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ADVANTAGES OF USING UNIVERSAL GEARED MOTOR REDUCERS WITH EXTERNAL HELICAL GEARS

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Abstract: It is undeniable that in large–scale production, special–purpose reducers are increasingly being used instead of universal ones, which is certainly a cause for concern among manufacturers of universal reducers. However, in many applications, universal reducers are practically irreplaceable, as their various configurations – adapted for different mounting forms and positions – can meet nearly all customer requirements at an acceptable cost. This paper highlights the main advantages of using universal geared reducers with external helical gears.
Keywords: universal geared motor reducers, external helical gears, main advantages

1. INTRODUCTION

Universal gear reducers, unlike special–purpose ones, are intended for transmitting mechanical energy and motion, typically from an electric motor to the working machine. They are designed for various installation forms and orientations, and in smaller production series they are considerably less expensive than special–purpose reducers, which are built for a precisely defined power rating, speed, and predetermined installation form and position, containing no unnecessary parts or machining.

Naturally, in large–scale series production, it is not justified to use universal reducers – mainly due to their price, dimensions, and relatively large mass. In such cases, special–purpose reducers are generally applied, for example in construction, agricultural, and similar machinery. However, even in those instances, there may occasionally be reasons for applying universal reducers [1].

2. PROBLEM DESCRIPTION

Universal gear reducers with cylindrical gears and external toothing are manufactured both with coaxial (or nearly coaxial) shafts and as parallel–shaft reducers, in order to more fully meet customer requirements. Coaxial reducers are, by their very nature, multi–stage units and are most commonly produced as motor reducers, although they can also be supplied without a motor. Parallel–shaft reducers, apart from a large portion of single–stage versions, are most often produced as non–motorized reducers. However, they too can, on special request, be manufactured with a motor, provided the motors are small enough to be supported by the reducer housings.

Coaxial reducers are always multi–stage and are considerably more compact than parallel–shaft reducers, which means they occupy significantly less installation space. This is the main reason why they are more frequently encountered in practice. They are subdivided into reducers with a front housing opening and reducers with a top (or bottom) housing opening. The front–opening type is further divided into reducers with a single (rear) opening and reducers with both front openings, while the top–opening type is divided into reducers with an opening on the low–speed chamber and reducers with openings on both chambers. Customers are not concerned with these openings – they are of interest only to manufacturers, since they provide access for installing large gears inside the reducer housing.

Parallel–shaft reducers are divided into single–stage and multi–stage designs, and all these reducers are further divided into conventional so–called industrial reducers and into flat so–called shaft–mounted reducers, usually with a hollow output shaft, although this is not always the case.

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Conventional multi–stage reducers are used less frequently today, mostly in large–size units, while shaft–mounted reducers, despite their non–elastic connection between reducer and working machine, are increasingly applied in smaller sizes. This is because they eliminate the need for a large and expensive coupling to connect the reducer to the working machine, they do not require alignment of the reducer's output shaft axis with the machine's input shaft axis (which is often a major problem), nor do they require foundation mounting. Instead, only a support point on the working machine is needed to prevent the reducer from rotating. Moreover, these reducers occupy much less space in the axial direction, which makes them even more attractive in practice.
It should also be noted that both types of reducers can be produced with either two–part or one–piece housings. Reducers with two–part housings are very simple to assemble, although it is somewhat more difficult to ensure accurate alignment of the bearing seats. In contrast, one–piece housings are more complex to assemble but significantly simpler to manufacture [2].
In addition, many of these reducers can be interconnected in order to build more complex reducer systems, although such solutions will not be examined in detail here.
It should also be considered that all these reducers can be supplied either with or without a motor, most commonly with a four–pole asynchronous motor. To simplify design and improve the overall appearance of their reducers, most manufacturers use special reducer motors. Naturally, these motors are somewhat more expensive than standard IEC motors, since they feature special (smaller) flanges, special shaft ends, reinforced bearings, and seals at the free shaft end to prevent oil leakage from the reducer into the motor housing. They must also be kept in stock to ensure fast delivery, as it has become standard practice today for a universal motor reducer to be delivered within 72 hours, which poses a serious challenge for every manufacturer.
Reducer manufacturers who do not own motor factories and therefore cannot guarantee fast delivery of special reducer motors most often produce non–motorized reducers. Even those who can supply reducer motors still manufacture non–motorized versions with either a conventional input shaft or with an adapter for IEC motors with B5 or B14 flanges, in order to meet specific customer requirements. The latter solution is more attractive, since both customers and manufacturers can obtain standard motors more easily and quickly than special reducer motors. In addition, IEC motor adapters can be supplied either with or without couplings – most commonly elastic couplings. The solution without a coupling is simpler and more compact, and is preferred by most manufacturers, although it makes it more difficult to ensure precise alignment between the motor shaft and the hollow input shaft of the reducer. The solution with a coupling is more complex to produce but enables smoother operation and easier connection between motor and reducer. However, in this case, the motor is mounted on a larger console, which negatively affects the dynamic stability of the entire structure, especially in shaft–mounted reducers [3].

