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# Chassis design of skid steer loaders

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**Abstract.** The article provide analyzes the design features of the chassis components and assemblies of skid steer loaders. Describes the various options for frame design, engine layout and hydrostatic transmission. A comparison of the wheel and tracked propulsor used on loaders is given.

## 1. Introduction

Skid steer loaders are widely used in the road construction industry, utilities and agriculture, as well as in other areas due to their compactness, maneuverability and versatility. High accuracy and efficiency when performing working operations is achieved through the use of hydrostatic transmission. At the same time, the change of torque on the wheels and the speed of movement of the loader occurs continuously. The possibility of using in combination with a loader of various attachments significantly expands the functionality of the machine [1].

Currently, many models of skid steer loaders are on the world market. All of them have a similar purpose, however, the design features of individual machines may differ significantly [2].

## 2. Purpose and objectives of design

The purpose of the skid steer loader design is to create a compact machine, capable of effectively and safely fulfilling its function. In this regard, the design solves the problem: the choice of propulsion (wheeled or tracked), the choice of the layout scheme, the selection of units (engine, transmission), the selection of materials for the manufacture of loader parts.

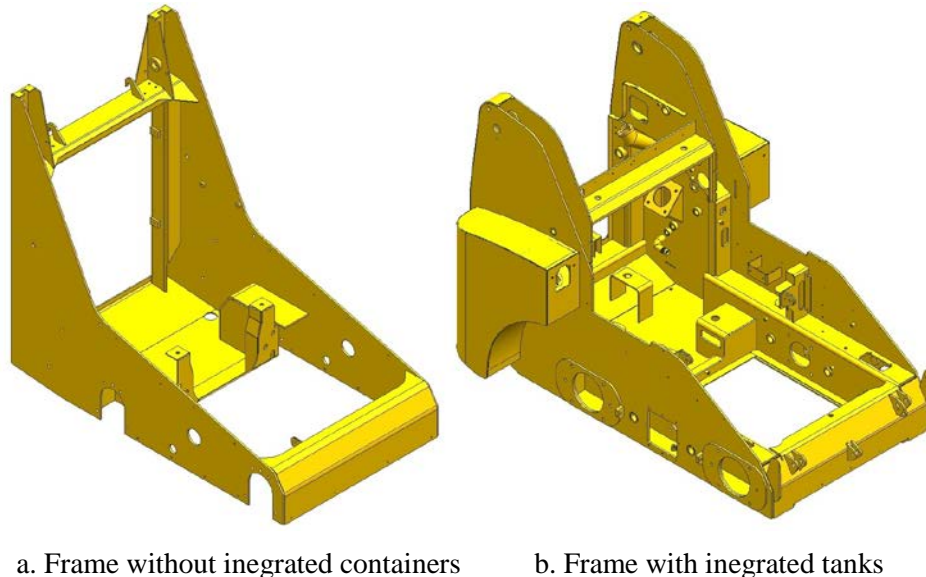
## 3. Frame design

The basis of the chassis loader is a rigid frame, which is a welded construction of sheet steel (Fig 1). The most loaded frame elements have a box-shaped cross section. High strength steel is used for their manufacture. These are side sheets, rear pillars, bottom, front sheet, transverse beams. The choice of the shape and thickness of the frame parts during design is usually determined by calculation using the finite element method [3].

On the frame mounted the components and assemblies of the loader: engine, transmission, boom, cab, running gear, etc. In addition, the frame can serve as tanks for the placement of fuel and hydraulic fluid of the loader (Fig 1, b). In this case, the tanks are welded to the frame sheets. Placing the tanks outside the frame makes the engine compartment more spacious, which has a positive effect on the



maintenance of the engine and its systems, and also makes it easy to place additional optional equipment under the hood (air conditioner, preheater and others).



**Figure 1.** Construction of skid steer loader frame

Maximum tipping load - the characteristic of the loader, which determines its capacity. This load is defined as the weight of the load that is in the bucket or other loading equipment, under the influence of which the rear wheels of the loader will lift off the ground with the longest boom. To ensure a given load capacity, as well as the stability of the loader during operation, the heaviest elements - the engine, fuel and hydraulic tanks - are placed in the rear part of the frame.

