APPLICATIONS

Discrete Power Converter (DPC)

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Possible area of application of DPC (or *Kornich machine*)is significantly determined by its distinctive features of other types of known converters, as well as peculiarities of its design and kinematic scheme.

Let us first define the factors necessary to provide the working regime of the power converter based on the physical principle of its operation (see Fig.1).

1. Availability of a sufficient supply (resources) of a fluid or a free-flowing mass serving as a working substance which is able to activate of DPC and go through (from input to output) it as mechanism. When considering this factor, it is expedient to classify the said resources into two groups based on their origin:

1.1 Natural resources that are present and can be found in the environment or are formed as a result of natural growth, and to its physical properties can be assigned to free-flowing masses. The main criterion for the applicability of such substances as the primary driving force is their ability to form in the streams that can go from the top down by gravity through the DPC as a mechanism, in accordance with its principle of operation. Examples such substances are represent in the Table 1.

Table 1.

Natural resources of free-flowing masses as primary mover for DPC	
1. water	5. ice
2. sand	6. grain
3. gravel	7. seeds
4. snow	8. nuts, cones, kind of fruits or vegetables

1.2 Artificial resources resulting from industrial production or serving as components of various multi-ton technological processes (both continuous and discrete ones). Examples such substances are represent in the Table 2.

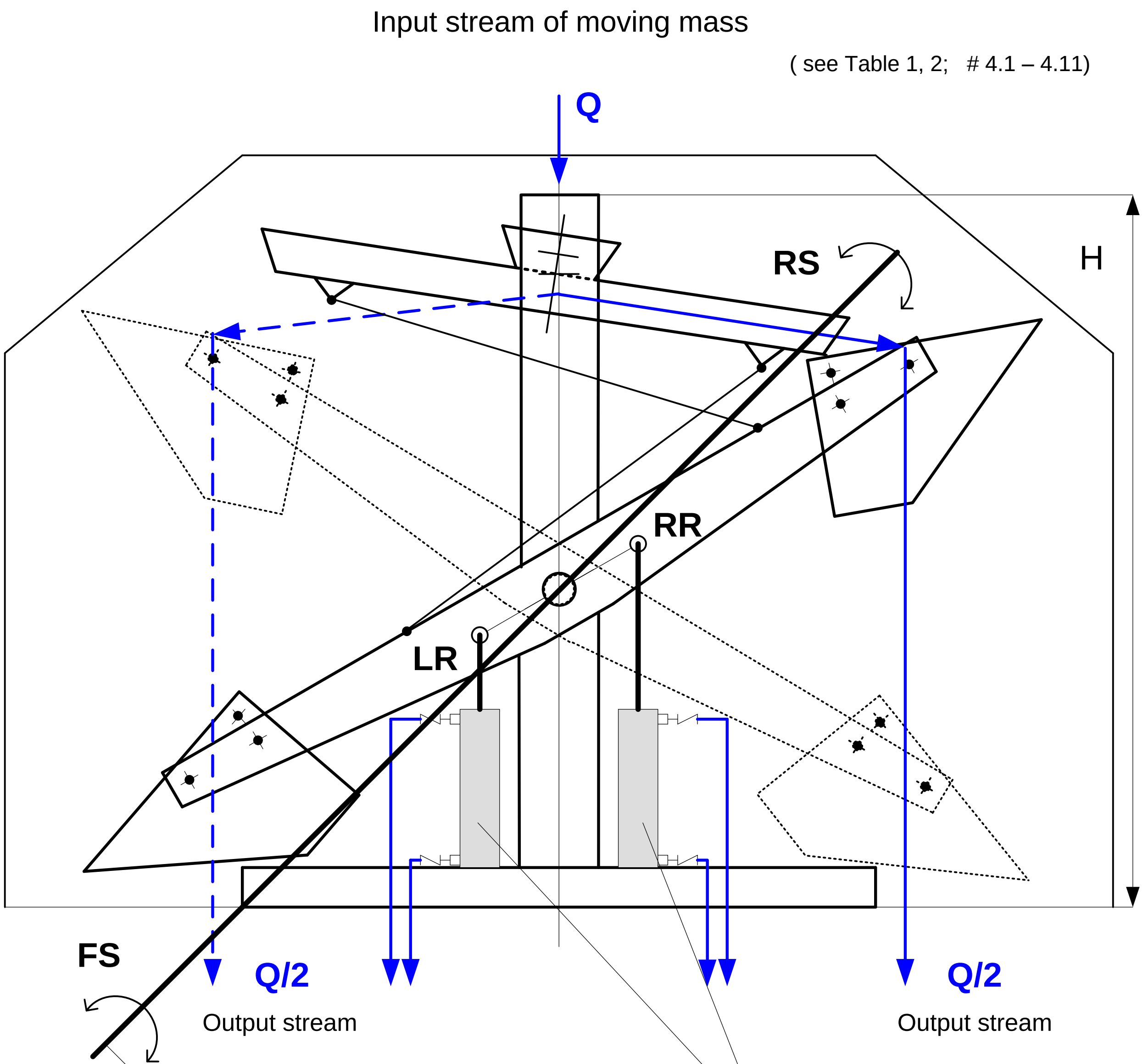
Table 2.

