Stone Crushing Mechanism

MEC 567 Project

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Introduction

Stone crushing Mechanism finds enormous uses within the manufacturing Industry. In mining or metal extraction industry, large blocks of minerals are extracted from earth. These large aggregates are continuously fed as input into the Stone Crushing machine. It is the machine's responsibility to processes the larger rocks and breaks them into smaller pieces. These smaller pieces can then be worked upon by the subsequent process.

How it works

There are many ways to actually make a functional Stone Crusher. The principle of compressive fracture is used and this can be achieved by gradual or impulsive loading. Some ways to apply a gradual loading are using a Kinematic mechanism, Hydraulics or Pneumatics. Impulsive loading can be applied by imparting high kinetic energy in the rocks and then having them collide to a fixed and stiff structure.

We will primarily focus on the kinematic mechanism as it involves implementing the knowledge gained within the course. The kinematic mechanism is used to convert the rotational input from a motor into compressive force to break the Stones into smaller pieces. Output link, Coupler, or Input links may be used to achieve the required compression. We will be creating a mechanism which acts as the "best" possible to achieve our goal.

For our mechanism, we will consider that it inputs rocks not bigger than 500mm in diameter while crushes them into pieces smaller than 100mm in diameter.

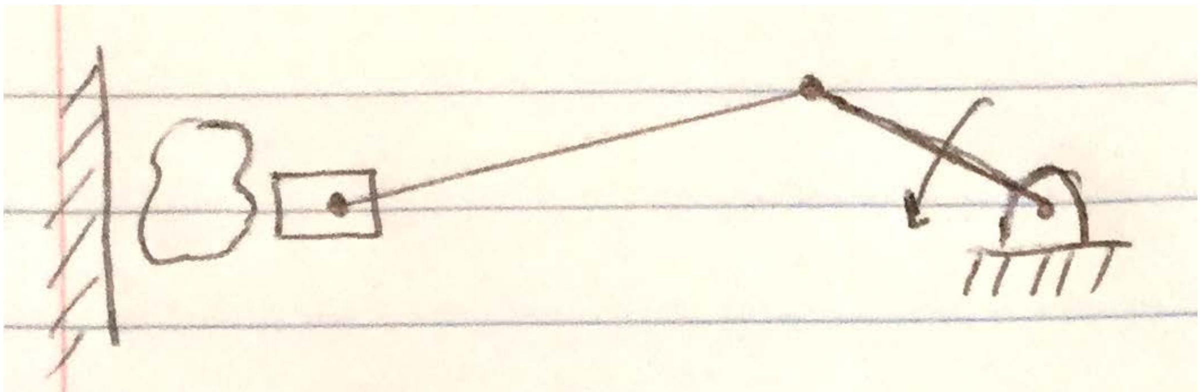
"Wellness" criteria

The "wellness" criteria defines the parameters which are most important to us in the machine and will help us determine the best possible mechanism from a set of good mechanisms.

The criteria we are most concerned with is the speed at which the machine crushes stones. The faster larger blocks are turned into smaller blocks, the better). It is noted that the speed is directly proportional to the volume of rocks the machine processes in unit time.

Systematic Synthesis- Design 1

Slider Crank Mechanism:-



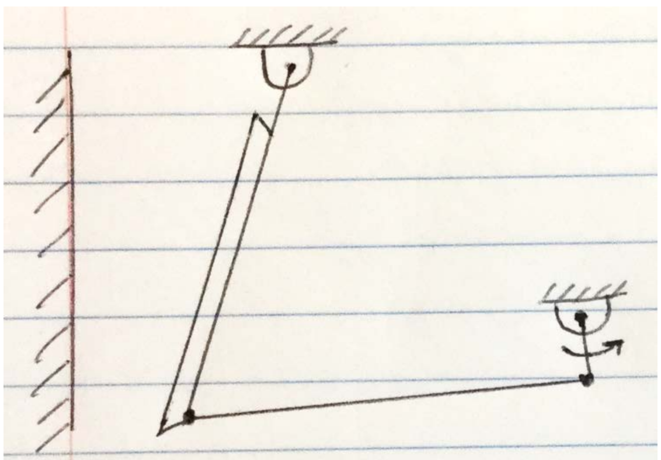
The first mechanism that comes to mind which can be used to crush something is the Slider crank mechanism. It seems like a good mechanism to compress things against a support due to its prominent linear motion.