#### **4. Engine selection**

Skid steer loaders are equipped with engines that have 30-40% more power compared to similar machines that have steered wheels. This is due to the need to overcome considerable frictional force when performing the bend, especially on a solid basis (asphalt, concrete). The most common on these machines were diesel engines with direct fuel injection. The implementation of modern environmental requirements for the power unit is ensured by the use of the Common Rail fuel injection system, the installation of a diesel particulate filter and other measures. There are also machines with a gas and electric power plant.

Engines for loaders are manufactured by both machine manufacturers and companies specializing in the manufacture of engines (Hatz, Deutz, Perkins, Lister-Petter, Lombardini, Honda, Kubota, Yanmar).

On skid steer loaders, air or liquid cooling engines are used. Preferably the use of diesel engines with a liquid cooling system, as they have a lower noise level, which is important when working in urban environments. In addition, it is possible to install a cheaper dependent loader cabin heater. The radiator installation of such a loader usually includes a monoblock radiator, consisting of two sections: engine cooling fluid and hydraulic system oil cooling. Sometimes a third section is needed - charge air cooling - in the case of using an engine with a turbocharger and intermediate air cooling. The radiator is installed in the back of the loader frame and is blown by a fan mounted on the shaft of the water pump of the engine, driven by the crankshaft. In the case of a transverse engine arrangement, the cooling fan has a hydraulic or electric drive.

To facilitate starting at low ambient temperatures, the engine is equipped with an air charge heater. The heating element is installed in the intake manifold or in the engine cylinders. Also apply fuel

filters with integrated heater. As an option, some manufacturers offer preheaters that run on diesel fuel, or electric heaters, powered by an external energy source.

### 5. Transmission design

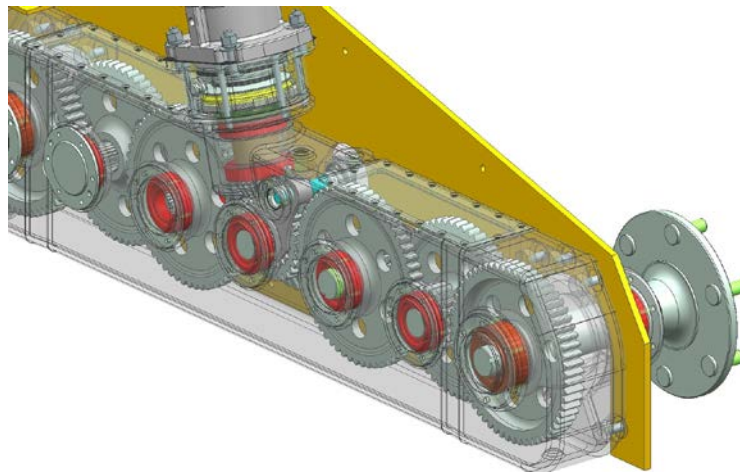
Hydrostatic transmission of loader consists of two hydraulic pumps and two hydraulic motors, forming a running circuit. On modern loaders, axial-piston hydraulic machines with an inclined disk are most often used. Changing the speed and direction of movement of the machine is infinitely variable by controlling the volume of working fluid supplied by the hydraulic pump [4].

The tandem pump is preferably connected to the flywheel of the engine through a friction clutch. The clutch somewhat reduces the dynamic load from the engine to the pumps, and also allows the engine to be disconnected from the transmission. This is necessary when starting the engine at low ambient temperatures. More viscous transmission oil may cause the engine to stop. As the engine warms up, the clutch smoothly turns on, the hydraulic pumps start working, they warm up, after which the loader can begin work.

The option of driving the right and left side pumps through separate shafts is possible. In this case, it is necessary to use a gear distributing gearbox, in which the gear ratio from the engine to the pumps can also be converted. This is necessary if the engine speed does not allow the pumps to create the necessary flow of hydraulic oil to the hydraulic motors. The use of a gearbox also reduces the length of the power unit.

