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APPLICATION OF "METHOD FOR TOTAL AND PARTIALS PRODUCT'S SUITABILITY DETERMINATION" AT PRODUCT "ACTUATOR"

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ABSTRACT:
The task of "Hydraulic Actuator" is moving of the artificial leg of invalid persons. It bends the artificial leg in the knee. The invalid person can climb up the stairs with it. The Actuator is designed for function and working load. "The Method for Total and Partials Product's Suitability Determination" is applied at the product in this paper. The application is done for the Actuator design improvement in the mining of easier and chipper production, maintenance, exploitation and recycling.
Keywords: Design for Manufacturing, Assembly, Exploitation, Maintenance and Recycling

1. INTRODUCTION

The hydraulic actuator is posted in the artificial leg "Endolite" (figure 1. and 2. [1]). The actuator is designed for working load and for function of artificial leg movement (bending of the leg in knee and extending in specific moment). The drawing of actuator is in the figure 3. The actuator is in the designing phase, so this is god moment to explore his suitability (manufacturability, assembliability, recycleability etc). The design improvement will be very important, if we will have serial production. By reason of that "the Method for Total and Partials Product's Suitability Determination" will be applied at the actuator. The Method procedure is explained in [7], its mathematical model in [8] and software for method called Manufacturability in [9].

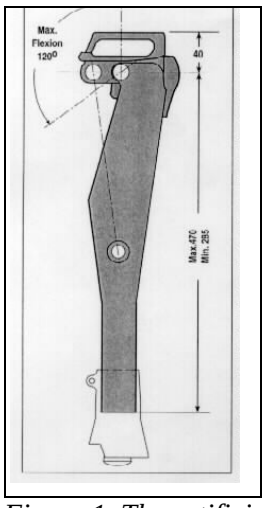

Figure 1. The artificial leg "Endolite" [1]

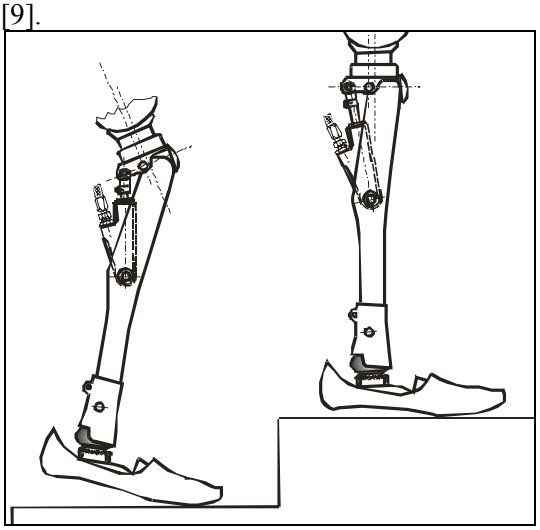

Figure 2. The actuator in the artificial leg [1]

2. THE METHOD APPLICATION'S RESULTS

"The Method for Total and Partials Product's Suitability Determination" is applied at product and the given results are shown in the Table 1, in column "values before design changes"