Artificial resources of free-flowing masses as primary mover for DPC	
1. pulp	5. powder
2. slurry	6. sawdust
3. blend	7. ash
4. granulated materials/small parts	8. water mixture / dissolver

2. Providing an elevation of the source of a fluid or a free-flowing mass over the converter itself. It is clear that the higher is this elevation:

$$\Delta h = hs - hc \quad \text{and} \quad H < \Delta h \qquad \text{(see Fig. 1)} \qquad (1)$$

where hs is the geodesic coordinate of the source of the moving mass (the input level), and hc is the geodesic coordinate of the level at which the exhausted moving mass is withdrawn by the converter (the output level),



As mechanical load there can be:

1. Sieve
2. Coarse screen
3. Mixer
4. Shaker washer
5. Shaker grate
6. Shaker shaft
7. Mechanical heater

As mechanical load there can be:

1. Water piston pump
2. Air piston pump
3. Juice press
4. Punch press for some materials
5. Press former for some materials
6. Cutter
7. Splitter

Fig. 1

It is clear that the higher is this elevation the larger the potential energy capacity of the source in question, however always should be $H < \Delta h$ (see Fig. 1)

Based on different combinations of the factors of the afore-listed factors 1 and 2, the possible applications of the proposed converter can be divided into two groups:

2.1 independent applications for which the power converter is designed as a self-dependent object connected only to a natural source (see classification in Table 1) of a moving mass and intended to generate useful energy of its output motion;

2.2 "built-in" applications in which the power converter is designed and created as a built-in component of various existing technological processes dealing with moving many tons of materials in the vertical plane. In this case the main purpose is to save, renew or generate useful energy without affecting seriously the initial process itself.

3. Applications of the discrete power converter

It is clear that every application of the proposed power converter must be of practical use, i.e. must have a "useful function" which can also serve as a classification factor. The useful function is determined by the character of the mechanical load connected to the power converter and by the type of the mechanical motion utilized as *output function in* the converter. The following useful *output functions* can be considered:

3.1. *Compressed air production.*

In this application a reciprocating motion of the rocking lever (beam in the construction of DPC), executed in the vertical plane by gravity of the moving mass, and is used. In this case two pneumatic piston pumps whose working rods are hinged to the corresponding arms of the rocking beam are used as mechanical load.

3.2. Pumping *of water and other liquids.*

In this application a reciprocating motion of the rocking lever (beam in the construction of DPC), executed in the vertical plane by gravity of the moving mass, and is used. In this case two hydraulic piston pumps with working rods are hinged to the corresponding arms of the rocking lever serve as mechanical load.

3.3. *Obtaining of large mechanical forces acting periodically.*

In this application a reciprocating motion of the rocking lever, executed in the vertical plane by gravity of the moving mass, is used. As mechanical loads the hydro- (or pneumatic-) cylinders of hydraulic (pneumatic) boosters are utilized; their working rods are connected to the corresponding arms of the rocking lever.

3.4. *Electric energy production.*

In this application the energy conversion sequence is somewhat more complicated than that in 1 and 2; namely, the output of the hydraulic (or pneumatic) piston pump is connected to the input of the hydraulic (pneumatic) turbine mechanically loaded onto electric generator. In order to smooth out the pulsing action on turbine, it is possible to incorporate a mechanical energy accumulator, e.g. an eccentric flywheel, between the input of turbine and the output of the piston pump.

3.5. *Separation (screening, flushing) of different fractions of fluid or free-flowing media in various technological processes.*

In this application a reciprocating rotational motion of the shaft of the rocking beam, executed in horizontal plane about the (vertical) pedestal of the converter, is used. In this case various swinging sieves, sifts and sizing screens whose swing axes are connected to the shaft of the rocking beam can be applied as mechanical loads.

