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# Researches on Design and Manufacturing of Innovative Double Gears Pumps

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**Abstract**

This paper presents the results of the researches with application in production for the innovative realization of the double gear pumps with minimum axial gauge and minimum number of parts for the increase of reliability in use and reducing the production costs. The innovative design characteristic is represented by adaptive dimensioning with minimum gauge, depending on requirements, the type of drive, the fixing method, the connections for the hydraulic circuit and intermediary sealing between stages which allows the operation with different liquid mediums.

The innovative technological characteristic is on integrated adaptive system (lean production) using computer assisted manufacturing on CNC machines with minimal production time and high quality. This way of production of double gear pumps is obtaining significant reductions in the cost of manufacturing and much smaller gauges the double pump available on the market.



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*Keywords:* gear pumps; innovative; adaptive; design

## 1. Introduction

There is a market demand of single and double pumps with low axial overall dimension and high reliability, which are used on machine tools, plastic injection and die-casting machines [1], [2].

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So far, there have been required only simple pumps Group 1 with very small overall dimensions and very high reliability for use on hydraulic power pack that led to innovative design of these pumps.

As a result of additional requirements appeared on the market were realized double pumps in innovative construction [2].

The usual gear pumps can be realized at the required parameters, but they have large overall dimensions that do not allow optimizing hydraulic installations of machines [3], [4].

Therefore it was important to investigate a way to reduce the gear pumps overall dimensions. A method to solve this problem consists of an innovative design that takes into account the required parameters and allows the development of compact construction with minimal number of pieces and very high reliability.

The innovative design requires the use of CNC machines (machining centers) in production, which ensures high precision of die-casting aluminum alloy pieces, along with a very high productivity [5].

The incorporated labor costs will be reduced due to the fact that CNC machines allow multi servicing (more machines can be operated by one man simultaneously) or work in automatic cycle.

## 2. Innovative solution for pumps design, compared with the classic pumps

Because double gear pumps consist of two stages, ie two simple pumps, to highlight the constructive changes, in a first step, we present innovations performed on simple pumps.

The components of the hydraulic standard pumps (Fig. 1) are: a fastening flange (position 1), a body (position 2), an end cover (position 3), two compensators (position 6) with the role of radial and axial bushings for pinions (positions 4 and 5) [6] and the role of frontal sealing at contact with pinions, by creating hydraulic axial forces.

In compensators are placed compensation seals that bound the area hydrostatic loaded by the working pressure that is in correspondence with the inlet [3], [7].

The construction also provides other components, such for sealing, for positioning and for blocking.

In this variant, the bushings are located in the compensator and the axial pump closing is made with a fastening flange and an end cover having a relatively high thickness.

