KOKKUVÕTE

Käesoleva bakalaureusetöö raames tutvus töö autor pöördsilindri ja selle komponentidega, et paremini mõista kriitilisi aspekte toote iseärasustest lähtuvalt. Peale detailidesse süvenemist uuriti suulise intervjuu kaudu kliendi vajadusi antud toote omaduste suhtes, mis on antud töö üks olulisemaid lähtepunkte. Järgnevalt analüüsiti ka hüdrosilindrite testimiseks loodud ettekirjutusi ISO standardi näol, mis paneb paika täpsed reeglid ja nõuded silindrite testimiseks. Ühtlasi pöörati antud töö koostamisel tähelepanu ka olemasolevate lahenduste leidmiseks patendiuuringute näol, kuid kasutatud otsingusõnade hulgast piisava sarnasusega patente tuvastada ei õnnestunud. Enne toote tehniliste nõuete formuleerimist vaadeldi ka alternatiivseid keevisliite kontrollimise meetodeid, mis autori hinnangul osutusid kliendiks oleva tootmisettevõtte seisukohalt nii majanduslikult kui ka testimisstandardist lähtuvalt ebapraktiliseks ja nõuetele mitte vastavaks. Eelmainitud etapid olid aluseks toote tehniliste nõuete formuleerimiseks, kus määratleti testitavast objektist lähtudes nõuded ja mõõtmed loodavale tootele. Peale lähtepunktide defineerimist tükeldati antud lõputöös käsitletav probleem osadeks, mis kirjeldavad toote loomise erinevaid elemente ja mõttekohti, mis nõuavad lahendamist. Järgmise sammuna otsiti lahendusi peaprobleemi alamprobleemidele ning kombineeriti seejärel erinevateks kontseptsioonideks, mis võimaldaksid täita eesmärgi, milleks on pöördsilindri hülsi testimine. Loodud kontseptsioonidest valiti töö autori subjektiivse hindamismaatriksi põhjal idee, mida hakatakse edasi arendama ja terviklikuks muutma. Selleks, et kontrollida, kas lahendusega ollakse teostataval ja sobival teel küsiti valitud kontseptsioonile tagasiside ka ettevõttest. Peale ettevõttest heakskiidu saamist alustati toote konstrueerimisega, mis hõlmas endas tekkivate jõudude analüüsimist, ostutoodete valikut ning tüüplahenduste genereerimist. Tekkivate jõudude analüüsimisel selgus, et suurima diameetriga hülsi testimisel tekkiv jõud ulatub ligikaudu 310kN-ni, mis tekitas kaks probleemkohta. Esiteks tekkisid esialgses kontseptsioonis ebavajalikud jõumomendid, mis oleks rakise mõõtmeid ebavajalikult suurendanud. Sellest lähtuvalt viidi kontseptsiooni muutes kõik tekkivad jõud ühte tasapinda. Teisalt valituks osutunud kontseptsioonis kasutusel olev treipingi padruni kriitilist telgjõu suurust tootjapoolne info ei kajasta. Sellest lähtuvalt tuli välja mõelda, kuidas saaks padrunit kasutada nii, et telgjõud ei rakenduks padruni pakkidele. Selle tulemusena jõuti ideeni keerata padrun teistpidi ning kasutada jõudu vastu võtva elemendina raami plaati ja vahetatavat puksi, mille sisediameeter on erinev vastavalt hülsi välisdiameetrile. Raami geomeetria valimiseks modelleeriti erinevaid ideid ning valiti autori hinnangust lähtudes sobivaim. Raami vastupidavuses veendumiseks analüüsiti seda SolidWorksi LEM-i mooduli abil, kus vastavalt tekkivatele pingetele viidi sisse vastavad muudatused, mis vähendaks

tekkivaid pingeid raamis. Lisaks raamile on valitud kontseptsioonis kasutusel ka varras ja kolb. Varda valimiseks ja dimensioneerimiseks analüüsiti selle tugevust nõtkest lähtuvalt. Lähtuvalt suurimast võimalikust telgjõust jõuti varda lubatud diameetrini, milleks on 50 mm – sellest lähtuvalt valiti ka ostutootena toorikuks trapetskeermega latt Tr 60 x 9. Varda lubatud diameetrist lähtuvalt ei ole võimalik testida pöördsilindri hülsse, mille sisediameeter seda ei võimalda. Kolvina kasutatakse ettevõttes laialdaselt kasutusel olevat tüüpkolvi lahendust, mis on vahetatav ja vastab testitava hülsi sisediameetrile. Järgmiseks probleemkohaks oli varda kinnitamine raamile nii, et tugevus oleks tagatud. Selle lahendamiseks kasutati spetsialistiga konsulteerimise tulemusena trapetskeermega mutreid, mis on raami külge keevitatud. Toote konstrueerimise viimase etapina kirjeldatakse lahti toote ohutuse ja kasutamisega seonduvad aspektid. Peale toote konstrueerimist lähtuvalt tehnilistest nõuetest modelleeriti vajalikud detailid ning vormistati tööjoonised. Töö viimane peatükk annab ülevaate tootele kujunevast omahinnast ning hindab subjektiivselt selle tasuvust. Toote omahinnaks kujunes antud lahenduse jaoks 3393,57 €, mille tasuvusaeg hinnanguliselt on 0,7 aastat.

Antud bakalaureusetöö tulemusena valmis terviklik lahendus pöördsilindri erinevas läbimõõdus hülsside testimiseks, kus on arvesse võetud erinevaid kriteeriume. Probleemi lahendamisel on läbi mõeldud ja analüüsitud erinevaid nõudeid loodavale tootele. Loodud lahendust on hinnatud majanduslikust aspektist. Eelmainitu põhjal saab järeldada, et töö autori püstitatud eesmärgid on lõputöö raames täidetud.