3. CHARACTERISTICS OF SPECIFIC REDUCER SOLUTIONS

The choice of reducer primarily depends on the type of connection between the reducer and the working machine, and in some cases also on the type of connection between the motor and the reducer. Regardless of whether it is a direct connection between the reducer and the working machine (via a coupling) or an indirect connection (via a belt, chain, or gear drive), the mounting of the reducer is always achieved either by means of feet, a flange, both feet and flange, or via the output shaft of a shaft–mounted reducer. This largely defines the reducer's installation configuration.
However, if it is necessary to ensure motor slip in cases of overload on the working machine – when an indirect motor–reducer connection is used (via a belt drive) – the design becomes more complex. This can also affect the choice of reducer, particularly if spatial constraints exist. Naturally, when such constraints are present, the selection process becomes even more complicated, as special attention must be paid to defining the installation position of the reducer. The final selection

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is based on the required motor power, the output shaft speed of the reducer (transmission ratio), and the service factor (which depends on the specific operating conditions of the reducer).

- Coaxial shaft reducers with a single front opening

Reducers with a single (rear) front housing opening (Fig. 1) are most often manufactured as two–stage gear reducers, although this is not always the case. The large rear cover enables the installation of relatively large gears, thereby achieving high transmission ratios. In doing so, they cover much of the transmission ratio range of the more expensive three–stage reducers, which represents their primary advantage.

Their main characteristics include simple design, easy assembly, and an aesthetically appealing appearance. These reducers are generally two–stage, although many manufacturers expand them by adding a single–stage unit to create three–stage versions, or by adding a two–stage unit to create four–stage versions. With these universal reducers, customers are provided with a wide range of transmission ratios (speeds), which in many cases meet nearly all customer requirements in terms of installation form and orientation, while maintaining a very compact design.

Figure 1. Characteristic designs of universal coaxial geared motor reducers with a single [4]

- Coaxial shaft reducers with two front openings

Reducers with two front openings are nowadays manufactured only very rarely (Fig. 2), since only relatively small gears can be installed through the front housing opening, which makes it impossible to achieve high transmission ratios. Almost all manufacturers of such reducers eventually switched to producing reducers with an opening located on the upper part of the housing.

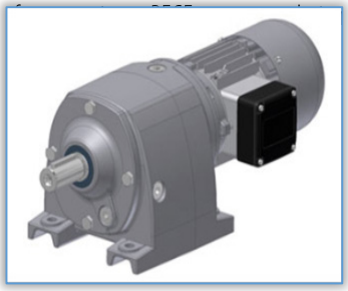

Figure 2. Characteristic design of a universal coaxial geared motor reducer with two front openings – HIMEL company solution [5]

- Coaxial shaft reducers with a top opening on the low–speed chamber

In order to increase the transmission ratio values of their universal coaxial geared motor reducers, almost all manufacturers at one point adopted the practice of opening the low–speed chamber (Fig. 3), allowing for the installation of larger output gear pairs and thereby increasing the overall gear ratio of the reducer.