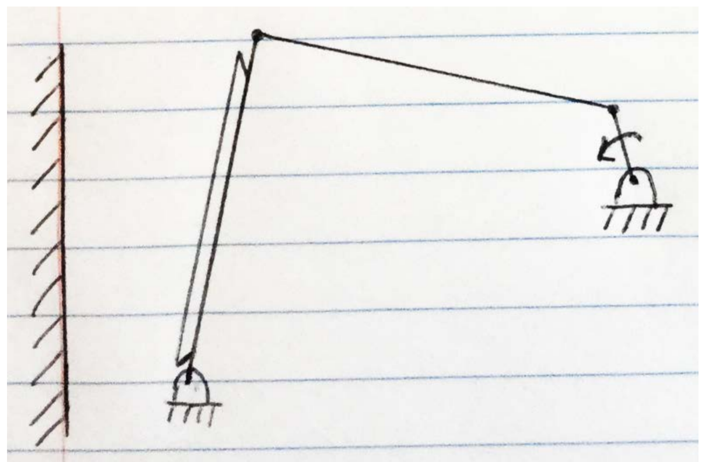
However, on further thinking, it is found that it suffers a big problem. It cannot handle continuous flow of large rocks. It can only process a single rock at a time. Also, rocks of aproximately same size can be efficiently crushed. If the rocks are too small, the slider wastes precious time in idle motion. Thus other mechanisms are found which don't suffer with the same problem.

Systematic Synthesis- Design 2

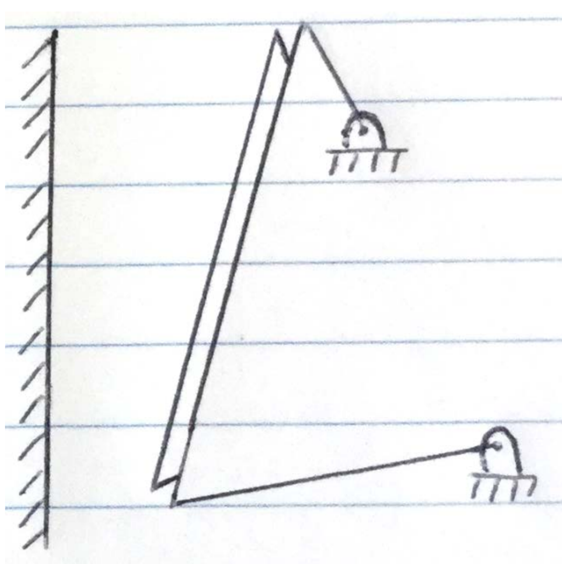
Crank Rocker Mechanism:-

The crank rocker mechanism is better suited to crush continuous flow of rocks. To achieve crushing, one of the moving links is repurposed for the task of crushing. The movement of the link compresses the large rocks against a fixed stiff support to cause compressive failure and thus form smaller rocks. It can efficiently process rocks of sizes with large variation as smaller rocks are compressed in lower region while the larger rocks are compressed at the top. Also, gravity can be used as the rocks which are not small enough cannot escape the crusher without being crushed. Three Inversions possible.



