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PROCEDURE OF UNIVERSAL GEAR UNITS ADOPTION

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ABSTRACT:
Universal gear units are simple products, which are often used and embedded in many types of constructions, machines and vehicles in mechanical engineering, civil engineering, transportation and many other fields of industry. Because of technical and economic reasons, it is very important to adopt proper and optimal gear unit. There are three ways of gear units adopting and they are explained in this paper.

KEYWORDS:
Universal gear units, adoption, technical characteristics

1. INTRODUCTION

Universal gear units represent a rather simple group of products, which are being produced for a long time period, which are developed almost to the perfection and which are almost well known in detail. Therefore, the procedure of their adoption, mainly, shouldn't be a problem, but is everything so easy?

2. PROBLEM DESCRIPTION

When gear units adoption is talked about, it has to be emphasized that there are at least three different ways of adopting:

1. Adoption which is done by purchaser of gear units, using catalogues of already defined manufacturer. Adoption procedure is precisely determined by manufacturers in their catalogues, so practically no problem can occur by this way.
2. Adoption which is, also, done by purchaser of gear units, but from the gear units market offer, without previously defined manufacturer. This adoption way is rather complicated and it is very little treated in the literature, but usually as economic category.
3. Adoption which is carried out by gear units designers in order to select optimal design solution. This adoption procedure is also poorly treated in literature, so that this paper would try to treat that problem more detailed on this place.

3. GEAR UNITS ADOPTION USING MANUFACTURER'S CATALOGUES

Gear units manufacturers, through their catalogues, provide detailed instructions for adoption and mounting of their products, and the customers and purchasers should comply with them when adopting gear unit. Mainly, in the frame

of required speed ratio it is necessary to adopt that gear unit which satisfy the condition:

$$T_N \geq f_B \cdot T, \tag{1}$$

ie. the output torque – load capacity of gear unit (T_N) should be greater than product of service factor (f_B) and operational torque (T), as it is shown on Fig. 1.

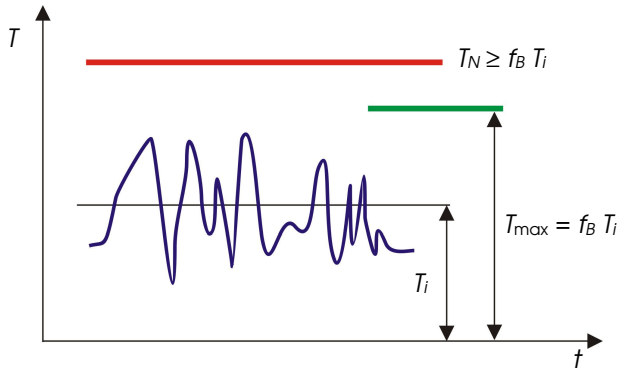

Figure 1. Gear Units Torque Diagram

In the frame of necessary motor power and required revolution number of motor gear units, the adopted gear unit has to satisfy the condition that value of permissible service factor is greater than necessary value, ie.:

$$f_{BD} \geq f_B \tag{2}$$

After that, it is required that existing overhang loads at the gear unit shaft have to be smaller than permissible values of overhang loads:

$$F_{Rexis.} \leq F_{Rperm.} \tag{3}$$

$$F_{Aexis.} \leq F_{Aperm.} \tag{4}$$

and also, transmitted power (P) have to be smaller than, so called, thermal capacity of gear unit (P_Q), ie. the following condition has to be satisfied:

$$P \leq P_Q \tag{5}$$

Manufacturers of gear units always consider this condition when they compile their catalogues, and if the condition is not satisfied for particular gear unit, that gear unit can not be shown in the catalogue.

Some gear units manufacturers indicate the maximum temperature up to which their gear units can be exposed:

$$\theta \leq \theta_{perm.} \tag{6}$$

or they indicate permissible vibrations up to which their gear units can be exposed:

$$v \leq v_{perm.} \tag{7}$$

or they refer the customers to the standards which regulate these fields.

Therefore, there is no bigger problem when adopting gear unit from the catalogue.