The design of these reducers is exceptionally attractive, although in most cases they are installed inside machines in such a way that they are practically not visible and thus do not affect the final appearance of the machine in which they are integrated.

Figure 3. Characteristic designs of universal coaxial geared motor reducers with a top opening on the low-speed chamber – SEW company solution [6]

- Coaxial shaft reducers with a top opening on both chambers

In order to allow the installation of large gears in all gear pairs and thereby achieve even higher transmission ratios, many manufacturers have introduced top openings on both chambers of the housing (Fig. 4). This naturally led to a certain reduction in the strength and rigidity of the housing, but not to the extent that would make their reducers unreliable.

All these reducers, with coaxial or nearly coaxial shafts, are supplied with feet, small, medium, and large flanges, as well as with a flange for mixers. They can also be delivered with feet and usually a small flange. Thanks to this versatility, they can be used in all applications where the drive is provided by an electric motor, as

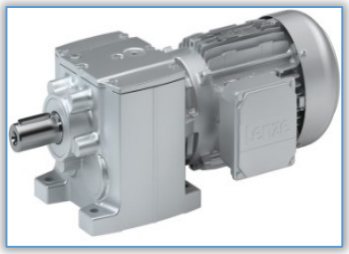

Figure 4. Characteristic designs of universal coaxial geared motor reducers with top openings on both chambers – LENZE company solution [7]

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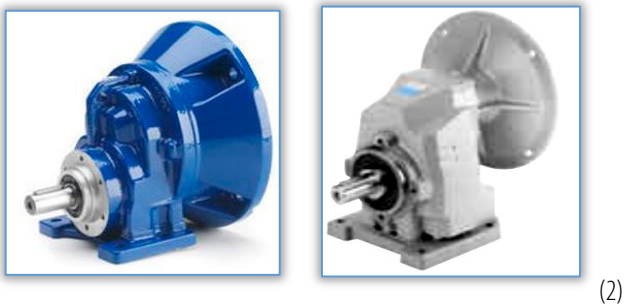
motor reducers, but they can also be very successfully used as non–motorized reducers, primarily due to their compact design.

4. CHARACTERISTICS OF SINGLE–STAGE UNITS

Classical single–stage parallel shaft reducers with a monoblock housing

Classical single–stage parallel shaft reducers are divided into three large groups: reducers with vertical shafts, reducers with horizontal shafts, and reducers that can be used with either vertical or horizontal shaft arrangements. Reducers with vertical shaft positions (Fig. 5) are most often supplied as motor reducers, although they can also be delivered without a motor. The elevated position of the input shaft enables the installation of large electric motors, especially when the reducer is connected via an adapter for IEC motors to a standard IEC motor with a large B5 flange. In these reducers, the gears are installed through the rear end opening, although there are also designs where the gears are mounted through a special bottom opening in the housing (Fig. 5–2). These reducers are suitable for all types and positions of installation.



(1) (2)

Figure 5. Characteristic designs of single–stage universal geared motor reducers with parallel shafts and vertical shaft arrangement: (1) STM TIM company solution [8]; (2) REGAL company solution [9]

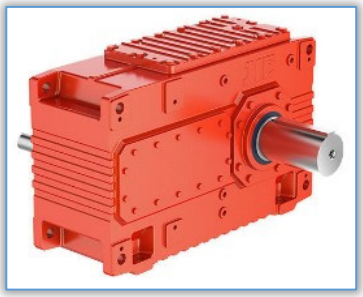


Figure 6. Characteristic design of a single-stage universal geared motor reducer with parallel shafts in a horizontal shaft arrangement – JIE company solution [10]

In single–stage reducers with parallel shafts and a one–piece housing with a horizontal shaft arrangement (Fig. 6), the gears are installed through a special opening, usually on the upper part of the housing, although this is not always the case. Nowadays, they are used less frequently because they occupy more installation space and are most often used in the non–motorized version for medium and larger reducers.