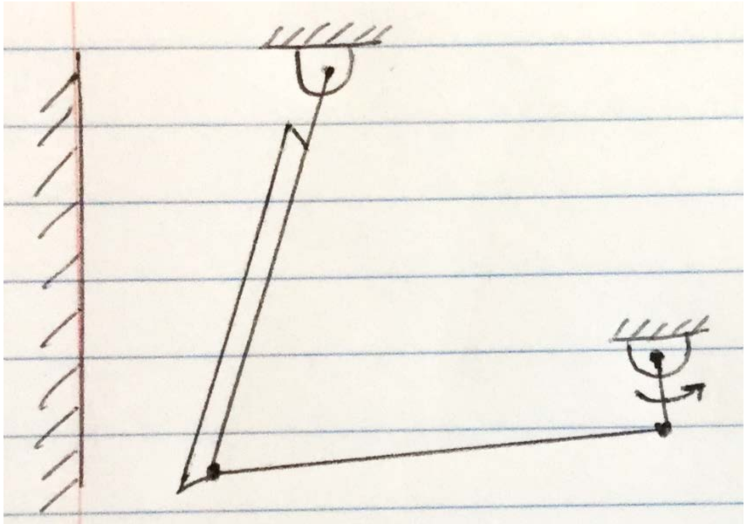


Output link as Crushing link

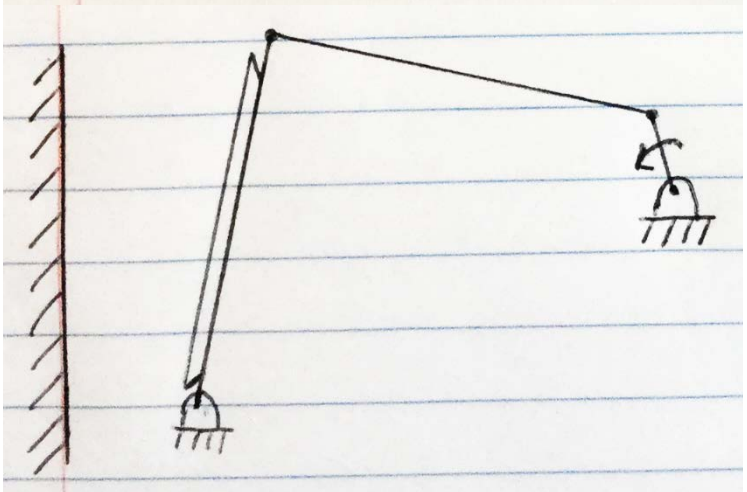


Rocker as Crushing link

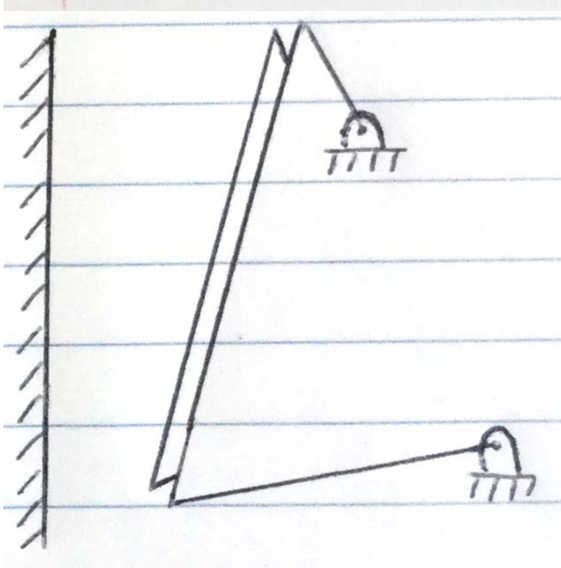
Consideration 1- Geometric constraints:-



Input rock size remains constant, when the mechanism is working. Output rock size governed by extreme positions of Rocker link

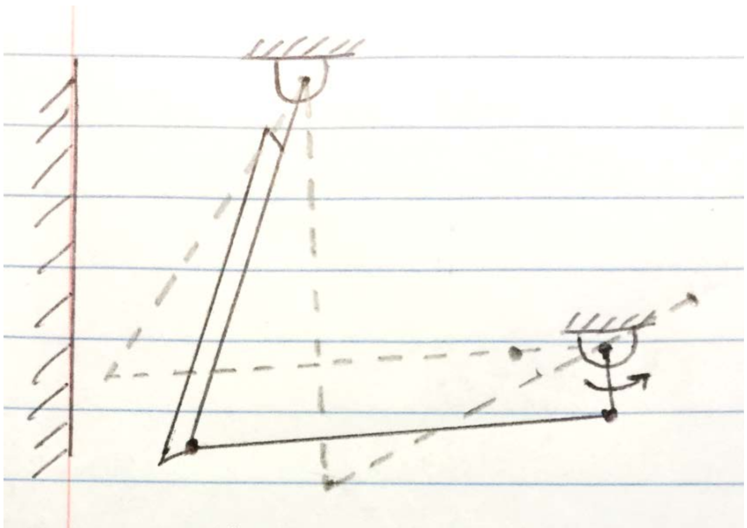


Output rock size remains constant, when the mechanism is working. Input size governed by extreme positions of Rocker link

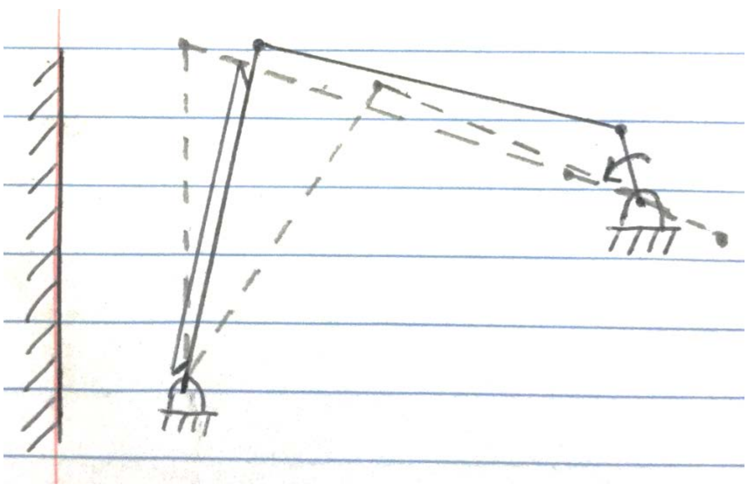


Neither input nor output size is constant. As parameter controlling is difficult, this case is rejected