4. GEAR UNITS ADOPTION IN THE FRAME OF OFFERED PRODUCTS ON THE MARKET

Gear units adoption from the offer of different gear units manufacturers is very interesting problem. Because of previous positive experience, good business relationships, possible discounts etc., purchasers of gear units are oriented to particular provider and manufacturer. Therefore, selecting particular manufacturer is rather simplified. It is very rarely that the same customer buys particular types and dimensions from one provider, and other types and dimensions of gear units from other provider. Usually, it is about related commerce, and some recommendations about gear units adoption are not able to do anything, but they could. From the economic point of view and if technical parameters are satisfied, price of gear unit is crucial factor when adopting gear units. However, is it really right and should the price of gear units be the crucial factor?

If the gearbox with the same technical characteristics can be found at different manufacturers, and it can, adoption of gear unit with the condition $T_N \geq f_B \cdot T$, guarantees that gearbox will operate at least 10.000 hours, ie. it will operate at least 5 years with the foresaw exploitation regimes. It means that selected gear unit will certainly operate properly during the warranty period, and that the purchaser will be satisfied. Nevertheless, if output torque (T_N) of a gearbox, or permissible service factor (f_B), has greater value, it means that the gearbox will operate longer, ie. it is more durable and has a bigger price. If the purchaser's interest is long life operation of gear unit and if there are several gear units with the same price, priority should be given to those gear unit which is more durable. However, if the price is the only interest, and it is the usually case, then economics have to decide. Of course, the price is market category and sometimes it doesn't represent the real value of gear unit. The price can be much lower than real, when the manufacturers want to obtain new costumers. Also, the price can be much higher when the gearbox belongs to famous trade mark and when the customer is secured about its quality and doesn't ask about the price.

This adoption procedure is rather complicated and still not enough defined.

5. GEAR UNITS ADOPTION CARRIED OUT BY GEAR UNITS DESIGNERS

When defining conception of motor gear units, designers, also, carry out adoption of gear units, ie. they have to determine one concept solution which will be in advantage regarding to other competitive solutions. The basic parameters during this process, in the frame of equal shaft height, are the value of maximum output torque (T_{Nmax}), the value of the biggest speed ratio (u_{max}), mass of gearbox, overall dimensions, power losses in gearbox, mounting types and positions, etc. For example, if load capacity (T_N) of two-stages gear unit is observed, it can be noticed that different manufacturers have different values, in the frame of the same shaft height (Fig. 2).

Regarding just load capacities of different solutions of gearboxes, it can be concluded that the most favourable solution is gear unit of manufacturer F. However, it can not be always the case, so speed ratios have to be taken into the consideration. Some manufacturers tend to achieve large values of both load capacity and speed ratio of gear units. Other manufacturers produce gearboxes with great load capacities in the frame of small speed ratios, so that their solution is good for customer, but bad by concept because great values of speed ratios are not covered. Nevertheless, these manufacturers are oriented to those customers who are interested in this scope of load capacities and speed ratios, and with them satisfy this technical problem and their economic interest.

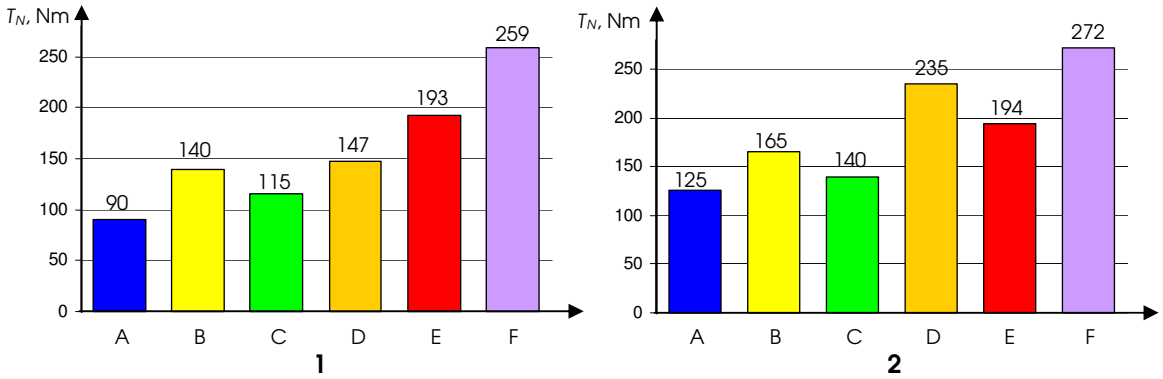

Figure 2. Comparative shematic review of load capacities of two-stages (1) and three-stages (2) gear units of different manufacturers

Because of that, particular manufacturers, in the frame of the same housing, offer two sets of gears (Fig. 3): (1) with small load capacity and great speed ratios and (2) great load capacity and small speed ratios.