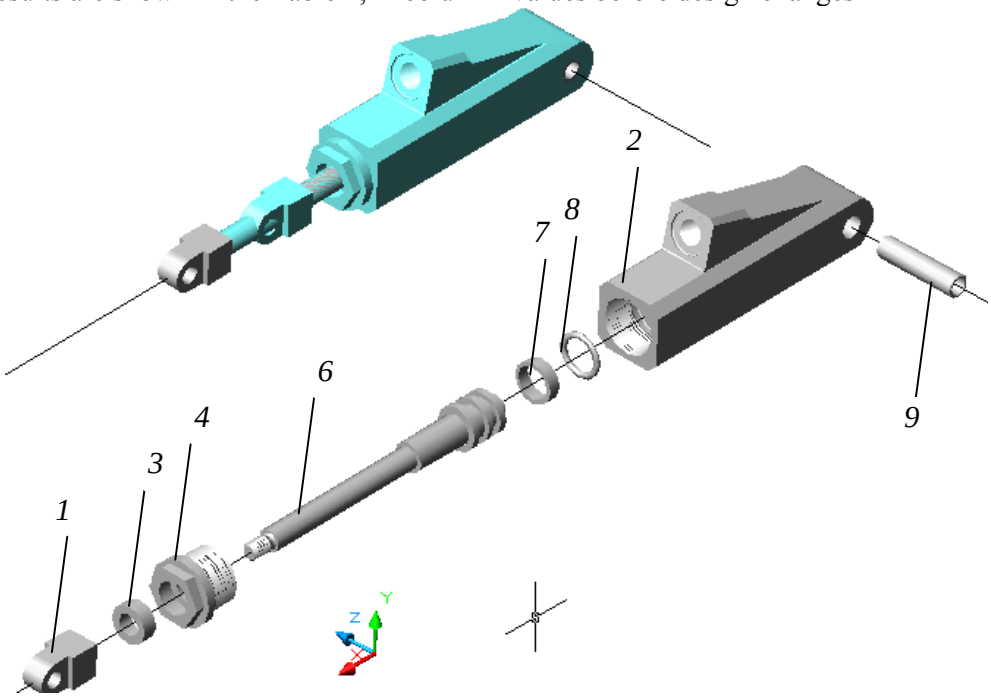

Figure 3. The actuator appearance with parts.

Table 1. Values of "Actuator" before and after design changes

	values before design changes [%]	values after design changes [%]
total suitability of product T_u	70,40	72,96
manufacturability T_i	65,63	69,37
manufacturability of whole product T_{ip}	56,33	62,08
manufacturability of product's parts T_{id}	76,44	77,53
assembliability T_m	84,66	84,66
assembliability of whole product T_{mp}	83,83	83,83
assembliability of product's parts T_{md}	85,51	85,51
exploitability T_e	75,31	81,41
exploitability of whole product T_{ep}	76,35	89,21
exploitability of product's parts T_{ed}	74,28	74,28
maintenanceability T_o	62,52	62,85
maintenanceability of whole product T_{op}	54,71	55,30
maintenanceability of product's parts T_{od}	71,44	71,44
recycleability T_r	60,18	63,39
recycleability of whole product T_{rp}	61,46	67,60
recycleability of product's parts T_{rd}	58,92	59,34

The next influence parameters have got low values during analyse:

a) The influence parameter "materials of product's parts are uniformed", which influence at parameter "manufacturability of prescribed materials in product" of whole product manufacturability T_{ip} has estimation 0,1. Because all six non-standard parts have different material.

b) The influence parameter "product will be able to satisfact the users in the future", which belong to the exploitability of whole product T_{ep} has the estimation 0,1. The part "eye" (position 1 in figure 3.) is connected for "piston" (position 6) with thread. At the other side, the "eye" is connected with axe for artificial leg (fig.2.). The connection disables rotation of "eye" around self-axe and the

unscrewing with respect to the piston. However, the piston can rotate around self-axe. The piston can unscrew from the eye after long period of exploitation and large number of piston movement cycles.

c) The influence parameter "participation of same material in product", which influence at parameter "participation of parts whose material can be recycled or used for energy production" of whole product recycleability T_{rp} has the estimation 0,1. The reason is the same as above mentioned parameter a).
d) The influence parameter "the part's manufacture is reasonable in production system" which belong to the parameter "manufacturability of part's configuration" for part 2 – "actuator's body" of product's parts manufacturability T_{id} has value 0,1. The reason for this estimation is part's geometrical shape, which is very complicated (fig. 3). So it is very difficult for machining, even using CNC mill machine.
e) The influence parameter "cones and contours are avoided in the interest of rectangle shapes", which is included in parameter "manufacturability of part's configuration" for part 2 – "actuator's body" of product's parts manufacturability T_{id} has value 0,1. The reason is the same as above mentioned parameter d).

3. RESULTS' ANALYSE

It is necessary to perform analyse of the reasons for the parameter's lower estimates. The aim is improve the product's suitability.