Consideration 2- Volume crushed:-



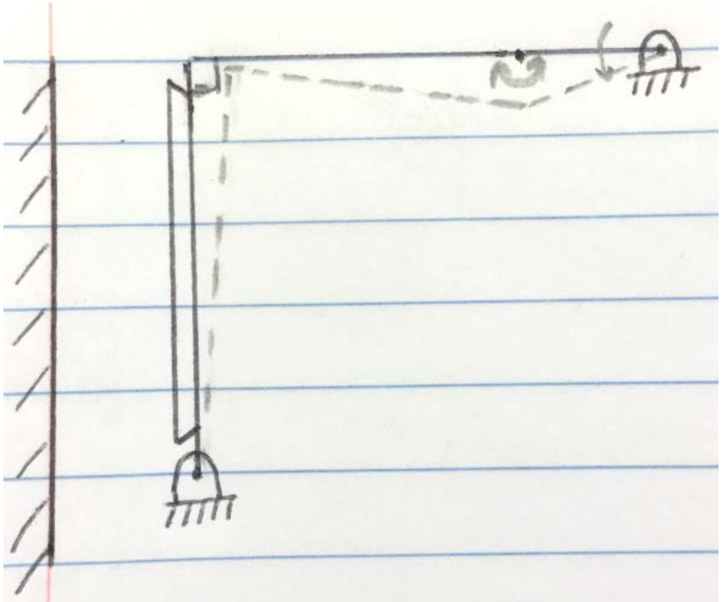
Takes more time as the crushed volume is less. As can be observed, rocks may take more than 1 rocker motions to completely crush a rock. As the other mechanism is better, we reject this mechanism



Takes less time as the volume of crushed stone is more. As can be observed, even the largest of rocks would be crushed in one rocker motion.

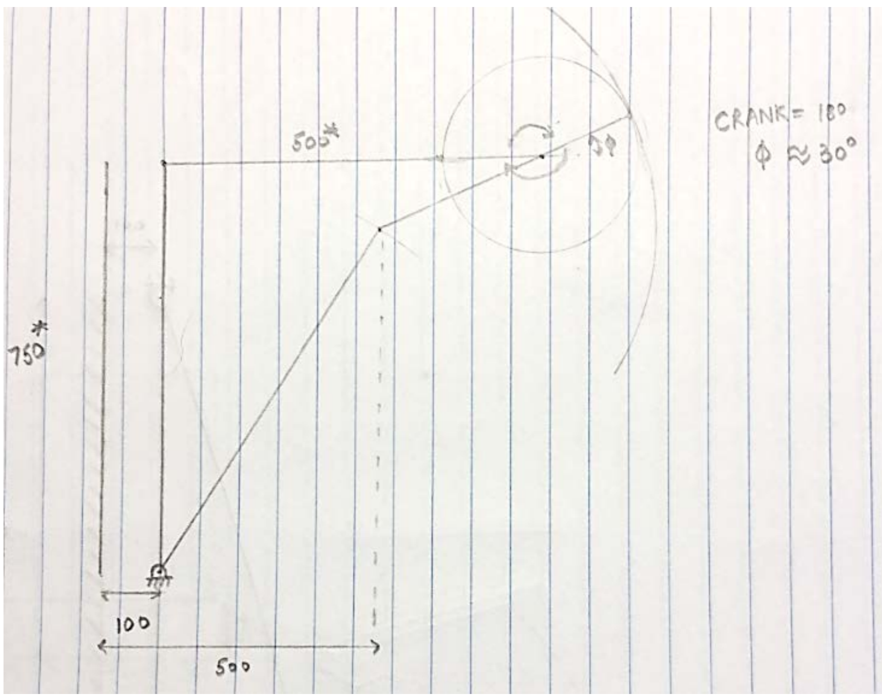
Consideration 3- Transmission angle and Mechanical advantage:-

To impose more constraints on the mechanism for the purpose of easier mechanism generation problem, we make the mechanism have optimal force transmission and mechanical advantage. To achieve this, the Transmission angle has been considered to be 90^{o} at extreme position as it will require maximum force there. Also, the crank is assumed parallel to coupler at extreme position to maximize the Mechanical advantage. The figure of such mechanism is shown below.