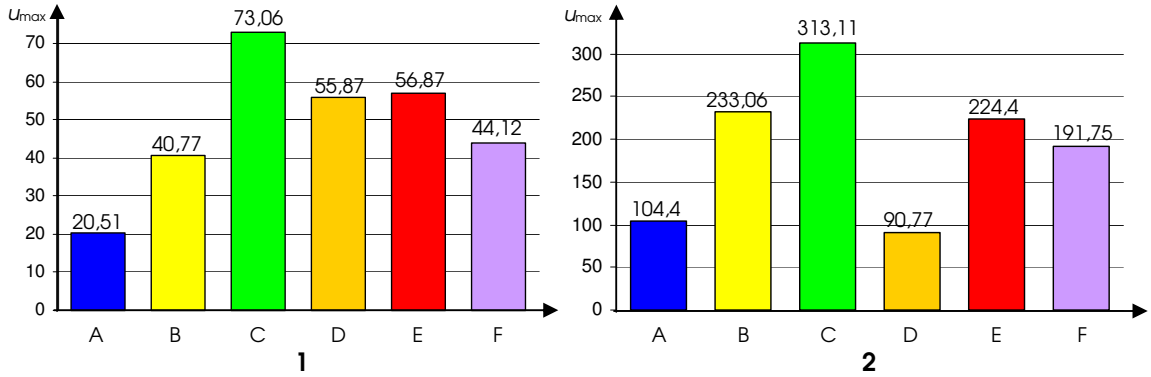

Figure 3. Comparative shematic review of speed ratios of two-stages (1) and three-stages (2) gear units of different design

Sometimes, mass og gear unit (Fig. 4), as its characteristic indicator, is not enough parameter, because some housings are made of cast iron and some of silumine, so they can't be compared. Because of old production casting technology, some housings are heavier and they don't show real design state. Although older production technology can be recognized at these gearboxes, customers prefer more these kind of gear units because of their resistance and robustness.

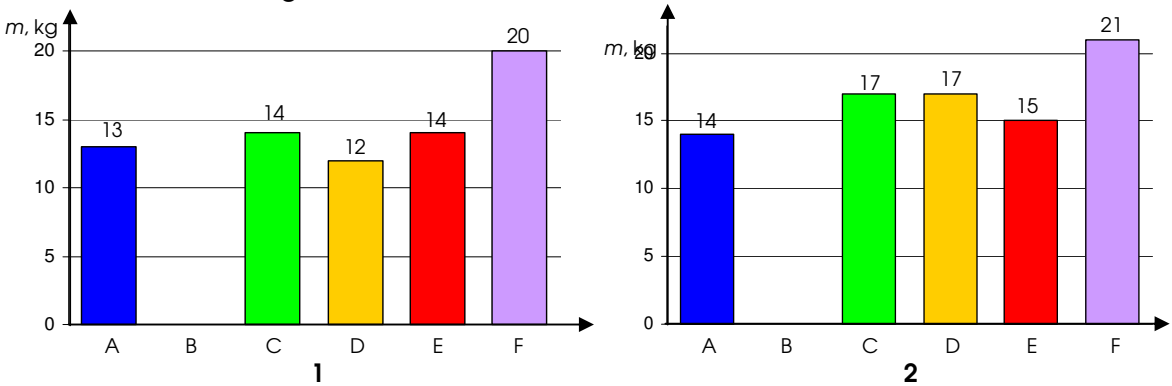

Figure 4. Comparative shematic mass review of two-stages (1) and three-stages (2) gear units of different manufacturers

Since leading manufacturers of gear units follow modern trends, mass of gear unit can be accepted as a relevant indicator, nevertheless big mass means good design solution for the customers, and for the manufacturers it means contrary. Gearboxes manufacturers, which do not have their own foundry, usually have gearboxes with smaller masses, since they are not ballasted with casting rejects.

As a good indicator of quality solution, it can be used ratio of load capacity of gear unit and its mass – T_N/m, or ratio of gear unit speed ratio and its mass – u/m, or more better the product of load capacity and speed ratio of gear unit devided by its mass – $T_N \cdot u/m$ (Fig. 5, Fig. 6).

