

Firewood Processor Design Considerations

Introduction

When a person or company is designing a firewood processor there are many constraints that need to be considered. The design choices made based on the constraints will affect how well the machine operates, how fuel efficient the machine is, the production capacity, and the cost to build the machine.

Production requirements

The first and most important constraint that must be defined is the average annual production volume the machine is to produce for the first three years of operation. If the volume is less than 500 cords per year the actual machine cost will become a limiting factor in having a reasonable production cost per cord. If the production volume is between 500 and 1500 cords per year the productivity and machine cost have about the same effect in production cost per cord. If you plan to process more than 1500 cords per year the productivity of the machine and the handling of the material into the machine and away from the machine will have the biggest impact on the production cost per cord. Our experience has been that even the most automated machine required at least two people at the machine to obtain a consistent production rate. Operating and maintaining a fire wood cutting machine will require a higher skill (higher paid) person than the support person. The labor to operate the machine should be calculated in man hours per cord, then use an average hourly labor rate to determine the labor content per cord.

Defining a cord of wood

The definition of a cord of firewood for this paper is a tightly stacked 4 foot X 4 foot X 8 foot volume of wood cut in 16" lengths. If tree length logs with a 10 inch butt diameter and topped at 3 inches are used it will require about 400 cuts to make a cord of wood. Larger logs will need fewer cuts per cord, smaller wood more cuts per cord.

Understanding the customer's needs and your competition

Understanding the customer's preferred size of finished split wood is important. Many customers do not want wood with a face larger than 6". Offering different lengths of cut may seem like a good idea and the longer the finished piece the less number of cuts, but the splitter must travel further per piece increasing the splitting time. If you have to sell to the 6" maximum face requirement, cutting logs larger than 12" in diameter will require additional splitting. This re splitting can be difficult, unsafe and expensive if the equipment and material flow is not well laid out and properly designed. If you are planning on making firewood production and sales a business, you must understand your competition and the market. In many areas some of the people cutting firewood steal the wood, steal the saw to cut the wood, steal the gas to run the saw and their truck, and sell the wood for just enough to buy their next drug fix. Dry firewood may be worth more to the customer but you will have to inventory it until it is dry and that will require working capital and a place to store it which increases your production costs.

Cutting and splitting basics

Sawing with a chain saw is a variable cycle time process in that it takes longer to saw a 24" diameter log than a 6" diameter log. Splitting is a fixed cycle time process in that it takes about the same time to split a 24" diameter piece as it does to split a 6" diameter piece. Typically the hydraulic pump to run the saw motor must be a fixed displacement type. The splitting pump will be a Hi-low or 2 stage pump or a horsepower limited piston pump to reduce the engine power required to run the splitter. The sawing and splitting do not have to be done at the same time, on or with the same machine, or use the same power source even though this is common practice on some commercial machines.

Moving the log

The raw material can have a major impact on the success of your system. Your log diameter, length, roughness and how much crook are important features to know.

We recommend processing tree length logs or as long of logs as possible to reduce the amount of hand sawing and handling. The last piece of the log is difficult to handle. If your last piece is 30" long and you are cutting 16" long wood it will over balance unless you have another conveyor after the saw or some way to hold it from over balancing. If you are processing 16" long wood with an average diameter of 6" from 20 ft long logs you will have one end cut every 15 pieces or 26 times per cord cut. With 40 ft logs you will only have 13 end cuts to fight with.

Conveying long, rough, crooked wood is very difficult with a chain or belt conveyor. If the log or a knot is contacting the side of the conveyor, the chain or belt may not pull the log. Having tried several different methods of conveying rough crooked logs we found having feed rolls to clamp and move the log the most efficient. With feed rolls you do not have to clamp the log to saw it and the last piece can be easier to manage. If the last piece is rough and crooked or has a broken end it will take extra time to position and could move binding the bar no matter how you hold the log.

It is almost impossible to consistently move rough or crooked wood into a splitter by dropping it, kicking it, or sliding it down an incline. If the grain is at an angle when it starts to split it could bind in the splitter knife and stall the splitting cycle. If you intend on dropping or sliding the cut piece into the splitter be sure to watch it fall and have a way to stop the saw and stop the splitting cycle to straighten the piece when it is out of position. Failure to have a proper method of stopping the conveyor, saw or splitter could cause serious injury!

Sawing the log

There are two primary methods to saw the wood, circle saw or chain saw and there are several chain sizes to consider when using a chain saw. The constraints in this decision are log diameter, production volume, power to run the saw, initial cost and maintenance cost. The log should be held with a hydraulic clamp to be safely cut with either type of saw.

Cutting logs over 18" in diameter and less than 26" in diameter will require a 60" circle saw with at least 50 hp to drive it. An 11 GPM hydraulic chain saw can cut logs up to 36" in diameter with a 17 hp motor driving the hydraulic pump.

A circle saw if properly designed will cut faster with a lower maintenance cost than a chain saw if you need to produce more than 3 cords of wood per hour. The initial facility costs will be much greater as you will need a spare saw blade or two, 25% or greater power just to drive the saw, multiple splitters to handle the wood coming off the saw, a method of handling several incoming truck loads of logs per day, handling and storing 9,000 pieces of split wood per day, then loading and shipping the finished product when dry. If you do not need to produce more than 2 cords per hour then using a hydraulic chain saw will be a better choice as the machine will be less expensive to build and operate. Actuating the saw can be manual with a lever or with a hydraulic cylinder.