3.6. *Separation (splitting) of stream of input moving mass (as dispencer*).

In this application the input stream of moving mass (Q) will be separated on two equal output streams (Q/2) as result of symmetrical consequent motion of capacities (buckets) on the each end of the rocking beam. This function is realizing as useful side effect during of performing some mechanical work at (3.1 – 3.5) paragraph. On some appropriate sites (specific landscape, etc) two output streams could be merged again and would be used as input stream for the next DPC, if requirement (1) can be satisfied. In such a way the *cascade configuration* (as chain of several DPC) can be realized with using the same original stream of moving mass as source of energy.

3.7. *Educational value as hydro-mechanical / electrical model*.

There is another useful application that makes sense to consider more in detail. We are talking about the similarities between hydraulical and electrical processes, which has long been known and used in the design (for example, when modeling processes and devices) and for educational purposes (for example, for illustrative purposes, the explanation of electrical phenomena). In electronic-hydraulic analogy the *current* represents of *flow* and electric potential (or voltage) represents the hydraulic head (as by formula (1) in paragraph 2) accordingly.

Since electric current is invisible and the processes at play in electronics are often difficult to demonstrate, the various electronic components are represented by hydraulic equivalents [1]. In this regard, the kinematic scheme of the DPC is a completely adequate hydro-mechanical model of the well-known electronic device – astable multivibrator that can operate in the mode of oscillator, i.e. continuously generate a sequence of pulses. The principal electrical scheme of multivibrator is represent on Fig.2.

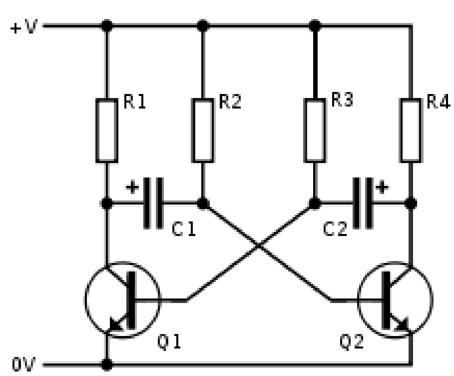


Fig. 2

“ … An astable multivibrator is a regenerative circuit consisting of two amplifying stages connected in a positive feedback loop by two capacitive-resistive coupling networks. The amplifying elements may be junction or field-effect transistors, vacuum tubes, operational amplifiers, or other types of amplifier. The example diagram shows bipolar junction transistors. The circuit is usually drawn in a symmetric form as a cross-coupled pair. Two output terminals can be defined at the active devices, which will have complementary states; one will have high voltage while the other has low voltage, (except during the brief transitions from one state to the other)… “[2]

Comparison of electrical circuit of multivibrator and kinematic scheme DPC mechanism is impressive even their visual coincidence: in both cases we can see a symmetrical structure formed by two criss cross united links (feedbacks) which has (in the terms of ' black box ') one functional input and two functional outputs.

As input of the DPC is a stream of moving mass (Q), as input of multivibrator is the input current from the voltage source (+V). It is also noteworthy that, in full accordance with the hydro-electric energy characteristic It is also noteworthy that, in full accordance with the hydro-electrical analogy, the energetic parameter of multivibrator is the value of a voltage of source of electric potential relatively to the zero (“ground”) power bus, and for DPC - the exceeding (the *head*) of height of the source of moving mass that determines a potential mechanical energy on the known formula E=mg□h, see (1).

Continuing the analysis we can see enough of the obvious similarity of structural elements that perform similar functions in the operating mode both of the devices.

Two electrical capacitors (C1, C2) in the multivibrator (for the accumulation of electrical charges) correspond to the two flow accumulation capacities (buckets) for moving mass, which are located on opposite ends of the swing beam.

Two transistor (Q1) and (Q2), which in the scheme of multivibrator work alternately as electric power amplifiers in switching mode in the design of the DPC have their analogues of the two levers (as symmetrical and equal arms of the beam, rocking on a common pivot point I as the horizontal axis of the converter). These levers also work as amplifiers (multipliers) the force of gravity (in accordance with the law of the lever) the dose moving mass that has accumulated in the converter.

In both structures we can see also two symmetrical feedbacks which transfer part of input energy to provide switching process between two stable states: with high energy and with low energy.

