KOKKUVÕTE

Antud bakalaureusetöö eesmärgiks oli läbi viia tootearendusprotsess kiirkinnitustega mootorratta pagasiraami projekteerimiseks. Käesolev töö käsitles konkreetselt Suzuki DRZ400S ja DRZ400SM mudelitele pagasiraami projekteerimist, kuid autori hinnangul võib välja töötatud kiirkinnituslahendus laieneda ka paljudele teistele kergenduuro mootorratastele.

Tööd alustati piirtingimuste määratlemisega, millest põhilisemad olid 10 kg kandevõime saavutamine, kohmakate kinnituste vältimine mootorratta küljes ning raami paigaldamise ja eemaldamise tagamine ilma tööriistu kasutamata. Kaardistati ka mootorratta ehitusest tulenevad nüansid, mis raami projekteerimisele teatud piirangud seadsid.

Turul juba olemas olevate lahenduste leidmiseks teostati turuanalüüs, mille käigus ei leitud konkreetsele rattale ühtegi kiirkinnitusvõimalusega pagasiraami. Küll aga andis turul olevate toodete võrdlus olulist infot enimkasutatavate kinnituspunktide, materjalide, pinnakatete ja hindade kohta.

Seejärel loodi kontseptsioonid võimalikeks kiirkinnituslahendusteks. Kaalutud lahendustest kõige sobivamaks osutus autori hinnangul ühes kinnituspunktis lehtmetallist detaili lükkamine poltide peade alla ning teises kinnituspunktis asukoha fikseerimine ostutoodetest vedruga lukustussõrmede abil.

Mootorratta sabaosa mõõdeti kasutades käepäraseid mõõtevahendeid nagu nihik, mõõdulint ja nurgik. Autor tõi välja, et võimalusel tuleks sellise ruumiliselt keeruka objekti mõõtmiseks kasutada 3D-skanneerimist. Mõõtmistulemused kanti tabelisse ning nende põhjal modelleeriti Autodesk Inventor tarkvaraga ligikaudne mootorratta sabaosa CAD mudel. Selle põhjal modelleeriti kontseptsioonide loomise etapis välja valitud kinnituslahendused ja pagasiraami põhiosa. Välja töötatud lahenduses mängis olulist rolli sobiva lukustussõrme leidmine. Vastavalt kasutatud lahenduste piirangutele valiti põhiosa komponentideks 3 mm lehtmaterjal ning 18 x 1,5 mm ümartoru. Raami materjaliks valiti erinevaid parameetreid ja nende olulisust võrreldes roostevaba teras AISI 304.

CAD keskkonnas modelleeritud raamile teostati LEM tugevusanalüüsid Autodesk Inventor Nastran tarkvaraga. Kõige olulisemaks tulemuseks peab autor 5g koormusolukorras, ehk pagasi poolt 490,5 N rakendamisel ja raami enda massile viiekordse raskuskiirenduse määramisel, tugevusvaruteguri 2 saavutamist. Tänu sellele ei pidanud töö autor vajalikuks raami konstruktsiooni optimeerida.

Töö raames toodeti ka kaks prototüüpi, mille käigus ilmnes küll mõningaid tõrkeid tootmise seisukohalt, kuid suudeti paari muudatuse abil täielikult toimiv toode valmis teha. Ühe prototüüpimiseks toodetud raamiga teostati purustav tugevuskatse hüdropressi abil. Katsest selgus, et raami reaalne tugevus oli ligilähedane LEM analüüsidest saadud tulemustega. Plastsed deformatsioonid hakkasid tekkima ligikaudu 1200 N rakendamisel. Tulemuste kontrollimiseks sooritati LEM analüüs, kus eelmainitud jõud rakendatavaks koormuseks määrati. Analüüsi tulemusena saadud maksimaalne pinge 214,1 MPa on väga lähedal raami materjali AISI 304 voolepiirile 215 MPa. Sellest järeldab autor ka eelnevalt sooritatud analüüside paikapidavust. Teise prototüübiga testiti kiirkinnituslahenduse toimivust. Lahenduse töötab autori hinnangul rahuldavalt, kuid paigalduse mugavust annaks optimeerida tootmistäpsuse parandamise teel.