Käesoleva töö autor leiab, et saadud tulemus on reaalses elus teostatav ja piisavalt läbi mõeldud, kuid kindlasti on tootearendus pidev protsess ning kindlasti on võimalik antud probleemi lahendada ka teisiti ja optimaalsemalt. Tuleviku perspektiivis saaks antud ideed kindlasti edasi arendada. Veelgi parema lahenduse saamiseks vajaks lahendamist probleem seoses väiksema mudeli testimisega – kuidas lahendada konstruktsioon nii, et varras saaks olla piisavalt väikese diameetriga, võimaldades testida ka kõige väiksemat hülssi. Teisalt on üks võimalik edasiarendus tsentreerimise lahenduse muutmine majanduslikult soodsama vastu.

Kokkuvõttes saab öelda, et esmapilgul lihtsana tunduv probleem võib osutuda palju keerukamaks kui arvata võib. Teisalt on keeruliste probleemide lahendamine hariv ja põnev väljakutse. Töö autori arvates oli antud bakalaureustöö erialaselt silmaringi laiendav ning õpetas erialaseid teadmisi kombineeritult kasutama.

SUMMARY

In this bachelor's thesis, the author got acquainted with the slewing cylinder and its components to understand the critical aspects based on the specifics of the product. After investigating details, the customer needs for the characteristics of the given product were investigated, which is one of the most important starting points for this work. Next, the prescriptions for testing hydraulic cylinders were also analyzed based on the ISO standard, which sets precise rules and requirements for testing hydraulic cylinders. At the same time, existing solutions in the form of patent research were investigated, but it was not possible to identify patents with similarity according to the search terms used. Before formulating the technical requirements of the product, alternative methods for cylinder testing were analyzed, which in the author's opinion are impractical from the customer's point of view economically and according to the testing standard. The above-mentioned steps were the basis for formulating the technical requirements of the product, where the requirements were defined based on the testing object. After defining the starting points, the solvable problem in this thesis was divided into parts that describe different elements of product creation and ideas that need to be solved. The next step was to find solutions to the sub-problems of the main problem and then combine them into different concepts that would allow to fulfill the goal of testing the slewing cylinder hollows. Based on the author's subjective evaluation matrix, one concept was chosen from the created concepts, which will be developed to the final solution. In order to check whether the solution is realistic and suitable, the feedback from company was also asked for the chosen concept. After receiving approval from the company, the design of the product began, which included the analysis of the forces involved in the concept, the selection of purchasable products and the generation of standard solutions. The analysis of the involved forces revealed that the force, which is generated when testing the largest diameter hollows reaches approximately 310 kN, which caused two problems. Firstly, the original concept generated unnecessary moments of force that would have unnecessarily increased the dimensions of the testing fixture. According to moments of force the concept was changed, all the forces were brought into one plane. On the other hand, the critical axial force of the lathe chuck used in the chosen concept is not shown in the information provided by the manufacturer. Based on this, it was necessary to think about how the lathe chuck could be used so that the axial force would not be applied to the jaws. As a result, the idea was to turn the chuck upside down and use a frame plate and a changeable bushing with an inner diameter according to the outer diameter of the hollows as a force-receiving element. In order to select the geometry of the testing fixture, different ideas were modeled and the most suitable one was selected based on

the author's opinion. To ensure in the durability of the frame, it was analyzed using the SolidWorks FEM module, where corresponding changes were made according to the resulting stresses. In addition to the frame, the selected concept also uses a rod and a piston. To select and dimension the rod, its strength was analyzed for buckle. Based on the maximum possible axial force, the permissible diameter of the rod was found, which is 50 mm - based on this, the trapezoidal thread bar Tr 60 x 9 was also chosen as a purchaseable product. Due to the permissible diameter of the rod, it is not possible to test hollows of a slewing cylinder which inside diameter does not allow it. The type of piston used is a widely used standard piston solution in the company, which is changeable and corresponds to the inside diameter of the hollows. The next problem was attaching the rod to the frame so that the strength was guaranteed. To solve this, trapezoidal thread nuts welded to the frame were used as a result from consultation with a specialist. As a final step in the design of the product, aspects related to the safety and use of the product are described. After construction of the product, the necessary details were modeled based on the technical requirements and technical drawings were made. The last chapter of the work gives an overview of the product price and subjectively evaluates its profitability. The price of the product for this solution was € 3393,57 with an estimated payback period of 0,7 years.

As a result of this bachelor's thesis, a complete solution for testing hollows of different diameters of slewing cylinders was achieved, accorded to different criteria. In solving the problem, various requirements for the created product were analyzed. The created solution has been evaluated from the economic aspect. On the basis of above, it can be concluded that the goals set by the author of the thesis have been achieved. The author of this work finds that the obtained result is realistic, but product development is definitely continuous process and it is certainly possible to solve this problem in a different and more optimal way. In the future, this idea could certainly be further developed. To get more developed solution, it is necessary to solve the problem of testing a smaller model - how to solve the design so that the rod can be small enough in diameter allowing the smallest hollows to be tested. On the other hand, one possible further development is to make the centering solution more economically advantageous. In conclusion, it can be said that a problem that seems simple at first look can be much more complicated than you might think. On the other hand, solving complex problems is educational and exciting challenge. According to the author of the thesis, this bachelor's thesis was broadening the mind and taught how to use professional knowledge.