COMPARISON OF MECHANICAL AND HYDRAULIC DRIVE SYSTEMS

Mr. Erich Wirzberger
Project Manager
Hydraulics for Civil Engineering
Mannesmann Rexroth GmbH

I. Power Transmission

Mechanical

sprocket chains
gear racks
pinion gear chains
ropes
pinion gear segments
via cable drums by means
of drives through el. motors

Hydraulic

hyd. cylinder
pipe lines
pressure source
(if necessary, rotation motors)

II. Design Segments

Mechanical

individual design
elements, e.g.
stroke devices
drives, frames
etc.
for a certain
system
= individual
manufacturing

Hydraulic

design elements which
can be manufactured
in series
exception:
cylinder
except for zero
stroke components

III. Space Requirements

Mechanical

stroke devices and
drive elements have
to be positioned in
close proximity of
each other
power deflection or
power transformation
over long distances is
very difficult and
expensive

Hydraulic

long distances or deflections
are no problem
can be economical in civil engineering
projects

IV. Maintenance

Mechanical	Hydraulic
continuous maintenance and lubrication	energy carrier is also lubricant normally, maintenance consists of checks.

V. Specific Characteristics

Mechanical	Hydraulic
soft acceleration and deceleration as well as a precise overload protection required expensive and time consuming design and are not precise slipper clutches	soft acceleration or deceleration are no problem - variable displacement pumps - proportional valves Overload protection works precisely and can be adjusted

When are mechanical systems used ?

- very small forces with series drive
- long stroke or drive paths
  e.g. sliding gates in locks

Where else can the hydraulic drive be applied ?

- cylinder completely or partially under water
- drive station completely under water

5. COMPARISON OF MECHANICAL AND HYDRAULIC DRIVE SYSTEMS

To better understand the specific properties of hydraulic and mechanical drives the major differences are listed below.

5.1 POWER TRANSMISSION

5.1.1 With a mechanical drive the stroke and/or drive elements consist mostly of sprocket chains, gear racks or pinion gears, as well as ropes, spindle drives, and pinion gear segments.
These elements are then driven via pinion or cable drums by means of multiple stage spur gears or worm gears through electrical motors. Also included in this system are various other devices such as limit switches, position indicators, locks, etc.

5.1.2 When using hydraulic drives in civil engineering the stroke device used is usually a hydraulic cylinder (linear motor) which is provided with hydraulic oil from a pressure source (to some extent also rotation motors). In other words, the means of power transmission are not mechanical elements which are subject to wear and tear, but a hydraulic medium.

5.2 DESIGN ELEMENTS OF THE MECHANICAL AND HYDRAULIC DRIVE

5.2.1 The individual design elements of mechanical drives, such as stroke devices, drives, frames, limit switches, etc. are normally designed for one particular system and then manufactured individually. Spare parts are hard to get, have long lead times, and are very expensive.

5.2.2 On the other hand, hydraulic drives are assembled from elements which are manufactured in series. Only the cylinders might be manufactured individually. However, it is the industry's goal to manufacture zero stroke components at least in mini series and manufacturer only the cylinder pipe and piston rod in accordance with the required stroke dimensions of each individual case. This means that spare parts are available from stock, and since they are produced in series, they are very inexpensive.

5.3 SPACE REQUIREMENTS

5.3.1 In case of mechanical drives stroke devices and drive elements have to be arranged in close proximity to each other. Power deflections and transformations over long distances are very difficult to arrange and very expensive.

5.3.2 On the other hand, with hydraulic drives it is not difficult to transform energy over long distances. Stroke device, i.e. cylinder and pressure oil source with control can be apart 100 meters or more.

Another advantage is the low space requirement which can be of particular advantage in civil engineering.

5.4 MAINTENANCE

5.4.1 With mechanical drives the stroke devices, such as chains, pinions, spindles, etc. require constant maintenance and lubrication.

5. COMPARISON OF MECHANICAL AND HYDRAULIC DRIVE SYSTEMS

To better understand the specific properties of hydraulic and mechanical drives the major differences are listed below.

