or drill string gets precarious and clasped is called Buckling investigation.

Table 3.6 Initial modes and corresponding load

Si no	Mode	Load Multiplier
1	**1**	**-96102**
2	**2**	**-95113**
3	**3**	**-93432**
4	**4**	**-90640**
5	**5**	**87973**
6	**6**	**91307**

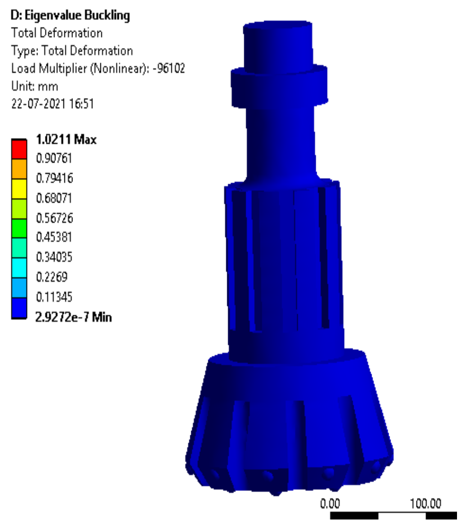

Figure 3.6 First mode and corresponding buckling deformation

3.7. FATIGUE ANALYSIS:

In materials science, burnout is the wear of fabric due to intermittent pressure. This is the tolerable and limited major damage that occurs when the material is recycled. Well below the strength of the fabric, this has historically been considered the ultimate elastic limit or yield point. When the material is easy to copy, pile up and dump, it will be lost. In pressure concentrators, such as on the surface, in a constant slip system (PSB), through the interface of the connection, and through the grain boundaries of the metal, it may start to crack. It will grow unexpectedly, so the structure will break. The appearance condition mainly affects the service life; square holes or sharp corners can make people afraid of the beginning of weakness. Round holes and sudden changes or rounded corners increase the drainage resistance of the structure.

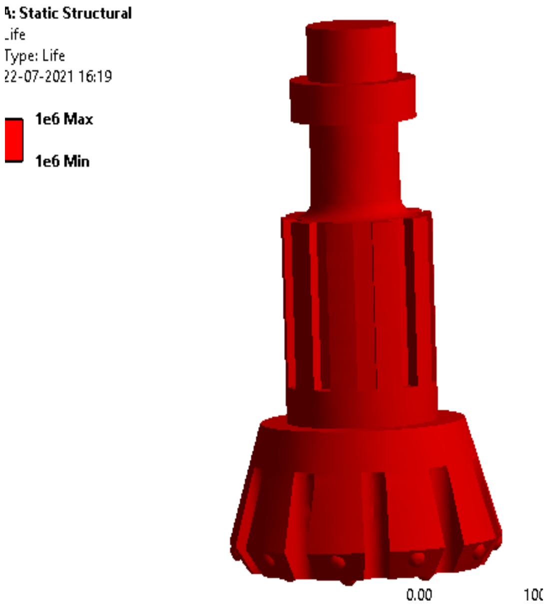

Figure 3.7 Fatigue life estimation is 1000000 for the applied load condition

4. RESULT AND DISCUSSION

From Figures (4.1 to 4.3) indicates the maximum total deformation for different types of drill bit material while applying load of 2000rpm and max equivalent stress and maximum principal stress and minimum principal stress are 2.178, 1.2mpa, 2.9mpa for structural steel, and 2.678 Mpa, 3.52 Mpa, 2.25Mpa for tungsten carbide and 0.9154 Mpa and 1.16 Mpa, 0.702Mpa for titanium carbide respectively.

Comparing maximum equivalent stress, titanium carbide max stress 0.9145 Mpa and total deformation is 0.000184 mm which is less than other two hence **titanium carbide is better material compare to** structural steel and tungsten carbide

The amount of deformation has been reduced gradually for 0.002mm to 0.000184mm respectively. The applied load on titanium carbide is equal to critical load with reference to critical load with reference to modal shapes. Six modal shapes for titanium carbide exhibit the stress distribution during drilling operation and prevention of the buckling phenomenon for the material.

Model analysis conducted to finding initial modes and corresponding frequency for the Titanium carbide, Nature frequency for the mode as shown in below Graph.

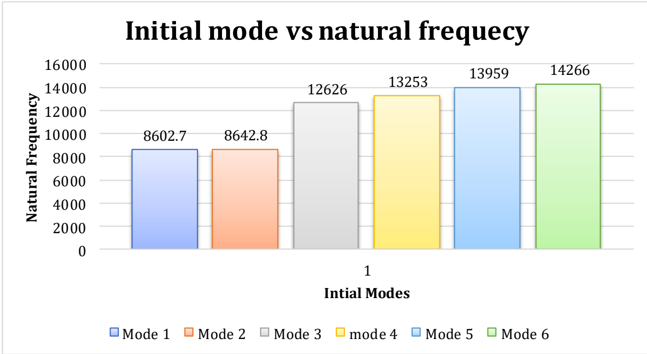

Figure 4.1 Initial modes and corresponding natural frequency

Buckling analysis conducted to finding initial modes and Load for the Titanium carbide, load multiplier for the mode as shown in below table.

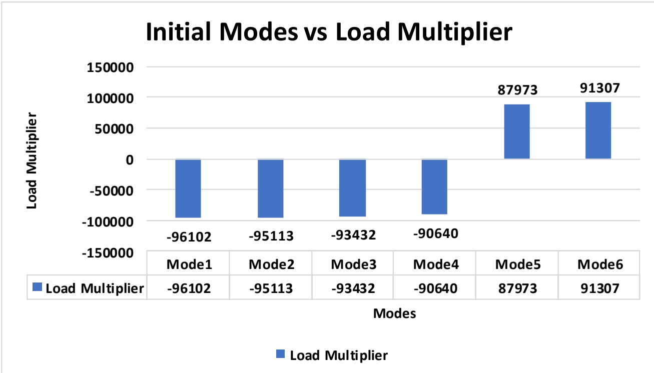

Figure 4.2 Graph of Initial Modes vs Load Multiplier

5. CONCLUSION

The titanium carbide material has exhibited excellent equivalent stress and principal stress and fatigue life in comparison with Structural Steel and Tungsten Carbide respectively. And can be in-corporated as a drill bit material. While drilling a rock, oil exploration and for heat pump in heat exchangers

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