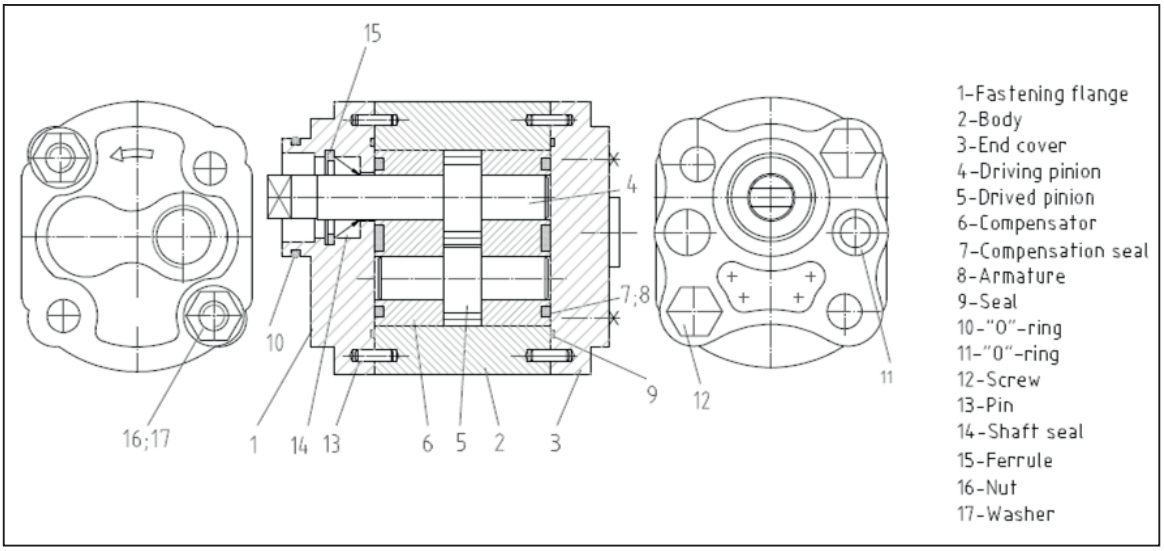



Fig. 1. Standard gear pump.

The innovative version, Fig. 2, consists of a pump that has the bushing in the body and cover and has only one compensator located in the body.

For compensating the hydraulic axial clearance, a narrow compensator is used (pos. 3). The axial sealing between the body and the compensator is provided by a single compensation seal, pos. 7, which has an armature, pos. 8, which assures a higher reliability.

The positioning of cover from the body is made with pins (position 13), which must take the forces generated in the bearings, by working pressure.

Due to the oil flow on the body and on the front face of the fastening flange, the bushings' cooling is much better and the life time is higher.

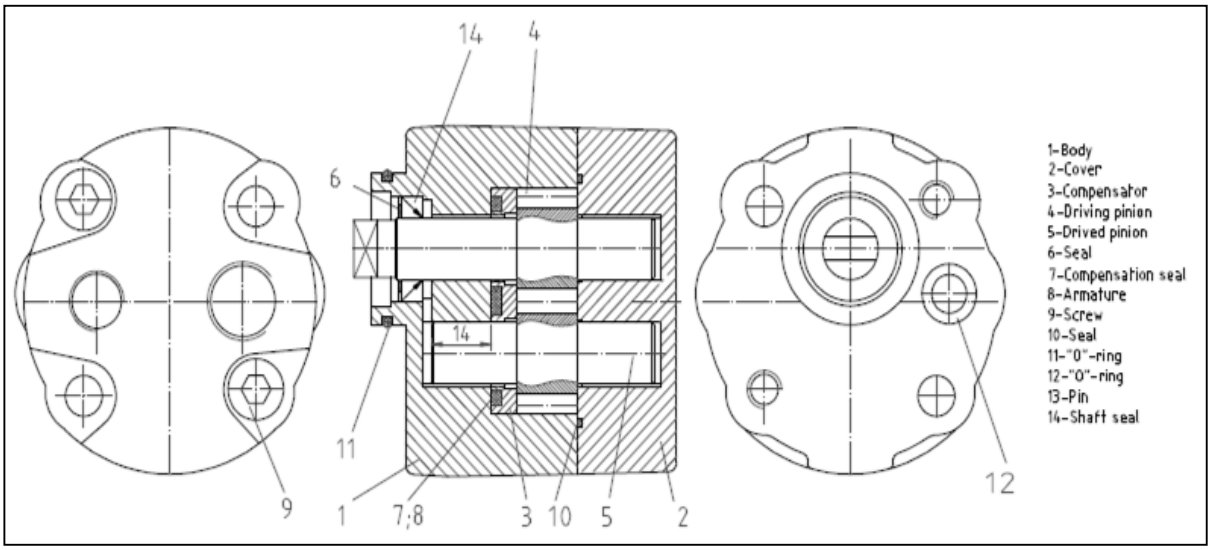



Fig. 2. Gear pump with innovative design.

The axial closing of the pump is assured with screws tight to the recommended torque, pos. 9.

The sealing between the back cover and the body are made with "O" rings, pos. 11 and pos. 12.

The load in the body bearings is smaller than in the flange bearings.

The point of application of bearing loading force is not symmetrically positioned.

This variant of pumps has a very small axial size because the body takes directly the axial force given by pressure and therefore does not require a thick cover back the pump. Furthermore, the pump has a single narrow compensator which takes the axial clearance. Due to the fact that the body is very robust, it can reduce the lateral size because the rigidity is provided by the form.

The body length depends on the bearings, the compensator thickness and the width of the pinions teeth.