Taking these parameters into the consideration, it can be concluded that the solution E is more favourable from the specific load capacity point of view (Fig. 5-1), from the speed ratio point of view the most favourable solution is gear unit of manufacturer C (Fig. 5-2), and from the point of view of both load capacity and speed ratio, the most favourable solution is produced by manufacturer E (Fig. 5-3).

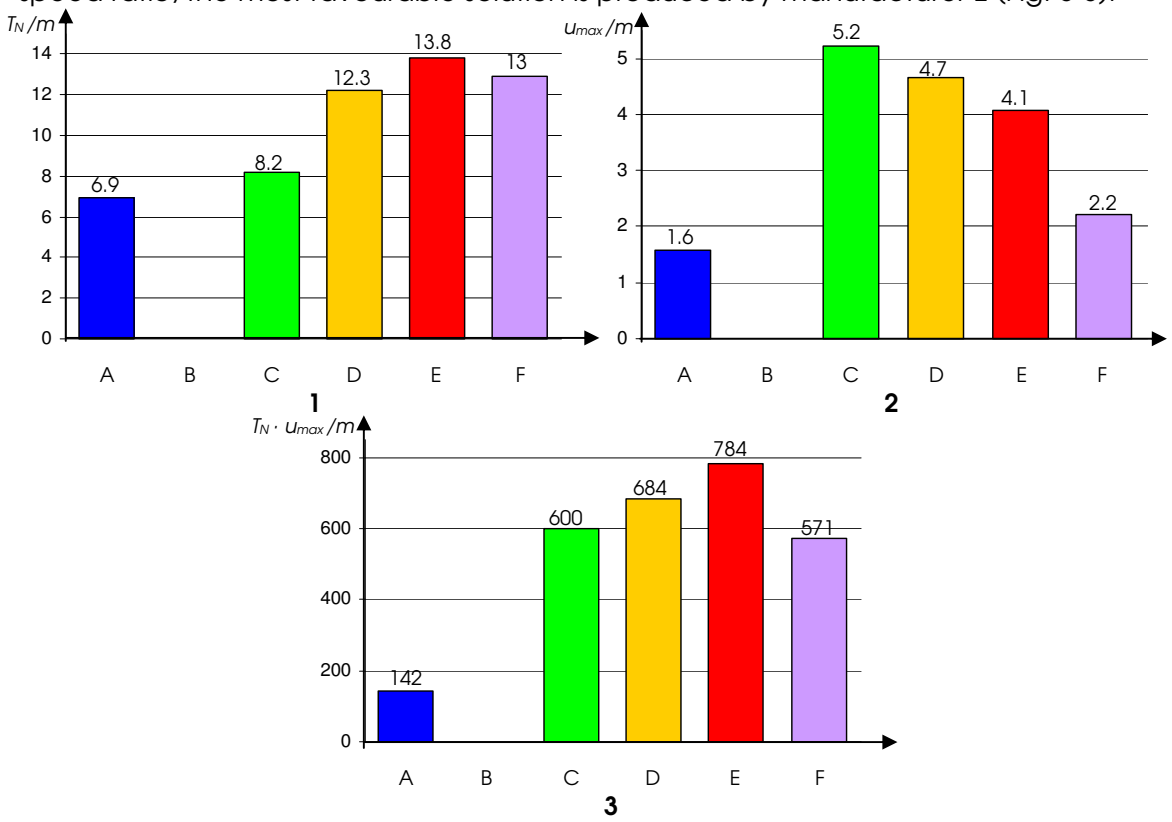

Figure 5. Comparation of characteristic parameters of two-stages gear units of different manufacturers *(1 – t_n/m, 2 – u_{max}/m, 3 – $t_n \cdot u_{max}/m$)*

Solution D is more favourable from the specific load capacity point of view for three-stages gear units (Fig. 6-1), from the speed ratio point of view the most favourable solution is gear unit of manufacturer C (Fig. 6-2), and from the point of view of both load capacity and speed ratio, the most favourable solution is produced by manufacturer E (Fig. 6-3).

Comparing these data it can be concluded that the most favourable two-stages solution is gear unit made by manufacturer E, but if only speed ratio is important, more favourable solution is made by manufacturer C. The most favourable three-stages solution is gear unit also made by manufacturer E, but if only load capacity is important, the better solution is D, or if only speed ratio is important,

the better solution is C. Analysing all gear units, it can be concluded that manufacturer E produce gear units with the most optimal design. Also, manufacturer C produce gear units with the highest values of gear ratio.