Töö tulemuseks on toimiv prototüüp kiirkinnitatavast mootorratta pagasiraamist, mis on edukalt testitud ja esialgsete omahinna arvutuste põhjal mõistlike kuludega toodetav. Lõputöö jätkuks võiks uuendada tootmisjoonised vastavalt prototüübi tootmisel tekkinud märkustele ning võtta täpsemaks omahinna analüüsimiseks nende põhjal hinnapakkumised suurema koguse tootmiseks.

SUMMARY

The aim of this bachelor's thesis was to carry out a product development process for the design of a motorcycle quick-release luggage rack. This work specifically addressed the design of a luggage rack for the Suzuki DRZ400S and DRZ400SM, but the author believes that the developed quick-release solution could be extended to many other light enduro motorcycles.

The work began by defining boundary conditions, the most important of which were to achieve a load capacity of 10 kg, to avoid big and rough attachments to the motorcycle and to ensure that the frame could be installed and removed without the use of tools. The nuances arising from the construction of the motorcycle were also mapped, some of which placed certain restrictions on the design of the frame.

In order to find solutions that already existed on the market, a market analysis was carried out, during which no luggage racks with a quick-release option were found for this specific motorcycle. However, a comparison of the products on the market provided important information on the most commonly used fixing points, materials, surface coatings and prices.

Concepts were then created for possible quick fix solutions. According to the author, the most suitable of the considered solutions was pushing a sheet metal part under some bolt heads at one fastening point and fixing the location of the frame with spring loaded pins at another fastening point.

The tail section of the motorcycle was measured using handy measuring tools such as a caliper, tape measure and a 90-degree angle. The author pointed out that, if possible, 3D scanning should be used to measure such a complex object. The measurement results were tabulated, and an approximate CAD model of the motorcycle tail section was modeled using Autodesk Inventor software. Based on this model, the fastening solutions selected during the concept development phase and the main part of the luggage frame were then modeled. Finding a suitable locking pin played an important role in the developed solution. According to the limitations of the used solutions, 3 mm sheet metal and 18 x 1,5 mm round tube were chosen for the main components of the frame. Different parameters and their importance were compared and stainless steel AISI 304 was chosen as the frame material.

FEM strength analysis was performed on the frame modeled in the CAD environment with Autodesk Inventor Nastran software. The most important result is that a safety factor of 2 was achieved in 5g load situation when 490.5 N is applied by the luggage and the weight of the frame is multiplied by five with the acceleration of gravity. Due to this, the author of the work did not consider it necessary to optimize the construction of the frame.

Within the framework of the work, two prototypes were also produced, during which some defects in production were revealed, but with the help of a few changes, a fully functional product was put together. One prototype was subjected to a destructive strength test using a hydraulic press. The experiment showed that the actual strength of the frame was close to the results obtained from the FEM analysis. Plastic deformations began to occur with the application of approximately 1200 N. To verify the results, a FEM analysis was performed, in which the aforementioned force was set as the applied load. The maximum stress of 214.1 MPa obtained from the analysis is very close to the yield strength of 215 MPa of the frame material AISI 304. From this, the author also concludes that the previously performed analyses are valid. The second prototype was used to test the performance of the quick-release solution. According to the author, the solution works satisfactorily, but the convenience of installation could be optimized by improving the production accuracy.

The result of the work is a working prototype of a quick-release motorcycle luggage rack that has been successfully tested and can be produced at a reasonable cost based on the initial cost calculations. As a continuation of work, the production drawings could be updated according to the remarks made during the production of the prototype, and for a more detailed analysis of the net cost, quotations to produce a larger quantity could be taken.