The fastening flange that contains the bearings is sufficiently rigid; over the bearings, no additional thickness is necessary to take over axial forces.

The pumps executed in innovative construction have the axial size (30 – 40) % smaller, compared to the standard pumps.

The pumps have a higher reliability and reduced manufacturing costs because they have fewer parts.

The technologies utilized to realize the pumps in innovative variant need CNC machines for manufacturing the cast aluminum pieces.

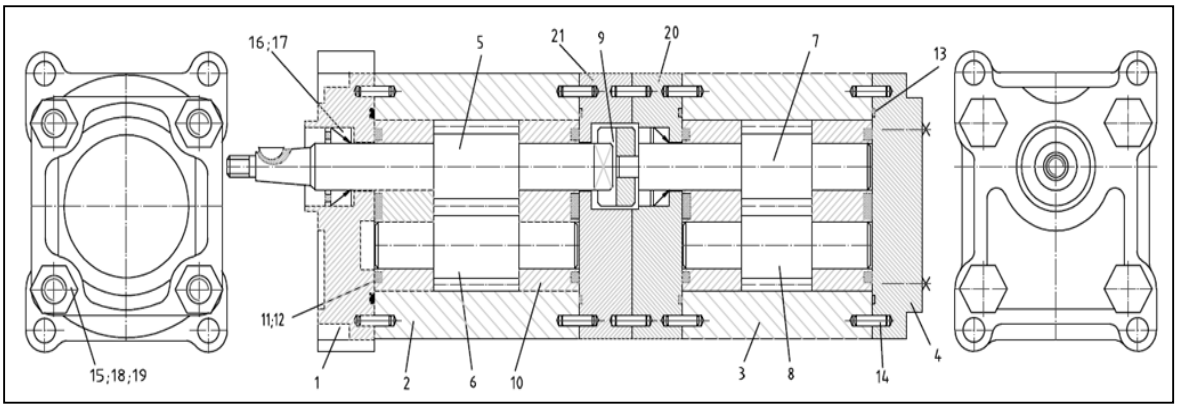
In the technological process there are some important aspects, except the dimensional and geometric characteristics, that need to be mentioned: processing of blind holes, relative positioning between the fastening flange and the body must ensure the gear pair parallelism and the contact of pinions frontal surface with the fastening flange, achievement of a highly precise geometries in conditions of the new construction to ensure sealing between moving elements for different pressures (max. 300 bar).

### 3. Double pumps in innovative solution

The standard double pumps do not allow optimizing the hydraulic mini power packs used on machine tools, plastic injection and die-casting machines because of the very high axial gauge [3].

For this reason, in most cases it is necessary to realize mini power packs attached to machine tool.

In figure 3 is presented a standard double pump.




1- Fastening flange
2- Body 1
3- Body 2
4- End cover
5- Driving pinion 1
6- Drived pinion 1
7- Driving pinion 2
8- Drived pinion 2
9- Intermediate coupling
10- Compensator
11- Compensation seal
12- Armature
13- Seal
14- Pin
15- Screw
16- Shaft seal
17- Ferrule
18- Nut
19- Washer
20- Intermediate flange
21- Intermediate cover

Fig. 3. Double gear pump – standard design.

The double pumps in innovative construction, shown in Fig. 4, have many differences from the standard pumps. Basically, the double pump consists of two simple pumps in innovative construction, mounted back to back with an intermediate coupling (pos.9).

The intermediate coupling cavity is located directly in the two bodies without requiring additional intermediate plates. The sealing between the two bodies is made by an "O"-ring.

At the front, the pump has a fastening flange and at the end has an end cover.