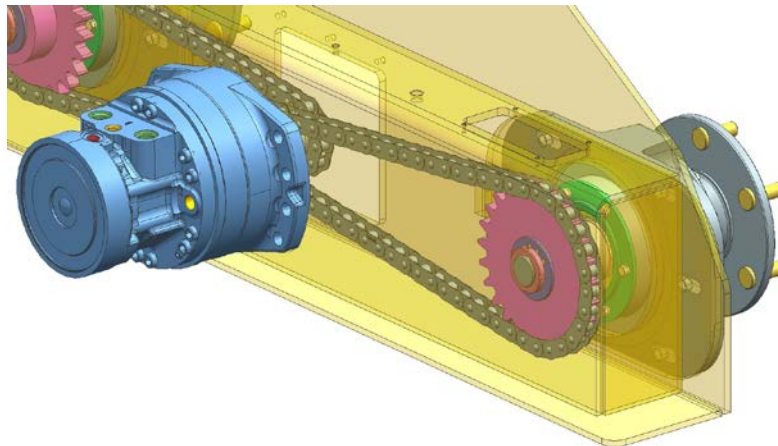
Depending on the torque value, there are "high-torque" and "low-torque" hydraulic motors. The torque on the shaft of "high-torque" hydraulic motors is 10 or more times greater than that of the "low-torque" at the same pressure values in the pressure line. On skid steer loaders, axial-piston or radial-piston hydraulic motors are used.

For transmission of torque to the wheels of one side, a gear onboard gear or chain transmission is used. The onboard gearbox is designed as a separate unit and is attached to the loader frame (Fig 2). It includes 11-13 gears, has a gear ratio of more than 20 and is used in combination with "low-torque" hydraulic motors.



**Figure 2.** Onboard gearbox

In case of using "high-torque" hydromotors, an onboard chain transmission with a gear ratio of not more than 3 will be used (Fig 3). The chain must have sufficient resource comparable to the life of the loader. The drive sprocket is usually made as one unit with the motor shaft. Chain onboard gear can be mounted in the housing, which is part of the loader frame. The wheels are mounted through the hubs, on the shaft of which the driven chain sprockets are mounted.



**Figure 3.** Onboard chain

There are also options to increase the gear ratio through the use of a two-stage chain drive or the installation of planetary gears on the hubs of all wheels.

To lock the wheels of the loader, a parking brake is used that is integrated in the hydraulic motor. There is also a version of this unit as part of the loader side gearbox. The brakes are normally closed and to start driving it is necessary to create a hydraulic oil pressure in the booster to open the friction discs.

The maximum speed of the skid steer loader is usually 12 km/h. However, some manufacturers offer loaders, the transmission of which has two modes: transport and operating. The transport mode is used when the loader moves for fairly long distances along a flat road surface at a speed of up to 20 km / h. The operating mode is used when performing loading operations and other operations performed with attachments. The possibility of using these two modes is achieved by using double-volume hydraulic motors in the transmission of the loader [5].

## 6. Propulsion selection

The most widely used wheel skid steer loaders. The onboard turning process is associated with overcoming significant frictional forces; therefore, multi-layer pneumatic tires with a special tread pattern are used on the loaders. Intensive use of the machine on a hard surface leads to rapid tire wear. Some manufacturers (Michelin, Trelleborg) offer airless tires that have a greater resource. Load in such tires perceive polyurethane knitting needles. They perform the depreciation function. The wheel rim has several layers of steel elements that increase lateral stiffness and improve resistance to damage from shocks and jams of sharp objects. However, airless tires are still more expensive than pneumatic tires.

There are also tracked skid steer loaders, which have a greater maneuverability on soils with a weak bearing capacity. Tracked loaders have a chassis system with track rollers, guide wheels and drive wheels. Such machines have a greater mass and carrying capacity compared to the wheel, they are more stable, so they can work with heavier attachments.

It is also possible to equip the loader with removable tracks that are mounted on tires.

Skid steer loaders do not have suspension. Vibration loads acting on the operator during operation are perceived by the elastic parts connecting the cab to the frame and the loader tires. It is also possible to install a seat with suspension.

## 7. Conclusions

Based on the analysis, it can be concluded that the most rational design of the chassis is the skid steer loader. A modern machine of this type should be equipped with an economical diesel engine of liquid cooling with a power supply system using Common Rail technology, equipped with means to facilitate

starting at low ambient temperature. The engine must have a power take-off shaft for driving the hydraulic pump of the working equipment. The design of the loader frame should provide sufficient space for servicing the engine and its systems during operation, as well as for installing additional optional equipment. Therefore, the most rational is a frame with integrated fuel, hydraulic tanks and onboard gear housings. The loader's transmission should include a tandem-type axial-piston hydraulic pump, high-torque radial-piston hydraulic motors and onboard chain transmissions.

Manufacturers of skid steer loaders regularly launch new models on the market that are more economical and comfortable to operate. Successful competition depends on progressive constructive solutions and technologies introduced at the same time.

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