a) Every each non-standard part is made from the different material, according the design documentation. The part actuator's body is from aluminium alloy AlZn5Mg1, because it must be light. so, the material of this part can't be changed. Also, the material for the part "spring" (position 5) can't be changed, because the spring have to be from elastic material, like Č.4230. the other parts: eye (position 1), flap (4), piston (6) and bush (9) can be manufactured from the same material. For example it can be steel. Č.1530., which have relative high R_m [2] and it is cheap. The value of parameter "materials of product's parts are uniformed" increases on 0,7 with this change.
b) The thread connection eye – piston must be insured of unscrewing. It can be done in different way [3]. We can simply lock by split pin (DIN 94, JUS M.B2.300 [3]). It is shown in figure 5. With this the product gives another part, but it is standard and very cheap part. So, this change of design won't much decrease suitability of product. The change will increase value of parameter "product will be able to satisfact the users in the future" from 0,1 on 0,7 and T_{ep} so.
c) The influence parameter "participation of same material in product", which influence at parameter "participation of parts whose material can be recycled or used for energy production" of whole product recycleability T_{rp} now gives the value 0,7 by reason of the design change above mentioned in a).
d) The part 2 – actuator body has complicated geometrical shape: radius 3,5 mm (fig. 6.a)) need to be avoid, because the diameter ø7mm isn't standard for milling cutters and it is difficult to made. Also, the chamfer of face 45° (marked with arrow in figure 6.a)) need to be avoid. The new part's shape is shown in figure 6.b). The new shape is easier for machining with CNC milling machine. The value of parameter "the part's manufacture is reasonable in production system" is increased at 0,5 with this. The unit time norm for part's production is lower for 22,71 min than before this design changes. For serial production of 3000 pieces (planed production for "Actuator") saving of time is 68130 min or 1135,5 working hours. If we have shift work and the shift has 7,5 h, the saving is 151,4 shifts. If we have 3 shifts at day, the saving is 50,47 working days. This data illustrate clearly how we can save with increasing the suitability of product, i.e. using "The Method for Total and Partials Product's Suitability Determination".
e) The value influence parameter "cones and contours are avoided in the interest of rectangle shapes", which is included in parameter "manufacturability of part's configuration" for part 2 – "actuator's body" of product's parts manufacturability T_{id} has value 0,1 now, by reason of the above mentioned design change in d). The complicated contours are avoided as possible.

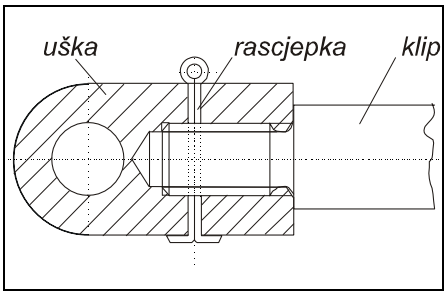

Figure 5. The thread connection eye – piston is locked by split pin

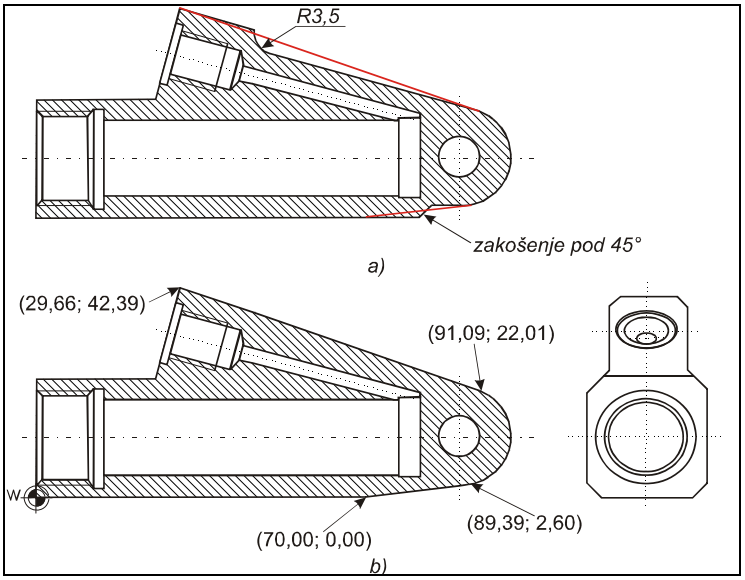

Figure 6. Improving of part 2 geometrical shape – - actuator's body: a) old shape, b) new part's shape

The above mentioned design changes will increase partial suitabilities: T_{ip}, T_{id}, T_i; T_{ep}, T_e; T_{op}, T_o; T_{rp}, T_{rd}, T_r. The total suitability of product T_u is increased from 70,40% to 72,96%. Table 1 shows the product's suitabilities before and after design changes.

4. CONCLUSION

There are three suggested design changes during analyse of the actuator. The changes increase for a little the total suitability of product from 70,40% to 72,96%. However, we have better variant of product using "The Method for Total and Partials Product's Suitability Determination". The difference between the unique time norm of part "actuator's body" before and after design changes shows how much we can save with increasing the product's suitability. This saving is explained in the part 3 d) of this paper. Recycleability T_r is the lowest of every partial suitabilities (T_r=60,18%). T_r is increased on 63,39% using design changes. The conclusion is: the product "actuator" is very god designed in the meaning of suitability and the design changes (obtained using "The Method for Total and Partials Product's Suitability Determination") in this paper improve it. It is needed to use the design changes, if we have serial production.

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