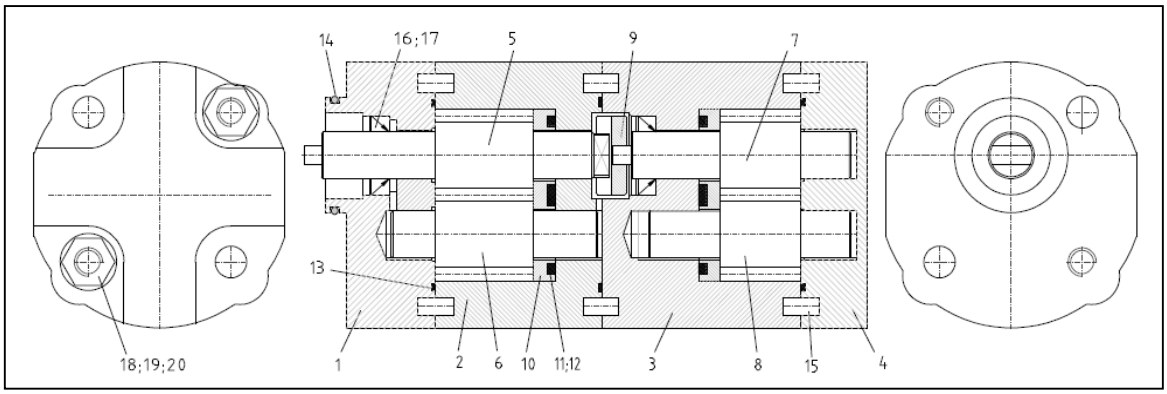
The bearings are made in the bodies, fastening flange and back covers.

The compensator used for the innovative variant is very thin and it is used one on each stage. An obvious advantage of this solution is found in the axial size reduction.

The number of parts is much smaller, leading to high reliability, the material consumption is lower and production costs are much lower.

The compensators have not bearings and therefore they deliver less heat during operation, which assures a higher reliability of seals and armatures.

Double pumps are calculated with the same formulas used for simple pumps, for each stage separately [3].




1- Fastening flange
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Fig. 4. Double gear pump – innovative design.

## 4. Evaluation of the hydrostatic loaded surfaces

A. Optimistic variant

This scenario assumes convenient sealing between pinion and compensator and occurs when the pump is unused with good geometric conditions, operating pressures are below 200 bar, pump speeds are high (losses occurring in less time), oil viscosity is high at low temperatures, radial clearances are small without recesses at the ends (pressure diagram is decreasing)-fig.5 and 6 [8], [9].

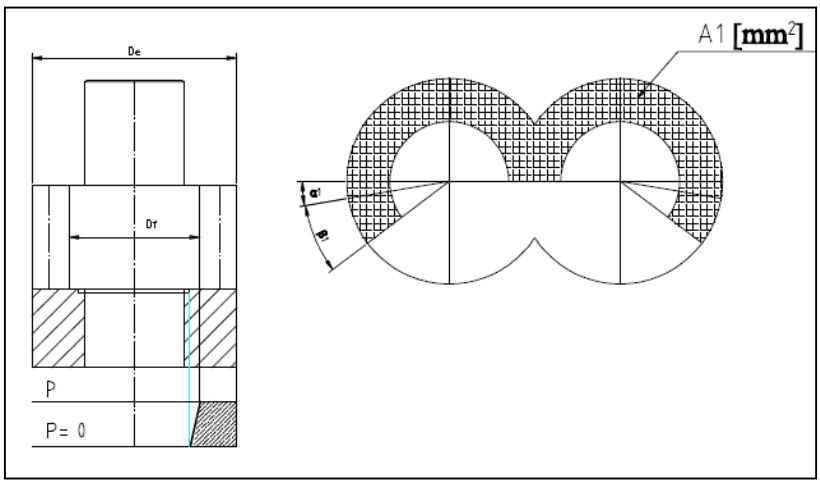


Fig. 5. Optimistic variant.

Where

| | |
|---|---|
| De | external diameter |
| Df | root diameter |
| P | pressure |
| A1 | compensation area. |

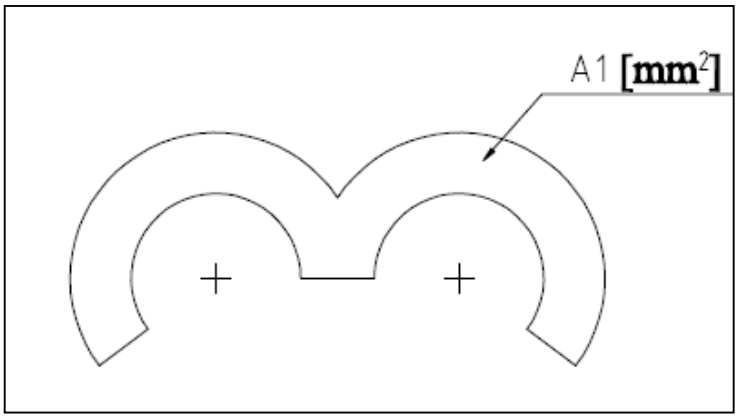


Fig. 6. The necessary area for compensation - Optimistic variant.