Oregon Chain division of Blount, Inc. recommends 50 to 70 pounds of force mid bar when sawing with their harvester products. The chain speed should be between 3000 and 9500 feet per minute with between 10 and 50 hp driving it. Limiting the chain speed to between 4000 and 5000 ft per minute will increase bar and chain life. The speed that the bar moves is somewhat chain speed dependent but cannot be too fast or the chain will stick. Feeding too fast onto a broken or angle cut knot can flip the chain off, stall the chain or cause the chain to wander and stall. Since the sawing feed speed is slower in large wood but the force to push the bar through the cut is the same or more than small wood, feeding the bar with a hydraulic cylinder is somewhat difficult to do effectively. The cylinder speed and or force must be controlled to keep from stalling the chain. There are several methods to do this and each has drawbacks or limitation. Cost of components, actual cutting speed and maintenance cost are some of the drawbacks or limitations. 6K Products has developed a feed modulating valve that changes the feed speed based on the saw motor pressure to make a more positive lower maintenance feed control possible. Some systems use back pressure on the motor outlet to control feed speed and pressure. This will reduce shaft seal life and power to the chain.

The least expensive to build and fastest cutting feed method is to have a lever and move it by hand. In testing done in the late 1970's and early 1980's we found manual feed to be 20% to 50% faster than hydraulic feed. Using our 30G basic saw with a feed roll in feed system we were able to saw 6" diameter X 16" pieces at a rate of up to 20 per minute in green wood.

Splitting the log

Splitting the log after sawing may be required to meet customer expectations. There are many successful splitter designs out there. Do not try making a splitting knife that has holes or windows for the wood to go through. This "French fry" cutter design cannot be made to work. Wood has grain that the split will follow, this grain will not always be the size of your splitting window so the wood will start to compress rather than cut. Once the wood will no longer compress it will either stall out the splitter cylinder or break the knife assembly. If you want to split multiple pieces from a large piece use a star shaped knife that allows the wood to expand as it passes through the blades.

The force to split the log can be reduced by having a vertical blade ahead of the side blades and a 1/2" square bar on the push plate in line with the vertical splitting blade.

The hydraulic cylinder should have an oversize rod if possible to reduce the cycle time. If you use an oversize rod the rating of the control valve must take into consideration the flow coming out of the butt

of the cylinder when retracting, as this will be greater than the flow into the rod side of the cylinder. This flow out of the cylinder may be great enough to require a larger return filter.

Splitting more than 2 cords per hour may be less expensive to do with two splitters and re splitting large wood may be best done with two splitters. How you layout the splitter configuration relative to the sawing can have an impact on the net output of the system.

Conveying the split wood

After the wood is split you will need to get it away from the machine. The production volume, the size and the length of the wood should be considered when determining if and what kind of conveyor is needed. For low production of small wood you may just want to throw the wood into the shipping device or pile it to dry. Loading it into trucks with side board will require an elevating conveyor. For high volume production using a radial stacking conveyor similar to gravel operations may be the best choice. A belt conveyor has the least hang up problems and is the lowest cost to maintain because slivers can get stuck in the chain conveyor sprockets. The conveyor cannot be too steep of a slope or the wood can roll backwards.

Powering the machine

Choosing a method of driving the hydraulic system of machinery is one of the most important decisions you will make. This decision will have upfront costs and cost of operation costs that should be carefully detailed before starting a project. Typically the sawing will require 15+ horsepower to drive the pump, and the splitting can be as low as 2 horsepower if speed is not important, but can take up to 75 horsepower if you want to split a piece every 2 seconds. If you can power the machinery with 3 phase electricity you will have the lowest operating energy cost but the machine will not be portable. For portable applications you may be able to use a tractor, skid steer loader, gas engine, diesel engine or some other piece of equipment. If you choose to tap off an existing piece of equipment, use a gas or diesel engine there has to be a way to set the idle speed so the pump output flow will not change with load more than 10%. Using an automotive gas or diesel engine will require adding an idle speed governor to the engine so the rpm will not drop under load. The engine power required to run the pump should be known in the SAE continuous rating which is similar to electric motor tag power. Most engine literature will have the brake horsepower rating listed. Brake horsepower can be 10% to 40% greater than the continuous rating depending on the engine. Using an auxiliary circuit on an existing machine may be a good choice, providing you understand the limitations this will create when properly designing and sizing the components on the firewood machinery. Using a tractor PTO pump will work if you properly design and size the components on the firewood machinery. Most hydraulic pumps are not designed to be belt driven. This makes direct drive of the engine or electric motor the preferred method. If you are planning on sawing and splitting with one engine or motor you may need a 3 or 4 section pump to run all the functions.

Conclusion

This paper is to provide basic objective information about firewood cutting machine design and is based on the experience and opinions of Ed Danzer and not 6K Products. If you find errors, take exception to statements contained herein, or would like clarification on the content please contact Ed Danzer at 360-

264-2141 or email ed@6kproducts.com . A last word of advice: be careful of what you wish for and good luck, you will need it.