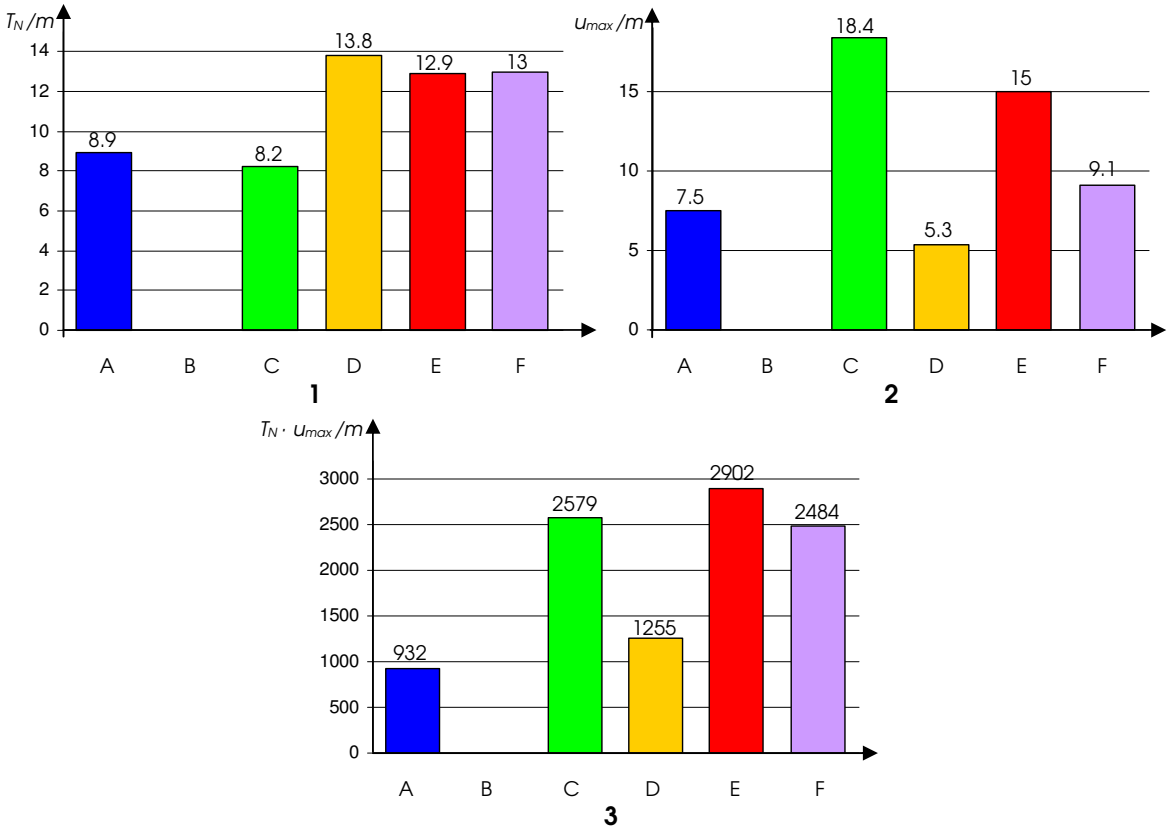

Figure 6. Comparation of characteristic parameters of three-stages gear units of different manufacturers *(1 – t_n/m, 2 – u_{max}/m, 3 – $t_n \cdot u_{max}/m$)*

However, final evaluation and final adoption of particular solution depend on variety of other costs, at the first place production costs, costs of mounting etc., so that these factors are also important to be analysed in the scope of this problem.

6. CONCLUSION

On the basis of implemented analyse, it follows that adoption of gear unit design conception is very complex problem, specially regarding to the possibilities of protection of authorized solutions, which is the reason of having such a large number of different solutions of universal gear units at the market. Especially, the approach of small manufacturer of gear units is interesting, when they tends to come in, with their special design solutions, to the area covered by gear units of great manufacturers. They try to achieve certain advantage to great manufacturers with those special gear units. For example, small manufacturers of gear units, with big values of speed ratios of two-stges gear units, tend to cover the area which great manufacturer cover with more expensive three-stages gear units, etc.

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