



Analysis of Cardan Shaft Defects and Ways to Restore Them

Murodjon Iskandarovich Rakhmatov

Senior teacher of the "Automotive and automotive industry" department, Tashkent State Transport University, Tashkent, Republic of Uzbekistan

Sharopov Zavqiddin Zayniddinovich, Boliyev Mansur Tuygunovich

Assistant of the Department "Automobile and automobile industry", Tashkent State Transport University, Tashkent, Republic of Uzbekistan

Annotation: An analysis of possible damage to the cardan shaft of the car was carried out. The main ways of restoring cardan shafts without further replacement of parts are considered.

Keywords: cardan shaft, repair, recovery methods, defects, damage, machine parts.

The driveshaft is an integral part of any car. The design of this mechanism was first described in the 16th century by the Italian engineer Gerolamo Cardano, after whom it was named. In mechanical engineering, the use of a cardan shaft in the 19th century was begun by the French industrialist Louis Renault, using the example of modifying the De DionBouton car. Thanks to the cardan shaft, strong vibrations were eliminated when the car was moving, a smooth ride on uneven roads was ensured, and a soft transmission of torque was ensured. After more than 100 years, the torque transmission mechanism has evolved slightly; however, the design of the cardan shaft assembly itself has changed depending on the model of the car on which it is installed.

The main elements of the cardan shaft mechanism are [1-2]:

- the central shaft is a hollow pipe made of a strong metal alloy;
- the intermediate shaft is necessary for rear-wheel drive vehicles to eliminate vibration that occurs when driving at high speeds;
- the cross is responsible for the rotation of two shafts, the angle of inclination of which does not exceed 20 degrees;
- outboard bearing - fixes and stabilizes the rotation of the intermediate shaft;
- the sliding fork is attached to the central shaft and compensates for the distance between the rear axle and the gearbox;
- intermediate fork - connects the central shaft with the intermediate one;
- An elastic coupling allows you to soften the blows of the driveshaft when deflected while driving.

The main function of the cardan shaft is to transmit torque from the gearbox to the drive axle. The main advantage of this shaft can be considered the ability to operate in off-road conditions, as well as the ability to withstand heavy loads, which is especially important for road construction equipment. The disadvantage of the cardan shaft is its weight, which significantly increases the total mass of the car. It is to reduce the weight of the cardan shaft that a large number of studies are



currently being carried out on the possibility of manufacturing this element from polymer composite materials [3].

Consider the main prerequisites for a shaft failure [1]:

- ✓ oil leaks in the area of the cardan transmission or the front of the cardan;
- ✓ vibration, beating when accelerating;
- ✓ clicks, as well as a crunch at low speeds or at the beginning of movement;
- ✓ hum at various speeds, increasing with acceleration;
- ✓ knocking, bumps after switching on the gearbox;
- ✓ creak;
- ✓ thumps when shifting gears;
- ✓ Ringing in the shaft pipe.

The signs listed above indicate that it is necessary to diagnose the condition of the cardan shaft, identify the problem and choose a method for repairing the damaged part. Below are some types of cardan shaft failures, as well as possible methods for their restoration [5-6].

1. Deformation of the flange-fork of the shaft. Occurs due to exceeding the maximum loads, as well as due to a violation of the technology for extracting the cross, problems with the fastening bolts. In order to avoid repairing the flange, it is necessary to: check the tightness of the bolts, periodically lubricate the hinge elements. One of the traditional ways to restore this defect is to bore the flange with further pressing of repair bushings by welding and final grinding of the part. The modern method of repairing this defect is gas-powder metal surfacing. In this method, a thin layer of metal is applied to the damaged part of the fork flange, at the end, the excess is removed by reamer, bringing the part to its original state. However, in case of severe damage, deep cracks and chips, replacement of the part is necessary.
2. Breakage of the cross of the cardan shaft. Causes: excessive load (permissible torque exceeded), shock load during operation of the cardan shaft. The main ways to restore the propeller shaft cross are:
 - The use of additional material, which involves surfacing, pressing bushings and galvanic build-up. The disadvantages of this method are the high cost and inefficiency due to the weakening of the tightness;
 - Plastic deformation method. This method increases the wear resistance of the surface of the cross. This is achieved by ultrasonic hardening after fine grinding. With the help of a trowel tool, a shock effect on the surface is carried out, as a result, the surface is subjected to plastic deformation.
3. Wear on the end surface of the spike of the cardan shaft cross. Causes: improper installation of the cardan shaft deformed bearing seats, misalignment of the axes of the mounting holes, lack of lubrication (improper maintenance). End surface wear should not exceed 0.2 mm. If the wear is greater, the end face can be restored with chrome plating, however, a more serious deviation from the limit value requires an immediate replacement of the cross.
4. Wear on the outer surface of the propeller shaft cross. This type of failure is not critical if the abrasion diameter is less than 0.02 mm. However, if this value is exceeded, it is necessary to perform air-plasma surfacing, as well as grind the part to obtain the desired size.



5. Rupture of the fork of the cardan shaft. Causes: exceeding the permissible load, shock loads, defect in the cardan shaft cross. The most common fork failures are worn holes or lugs. With minor damage, it is possible to restore the part without replacing the cross. If the surface is damaged, it is first necessary to clean the area to be restored, then metal is deposited on the lugs of the plug using direct current of reverse polarity, and the lugs are brought to their original size by grinding. In case of defects in the fork eyes, it is sufficient to weld the compensating sleeves into the inner surface. A possible way to update parts is gas-powder metal surfacing.
6. Twisting the propeller cardan shaft tube. Causes: exceeding the permissible load, shock load, unacceptable vibration of the cardan shaft. Pipe deformation requires immediate replacement of the part when twisting more than 3 degrees; when the pipe is restored, its physical characteristics are weakened.
7. Rupture of the shaft of the fixed spline connection of the cardan shaft. Causes: exceeding the permissible torque, shock loads. Replacing a splined part when it is damaged is certainly one of the right decisions; however, the high cost of spare parts forces one to resort to restoration methods. There are several ways:
 - tooth spread is suitable for restoring the inner and outer diameters;
 - Spark build-up is recommended for business class machines and is suitable for low wear parts. This method uses chromium sputtering;
 - Another method that uses chromium, but also other metals, is the galvanic method. In this method, damage zones are restored due to the settling, for example, of chromium particles when an electric current is passed through a spline joint located in bath with selected electrolyte. Chrome is used for minor defects; more serious damage is repaired with steel. The advantage of this method is its low cost, but one of the disadvantages is the difficulty in its implementation.

The damages listed in this article are only a small part of the possible breakdowns associated with the cardan shaft. Some defects are so serious that the replacement of parts is necessary for the successful operation of the car. One of the promising ways to increase the durability of cardan shafts is the use of polymer composite materials in their production and repair [2, 8].

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