Similar principles and algorithms (in the definitions of hydro/electric analogy) of the operating in the case of astable multivibrator and DPC (as mechanical oscillator) also leave no doubt:

“...The circuit [multivibrator] has two stable states that change alternatively with maximum transition rate because of the "accelerating" positive feedback. It is implemented by the coupling capacitors that instantly transfer voltage changes because the voltage across a capacitor cannot suddenly change. In each state, one transistor is switched on and the other is switched off. Accordingly, one fully charged capacitor discharges (reverse charges) slowly thus converting the time into an exponentially changing voltage. At the same time, the other empty capacitor quickly charges thus restoring its charge (the first capacitor acts as a time-setting capacitor and the second prepares to play this role in the next state). The circuit operation is based on the fact that the forward-biased base-emitter junction of the switched-on bipolar transistor can provide a path for the capacitor restoration. …Thus C1, C2 restores its charge and prepares for the next state … when it will act as a time-setting capacitor. " [2]

Similarly, the DPC also alternately switches by moving the accumulated weight of free flowing mass from the upper position (close to the feeding pipe) to the lower position, where the capacity (bucket) of spontaneous emptied, preparing for new filling in the next cycle. It was during this transition (working stroke) lever as arm of the rocking beam, executes mechanical work against the external payload (for example, piston pump). At the same time, the opposite arm of the rocking beam moves to the upper position to load the capacity (bucket) with free flowing mass through the feeding pipe. The changing of the direction input stream of free flowing mass only to upper position of bucket is provided due to the action of mechanical feedback on feeding pipe accordingly.

Therefore that transitions of opposing arms from upper position to lower position (and vice versa), which take place alternately in DPC is quite similar (energetically) of the switching transistors in the electronic circuit of multivibrator. The sequence of such transitions of rocking beam in DPC displays visually (as periodic mechanical oscillation of mechanism) that oscillating electrical process which is going similarly in the astable multivibrator. The period of these oscillation (or frequency) in both cases is determined primarily by volume of buckets in DPC or value of capacitors in the multivibrator (in terms of hydro-electrical analogy).

As a result of the comparative analysis, the following conclusions can be drawn:

3.7.1 DPC as a hydro-mechanical mechanism provides an informative contribution to the hydro-electrical analogy and can serve as an adequate (in terms of transforming various physical forms of energy) model of the known electronic device – astable multivibrator.

3.7.2. In addition to the known basic definitions of hydro-electric analogy, such as the electric current/ flow, pressure/voltage, DPC allows you to visualize by mechanical processes of such common concepts (including electronics) as:

- discrete switching between two potentially different states of the system as high and low levels of energy,
- the mechanism of action of feedback as the transfer part of energy of system for switching between different states,
- changing the direction of the input moving stream (like carrier of input power) as phase change timing (because of the actions of these feedbacks are), respectively, than the conditions of periodic oscillations in the system is provided.

3.7.3 overall use of DPC as illustrative models for educational purposes to demonstrate the commonality of the conservation laws of energy conversion and in different physical nature of technical devices.

4. Based on various combinations of factors mentioned in 1 and 2, we can determine a list of objects both of natural and artificial origin, which involve displacements of many tons of fluid or free-flowing masses in the vertical plane and

are most suitable for utilization as the sources of energy (resources) for the proposed power converter:

4.1. waterfalls;
4.2. mountain lakes and rivers;
4.3. rapids at the plain rivers;
4.4. artificial waterfalls formed by diverting the plain rivers and lakes to neighboring gorges, valleys and ravines;
4.5. open casts for sand, crushed stone and gravel exploitation;
4.6. elevators and drying units for grain and seeds;
4.7. open casts for mining and processing of comminuted ores and minerals;
4.8. granulation towers, columns and other equipment;
4.9. drying complexes and units in which vertical (downward) displacements of multi-ton free-flowing masses are involved;
4.10. transportation complexes and units involving vertical (downward) displacements of many tons of fluid and free-flowing masses;
4.11. systems for waste water disposal (sewage) and drainage systems.

5. On the basis of the whole set of the aforementioned factors, it is possible to outline the areas of industry which are most suitable for the introduction of the proposed power converter:

5.1. hydroelectric power engineering (micro-hydroelectric stations and units);
5.2. water supply, irrigation and watering;
5.3. water purification and sewerage;
5.4. ore mining and processing industry;
5.5. chemical industry (multi-ton production);
5.6. metallurgical industry (multi-ton production);
5.7. building materials industry;
5.8. food industry (multi-ton production);
5.9. special application: small power units without heat radiation and noise sources.

1 http://en.wikipedia.org/wiki/Hydraulic_analogy
2 http://en.wikipedia.org/wiki/Astable_multivibrator

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