Single–stage reducers with a one–piece housing designed for both horizontal and vertical shaft arrangements (Fig. 7) are most commonly used for medium–sized reducers. Their housings are often universal, the same as those used for the production of two–stage bevel–helical gear reducers. The possibility of installation in either vertical or horizontal orientation is particularly attractive not only to customers but also to manufacturers, as it reduces production costs and increases the versatility of their reducers. These reducers can be supplied with both solid and hollow output shafts.

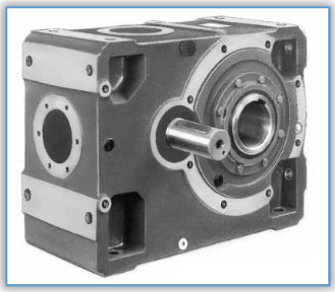


Figure 7. Characteristic design of a single-stage universal geared motor reducer with parallel shafts in a horizontal, but also possible vertical, shaft arrangement – ROSSI company solution [11]

Single–stage reducers with parallel shafts and a split housing

Single–stage reducers with parallel shafts and a split housing are most commonly manufactured with a horizontal shaft arrangement. Nowadays, they are produced and used less frequently because they occupy more installation space, and they are most often applied in non–motorized versions, particularly for large reducers (Fig. 8).

Within this group of reducers, there are also designs that can be installed with both vertical and horizontal shaft arrangements (Fig. 9).

Flat single–stage reducers with parallel shafts and one–piece housing

Flat reducers with parallel shafts and one–piece housing (Fig. 10) are most commonly manufactured as shaft–mounted gearmotors. They are suitable for installation in places with spatial

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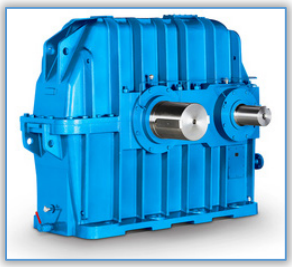

Figure 8. Characteristic designs of single-stage universal gear reducers with parallel shafts, split housing, and horizontal shaft arrangement – FLENDER company solution [12]

Figure 9. Characteristic designs of single-stage universal gear reducers with parallel shafts and split housing, which can be installed as reducers with both horizontal and vertical shaft arrangements – HANSEN company solution [13]

Figure 10. Characteristic design of a single-stage universal gearmotor with parallel shafts and one-piece housing – REGAL company solution [9]

Figure 11. Characteristic designs of flat single-stage universal gearmotors with parallel shafts and split housing – DODGE company solution [14]

limitations. In the presented solution, relatively large gears are installed into the reducer through a bottom opening in the housing, enabling the achievement of high transmission ratios. Their design is very simple and exceptionally attractive.

Flat single–stage reducers with parallel shafts and split housing

Flat single–stage reducers with parallel shafts and split housing (Fig. 11) are usually made with a radial parting plane in order to be adapted for axial mounting. They are most often intended for indirect connection with the electric motor via a belt drive, which provides an elastic drive with the possibility of slipping in case of overload of the working machine. Their design is very compact in the axial direction, since they are shaft–mounted reducers, i.e. reducers with a hollow output shaft.

Characteristics of multi–stage reducers

Multi–stage reducers with parallel shafts and one–piece housing

Multi–stage reducers with one–piece housing are most often manufactured as non–motorized reducers for medium sizes. However, they can also be supplied with a motor (Fig. 12). They are usually installed with a horizontal shaft arrangement. However, many manufacturers also provide the option of vertical shaft arrangement (Fig. 12).

Multi–stage reducers with parallel shafts and split housing

Multi–stage reducers with split housing (Fig. 13) are most often used as non–motorized reducers for medium and large sizes, although they can also be supplied with a motor. They are usually installed with a horizontal shaft arrangement.