B. Pessimistic variant

This scenario assumes a weak sealing between the pinion and compensator that appears when the pump is wasted or imperfectly executed, (geometric conditions at the limit of operation), pressures are high (250-300 bar), pump speeds are low (losses occur in longer time), oil viscosity is low (high temperatures - below 10 cSt seize appears), radial clearances are higher, the compensators and pinions front surfaces are not perfectly flat and allow the drain of oil through them (fig. 7 and 8) .

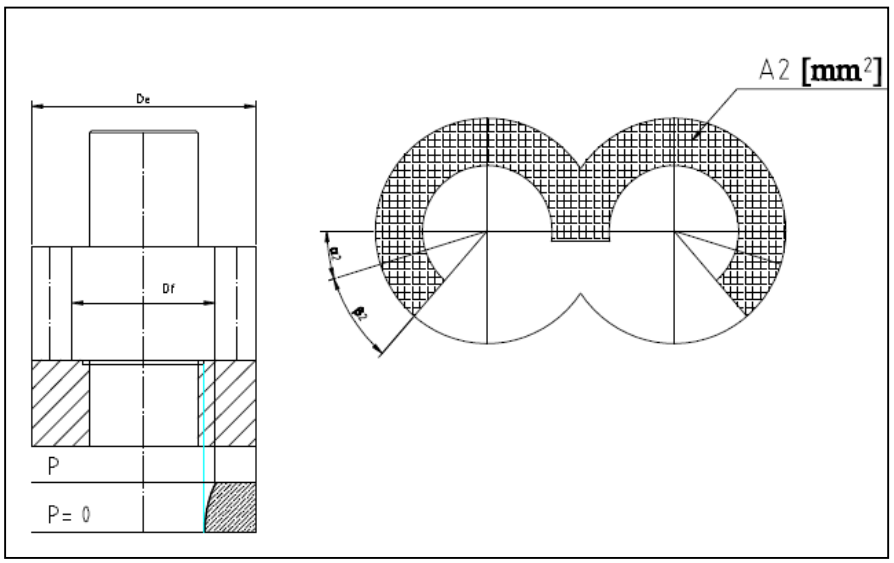


Fig. 7. Pessimistic variant

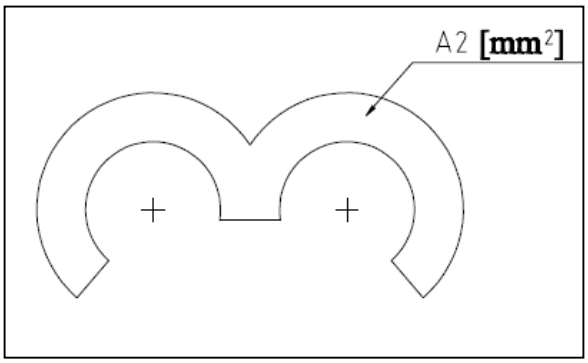


Fig. 8. The necessary area for compensation - Pessimistic variant.

A2 represents the compensation area.

Note that

$$\alpha 1 < \alpha 2,$$
$$\beta 1 < \beta 2,$$
$$A1 < A2\ [mm^2].$$

## Conclusions

The problem was for usual gear pumps in large overall dimensions that do not allow optimizing hydraulic installations of machine tools, plastic injection and die-casting machines. This problem was solved by the development of single and double gear pumps which are extremely compact, robust, reliable and with low manufacturing costs.

The results of the researches and the main constructive and operating advantages of innovative gear pumps are: an axial size reduction, a smaller number of parts, high reliability, high operating parameters, a lower material consumption and production costs.

The future plans are focused on increasing the performance in operating, extending to multistage pumps which serve special applications in industry, maintaining high quality standards with very high dimensional and geometric precisions.

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