5.1 POWER TRANSMISSION

5.1.1 With a mechanical drive the stroke and/or drive elements consist mostly of sprocket chains, gear racks or pinion gears, as well as ropes, spindle drives, and pinion gear segments.
These elements are then driven via pinion or cable drums by means of multiple stage spur gears or worm gears through electrical motors. Also included in this system are various other devices such as limit switches, position indicators, locks, etc.

5.1.2 When using hydraulic drives in civil engineering the stroke device used is usually a hydraulic cylinder (linear motor) which is provided with hydraulic oil from a pressure source (to some extent also rotation motors). In other words, the means of power transmission are not mechanical elements which are subject to wear and tear, but a hydraulic medium.

5.2 DESIGN ELEMENTS OF THE MECHANICAL AND HYDRAULIC DRIVE

5.2.1 The individual design elements of mechanical drives, such as stroke devices, drives, frames, limit switches, etc. are normally designed for one particular system and then manufactured individually. Spare parts are hard to get, have long lead times, and are very expensive.

5.2.2 On the other hand, hydraulic drives are assembled from elements which are manufactured in series. Only the cylinders might be manufactured individually. However, it is the industry's goal to manufacture zero stroke components at least in mini series and manufacturer only the cylinder pipe and piston rod in accordance with the required stroke dimensions of each individual case. This means that spare parts are available from stock, and since they are produced in series, they are very inexpensive.

5.3 SPACE REQUIREMENTS

5.3.1 In case of mechanical drives stroke devices and drive elements have to be arranged in close proximity to each other. Power deflections and transformations over long distances are very difficult to arrange and very expensive.

5.3.2 On the other hand, with hydraulic drives it is not difficult to transform energy over long distances. Stroke device, i.e. cylinder and pressure oil source with control can be apart 100 meters or more.

Another advantage is the low space requirement which can be of particular advantage in civil engineering.

5.4 MAINTENANCE

5.4.1 With mechanical drives the stroke devices, such as chains, pinions, spindles, etc. require constant maintenance and lubrication.

5.4.2 With hydraulic drives the energy carrier is also a lubricant. With hydraulic drives maintenance is kept at a minimum. Usually it consists of checks only. Comparisons have shown that maintenance expenses are only approximately 9 - 12% compared to mechanical drives.

5.5 SPECIFIC CHARACTERISTICS OF THE DRIVES

5.5.1 With mechanical drives special design measures are required for soft acceleration and deceleration in the end positions. These are achieved by means of start-up clutches, slipper clutches, or through the kinematics of the drive, such as cams, elbow levers, etc. A precise overload protection is very expensive in a mechanical drive. Normal slipper clutches are usually not very precise. Usually it is very difficult and expensive to change or adjust values determined in the design.

5.5.2 With hydraulic drives acceleration and deceleration stages as well as changes in speed, and/or various speeds can be achieved through quite simple and safe devices. Overload protection is no problem. It can be done with the most simple devices. To a large degree the values can be adjusted during start-up; speeds can be adjusted easily too. They can be changed subsequently, also.

When looking at these criteria the superiority of the hydraulic drive over the mechanical drive becomes obvious, and this includes the financial advantage which the hydraulic system has over the mechanical drive.

In central Europe the 0 point of the cost curve is at an operating power of approximately 3 - 5 tons, in other words, at this force the mechanical and hydraulic drives cost approximately the same.

With an operating power of 100 tons the price comparison is at approximately 46 : 100 in favour of the hydraulic drive.

Another reason is that today larger systems are built for which mechanical drives are out of the question.

5.5.3 The characteristic listed in the above comparison shows why more and more hydraulic drives are used. Mechanical drives are used only

a) for very low forces, where, for example, chain spindle drives (which are manufactured in series) etc. can be applied or

b) where long stroke or drive paths (longer than 20 m) are involved, e,g, with large sliding gates on locks

c) another reason for preferring mechanical drives could be architectural needs.

5.6 Recently the cases have increased where it seems more logical to arrange the cylinder below water level to avoid large superstructures etc. This is possible without any problems which we will demonstrate in later examples. Today there exists a number of systems where the cylinder works partially or completely under water. Controls and control units are arranged under the water level also. Naturally with these units the hydraulic drive is superior to the mechanical drive. Such problems can hardly be solved with a mechanical drive.