Combine head mover designing by modern software using

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Abstract. The development of technical solutions without using of modern computer-aided design systems is not possible at the present stage. The using of CAD and CAE systems made possible to reduce costs and save time for development of combine head mover. As a CAD and CAE systems were used KOMPAS-3D and APM WinMachine. As a result of a computational experiment, the minimum weight with the required structural strength and rigidity of the combine head mover design was obtained. Obtained data were the base of combine head mover prototype manufacturing and its successful test.

1. Introduction
The Altay region is one of annual leaders in grain production in Russian Federation. The average annual wheat production in the region is from 4 to 5 million tons. The sown area occupied by grain crops is about 3.5 million hectares. Acute problems of a timely harvesting campaign are inevitable, given such production volumes and relatively low grain yields. Besides unpredictable weather conditions worsen harvesting operations very often. So, depending on the weather, straight-combine or separate-combine method is used. Share of grain sown areas harvested by separate-combine method in the Altai region prevails. So, in some years up to 80% of grain crops are harvested by separate-combine method [1]. Separate-combine method involves using of both combine harvesters and self-propelled windrowers for mowing into windrows. In recent years, combine head movers for transporting headers used to quickly move harvesting equipment from field to field. The combine head mover is towed by a combine or self-propelled windrower and lets header transporting process in a more convenient way compared to header mounted on the harvester. In addition, the combine head mover solves the problem of harvesting equipment moving along public roads.

2. Results and discussion
The object of research is the designing process of combine head mover by using modern domestic computer-aided design and computer-aided engineering systems.

The research subject is the design of combine head mover for headers that have cutting width from 6 to 9 meters and weight of up to 2500 kg for using with Acros harvester and KSU self-propelled windrower produced by Rostselmash.

Engineering and scientific problems solution of developing new equipment and technologies is impossible without modern design and analysis systems today. Such systems called as SAPR in Russia or CAD and CAE in international practice. Computer-aided design and computer-aided engineering systems are considerable part of modern software that made it possible to carry out very significant
volumes of structural design work in a short time [2-8]. Moreover, the developed design is obtained if not optimal, then near optimal according to selected optimization criterion. This work uses the same methods that we have successfully tested when optimizing the front-end loader design [9].

This paper presents designing of combine head mover on the basis of technical enquiry. As CAD system was used KOMPAS-3D [10] and CAE system was used APM WinMachine [11]. The technical enquiry requests to design a domestic combine head mover. The combine head mover design should surpass competitors’ products in cost, structural strength and rigidity.

The first stage of project is blueprint of combine head mover on the basis of existing engineering solutions. The first stage takes into account dimensional specifications of hauling equipment and headers (figure 1).

![Blueprint of combine head mover](image)

**Figure 1.** Blueprint of combine head mover: 1 – chassis frame; 2 – front axle; 3 – rear axle; 4 – towing beam; 5 – tow hook; 6 – header mounting bracket; 7 – pull rod.

The next stage of project is founding of design factors that affect weight, dimensional specifications, structural strength and rigidity. These design factors are rear axle pinning point, header mounting bracket pinning points and profiled bar of chassis frame (figure 1).

The third stage of project is creation of experimental design. The experimental design involved finding the dependence of structural strength on design factors using the second order regression equation. We used a central composite design that based on a two-level factorial design with the addition of 2k points between the axes plus repeat points at the centroid [12-14].

The fourth stage of project is computational experiment implementation. Stress strain and weight of combine head mover were calculated during experimental runs (figure 2).

The fifth stage of project is determination of design factors optimal values. As optimization criterion was used the weight of combine head mover. Optimal values of design factors were obtained by Mathcad software [15].

The final stage of project is combine head mover structural modification in light of optimal values of rear axle pinning point and header mounting bracket pinning points. Also production technology
ability and transportation convenience in unassembled form were taken into account in the final stage.

![Figure 2. Some results of stress and strain calculations.](image)

The preproduction model made according to the research results confirmed the declared characteristics of strength and rigidity (figure 3).

![Figure 3. The preproduction model of combine head mover.](image)
3. Conclusion
The following tasks were solved during the project implementation:
1. The design of combine head mover is developed for using with Acros harvester and KSU self-propelled windrower produced by Rostselmash.
2. The three most significant design factors are found that affect the strength and rigidity of the structure.
3. Optimal values of design factors were obtained that allowed getting the required parameters of strength and rigidity with minimum weight of combine head mover.

4. References
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