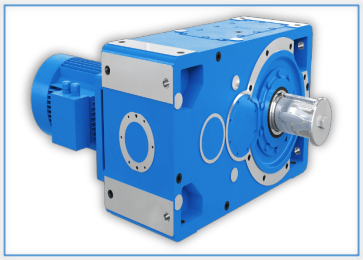

Figure 12. Characteristic design of a multi–stage universal gear reducer with parallel shafts and one–piece housing, supplied with a motor – ROSSI company solution [11]

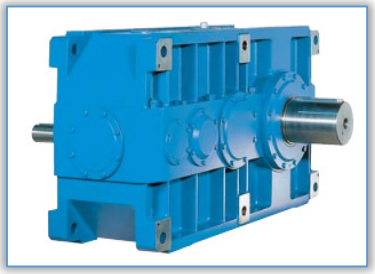

Figure 13. Characteristic design of a classic multi–stage universal gear motor reducer with parallel shafts and split housing – ROSSI company solution [11]

Flat multi–stage reducers with parallel shafts and one–piece housing

Flat multi–stage reducers with one–piece housing (Fig. 14) are increasingly being used today, and great attention is paid to their design. Some manufacturers add supports to the housings of their reducers (Fig. 14–2) so they can also be installed as standard (classic) foot–mounted reducers. Their very simple shapes give these reducers a very attractive appearance.

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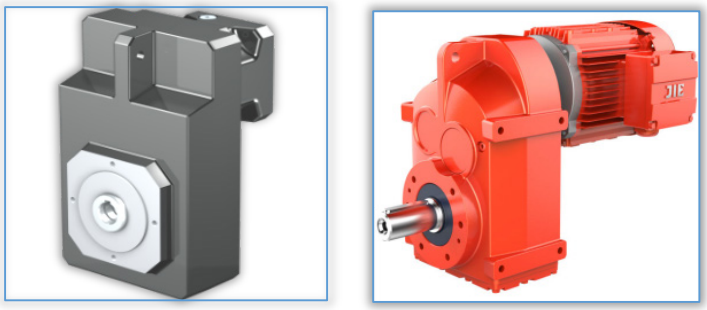

(1) (2)

Figure 14. Characteristic designs of flat multi–stage universal gear motor reducers with parallel shafts and one–piece housing: (1) STOBER company solution [15], (2) JIE company solution [10]

Flat multi–stage reducers with parallel shafts and split housing

Flat multi–stage reducers, manufactured with split housing along a radial parting plane (Fig. 15), are most commonly produced with a hollow output shaft, as shaft–mounted reducers, although this is not necessarily the rule.

(1) (2) (3)

Figure 15. Characteristic designs of flat multi–stage universal gear reducers with parallel shafts and split housing: (1) BONFIGLIOLI company solution [16], (2) BOCKWOLDT company solution [17], (3) RENOLD company solution [18]

Figure 16. Characteristic design of a flat multi-stage universal gear motor reducer with parallel shafts and split housing with an axial parting plane, solution by VARVEL company [19]

Within this type of reducers, with split housing, there are also reducers manufactured with an axial parting plane (Fig. 16), equipped with feet so that they can be used as conventional reducers with both vertical and horizontal shaft arrangements. The design of these reducers is particularly interesting.

5. CONCLUSION

The main advantage of universal gear reducers is that they possess the same technical characteristics required of special reducers. Furthermore, almost all universal reducers with coaxial shafts can be supplied with feet, with a small, medium, or large flange, as well as with a mixer flange, although they can also be delivered with feet and (usually) a small flange, thereby meeting all the requirements expected of special reducers. Universal reducers with parallel shafts can be supplied not only with the conventional solid output shaft but also with a hollow output shaft, as shaft–mounted reducers, which in many cases also fulfills the requirements set for special reducers.

Thanks to this universality, universal reducers can be used in all applications where the drive is provided by an electric motor as gear motor reducers, although they can also be very successfully applied as non–motorized reducers. Owing primarily to their compactness, high quality level, low cost, and short delivery times (which is certainly not easy to achieve), universal reducers today have wide applications in mechanical engineering.

Their connection dimensions are aligned with those of leading competitors to ensure interchangeability since connection dimensions are still not defined by standards. Possible

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drawbacks may include somewhat larger overall dimensions, slightly higher weight, a greater extent of machining required, and, in the case of large production series, somewhat higher cost due to increased material consumption and machining effort.

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