

Concept Design of Digger cum Winch Attachment for Skid Steer Single Arm Product

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Abstract— This paper focuses on conceptual design of Digger cum Winch attachment for SKID STEER machine to reduce the project execution time of highways. Today's market requirement for construction equipment is changed, customer wants to save time as well as money during execution of the project by using a single machine which will perform multiple tasks. Customers not only avoid use of multiple machines for different applications but also want to save tool or attachment changing time for the same machine. This urge comes in to mind because of huge development & investment in highway constructions to enhance good transportation. This brings idea of digger cum winch attachment which will serve different application like trenching, able to grounding of high extension cables as well as pipe installation across the road side. This attachment also serves the agricultural requirement to enhance productive & less time consuming environment. The digger is ideal for nurseries & landscaping application. This is multipurpose attachment, which can be used for trench, remove stumps, transplant trees, as well as loosen hard packed soil. For concept design and bench marking SKID STEER machine which effectively able to perform multiple task by simply changing attachment within short interval of time is good. The methodology adopted is to find a maximum digging force for the given cylinder pressure and this is done using parametric design. The second stage is to find the forces at all pivot points of the attachment, this is done using MathCAD. The digger cutter plate is made from HARDDOX 400 steel, while the child parts are made from EN10025-S355 to sustain long durability. Concept validation will be through Finite Element Analysis (FEA).

Keywords – Concept Design, Breakout Force, FEA, Skid Steer machine.

1. INTRODUCTION

Today's market requirement is quite different & customer needs are also changing which gives us opportunities to launch new segment of products which can deliver or fulfill the market needs. Digger cum winch attachment case falls into such one of the requirement which comes under agriculture and highway construction to make small trenches. Digger is useful for making trenches, grounding of high extension cable in highly dense areas, canalling, optical fiber cable installation; it is also used to loosen hard packed soil. Digger

attachment can be used on skid steer machine because it consumes less space & preferably can also be use in highly dense areas. This attachment use different tools for different application. For effective utilization digger is designed in such manner so that it can use its both sides for line up the trenches i.e. dual cutting edge both front & back. To enhance product life digger cutter plate is made from HARDDOX 400 steel while the child parts are made from EN10025-S355.

2. CONCEPT FORMULATION

It is very difficult to make trenches at critical road site work as well as time consuming in highway construction which lags actual project time. Even due to unavailability of workers and attachment replacing time for same construction equipment delay the project execution work. Grounding of high extension cable, communication optical fiber cables, cannels for irrigation required small trenches & urban area piping to supply water for societies also hamper (see Fig. 1). Before starting with problem statement it is very curious to ask 'What are the today's methods of digging the trenches?'



Fig. 1: Canal for farming

Maybe there are a few methods, but are they feasible or valid with time constraints. Current methods which are using now are critical and time consuming, so can we make concept for this issue which can reduce efforts, time, able to do multiple task & especially cost effective one. So these problems originate a concept of digger which not only solve such issue but also effectively utilized for different application for respective fields [2].

3. RESEARCH WORK

Digger attachment for Skid Steer is designed for multipurpose applications based on customer's needs. Digger child parts design for maximum breakout force. Work started with static analysis of a mechanism with given input conditions of hydraulic cylinder. Thus with this final breakout force and tractive force are calculated. Next CAD model of each child part is modelled in Uni-graphics 8.5 based on application and is then assembled. Parametric assembly of the mechanism is done for the purpose of understanding the feasibility of a mechanism and analyzing the behavior of mechanism by varying input conditions.

4. RESEARCH TASKS

- A. Market research where will be the key customers and different application for implementation.
- B. Concept generation of digger cum winch attachment.
- C. Modeling & Drafting with the help of UNIGRAPHIX 8.5 Tool
- D. Analytical calculation for worst load cases.
- E. Understand Product SS155 SKID STEER MACHINE.

Concept modeling of Digger cum winch attachment

A model is a representation or idealization of the structure, behavior, operation, or other characteristics of a real-world system. A model is used to convey the design information, simulate real world behavior, or specify a process. Engineers use models to convey product definition or otherwise define a product's form, fit and function.

Before designing of digger cum winch attachment - Skid Steer Arm, Tilt Ram & Quick Hitch is carefully understand how they are working together at pivots points. Considering locking pins of quick hitch as a bench marking point for back plate design because this locking pin work as a grabber for digger attachment. For design of back plate care should be taken for angles & faces of back plate are matched with face of quick hitch. This gives the idea about benchmarking principle of any product development process.

Side plate are responsible to give path and shape to make proper trenches size, while stiffening rib are give the backing support to overall structure. One of the important components which avoid bending movement in both LH & RH side plate is

C-channel & hollow tube (torsional). This will give additional strength to structure.

Cutter blade is a critical component of digger because it has to sustain both tilt ram & tractive forces. Digger cutter's shape is made in such way that it can utilize both edges so that trenches are made easily with less time. Winch is additional hand to this digger attachment for lifting cable rolls & pipes or may be rods on construction site [6] [7].