Synthesis:-

Thus, Synthesis can be done using graphical method for the mechanism.



Observation- Quick Return

For different values of Rocker and Coupler links, we can generate different linkages according to our conditions

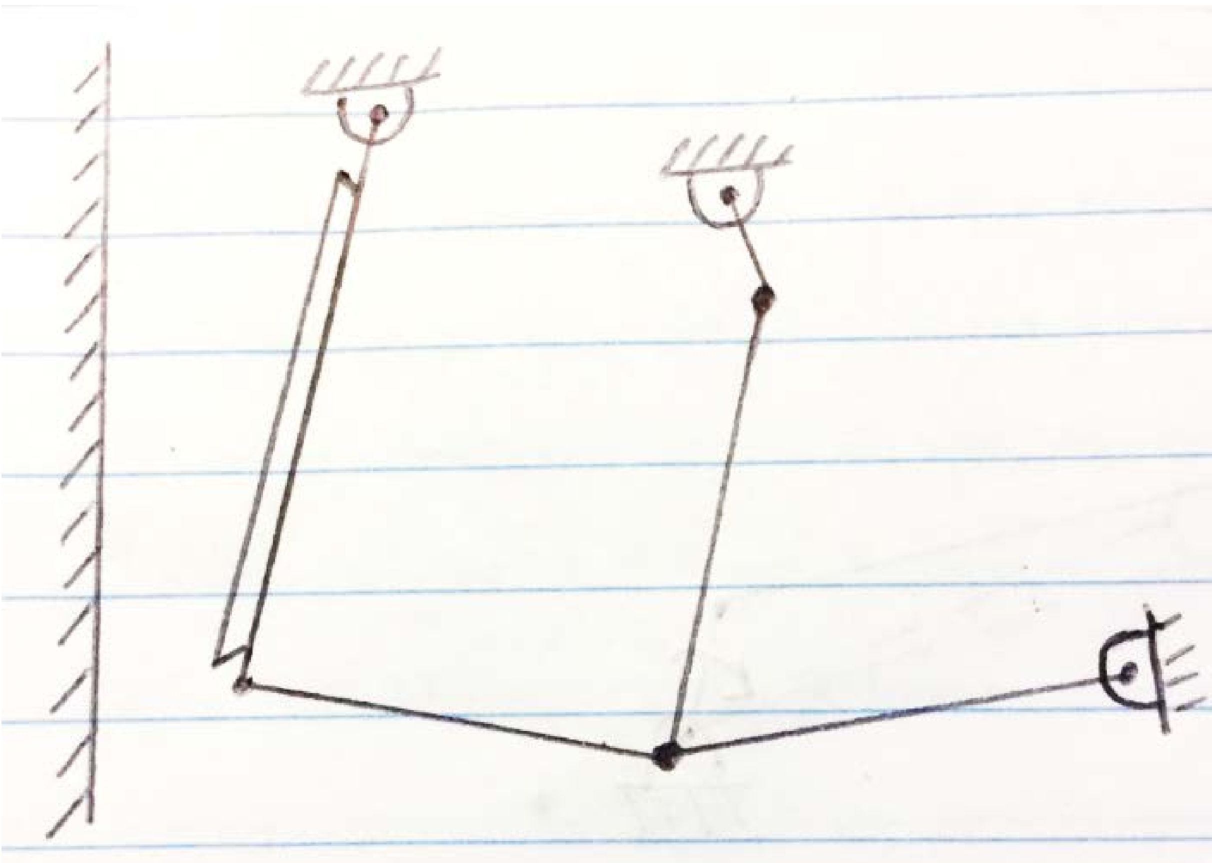
It is observed that the extreme rocker positions are reached at variable crank angles. Thus by choosing anticlockwise rotation of Input, we get a quick return mechanism. This makes sense as we want to spend more time crushing rocks than retracting the coupler.

Results:-

Thus, many mechanisms can be generated for different combinations of Rocker and Coupler links. The best mechanism is the one which has the smallest return time and the largest crushing time. Thus, a "wellness" criteria has been defined to compare many similar mechanism and find the best one.

Systematic Synthesis- Design 3

A double toggle position mechanism can also be synthesized to increase the Mechanical advantage even more. However, dimensional synthesis of this mechanism is a difficult problem and thus this mechanism has not been further discussed in the report.



Conclusion:-

Thus a 4 bar linkage optimized for Stone crushing has been synthesized and a method to find the "Best" possible mechanism has been presented.