Fig. 2: SKID STEER machine with digger attachment

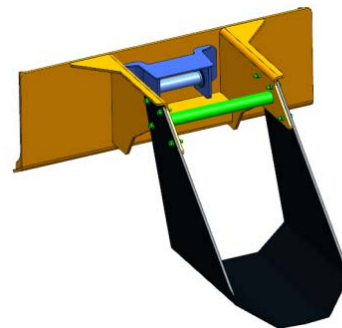


Fig. 3: Isometric view of digger cum winch attachment

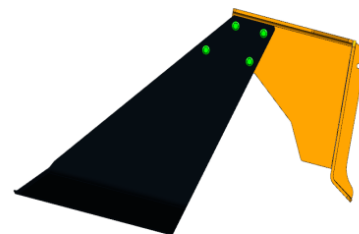


Fig. 4: Side view of digger cum winch attachment

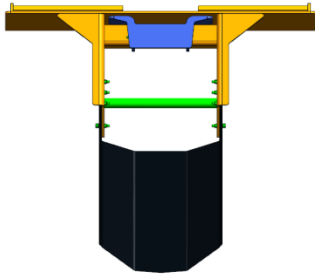


Fig. 5: Top view of digger cum winch attachment

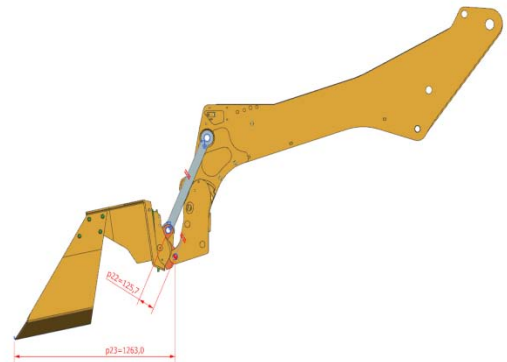


Fig. 4: Pivot point distance

5. MATERIAL & WELD DESIGN

Materials are the key factor in construction equipment manufacturing because due to high fatigue wear & tear of components occurs in rough territories such as mining industries, construction & agriculture. Digger attachment need’s material which have more yield value but it signifies more will be the cost of material, so considering aspect of optimization we can reduce it by selection of different material considering the load cases which occur in FEA. We identify three materials which are mostly used in construction equipment manufacturing industries for such application as follows- EN10025-S275, EN10025-S355 & HARDOX 400. Weld detailing is done based on standard BS7608 for better weld fatigue life.

6. FORCE/KINEMATIC CALCULATIONS

To find the forces at different points of the attachment is very important as it plays a crucial role in the analysis, for getting results close to the actual it is required to have accurate values of forces at all pivot points. The methodology adopted is to find a maximum digging force for the given cylinder pressure, and this is done using design view. The second stage is to find the forces at all pivot points of the attachment, this is done using MathCAD.

Tilt Ram Force Calculation -

1. System Pressure = 230 bar = 23 N/mm²
2. Cylinder Bore ID (D) = 100mm
3. Cylinder Rod OD (d) = 50mm
4. Closed Length – 632mm
5. Stroke Length – 333mm

Case1. Under the Application Ram Force

A) Ram Extension Force

$$Area = A = \frac{\pi}{4} * D^2$$

$$A = 0.785 * 100^2$$

$$A = 7850mm^2$$

$$F = P * A$$

$$F = 23 * 7850$$

$$= 180550 N$$

Now,

$$F_1 * S_1 = F_2 * S_2$$

$$F_2 = (F_1 * S_1) / S_2$$

$$F_2 = 180550 * 127.5 / 1263$$

$$F_2 = 18226 N$$

$$F_2 = 1822 Kg.$$

B) Ram Contraction Force

$$Area = \frac{\pi}{4} * (D^2 - d^2)$$

$$A = 0.785 * (100^2 - 50^2)$$

$$A = 5887.5 mm^2$$

$$F = P * A$$

$$F = 23 * 5887.5$$

$$= 135412.5 N$$

Now,

$$F_1 * S_1 = F_2 * S_2$$

$$F_2 = (F_1 * S_1) / S_2$$

$$F_2 = 135412.5 * 127.5 / 1263$$

$$F_2 = 13669 N$$

$$F_2 = 1366 Kg.$$

Case2. Under the Application Tractive Force
 Tractive force for Skid Steer 155 Model: 90% of its operating weight

$$T = 2844 * 90 / 100$$

$$T = 2559.6 \text{ Kg}$$

7. CONCLUSION

Concept design for digger cum winch attachment is verified in CAD software at various stroke lengths of the tilt ram cylinder. Digger is parametrically proved in CAD software. The movements of digger execute properly without any interference in Q-hitch. Even digger is able to dig at different stroke length of ram cylinder.

Future work on the digger cum winch attachment will be structural validation in Finite Element Analysis (FEA) under the known boundary & load condition. During validation in FEA there may be chance or scope of shape optimization in the digger CAD model [5].

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