Presentation

Fluid power genes and memes
About sharks, mice and a poor albatross chick

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Fluid power genes and memes

About sharks, mice and a poor albatross chick

I N N A S

Peter Achten
SICFP19, Tampere, Wednesday, May 22, 2019

Good morning everybody. What a delight to be here. And what a pleasure to have your full undivided attention for the next 45 minutes, or so.

Thank you Kalevi, for inviting me, although you might regret it. This presentation might be somewhat disturbing.

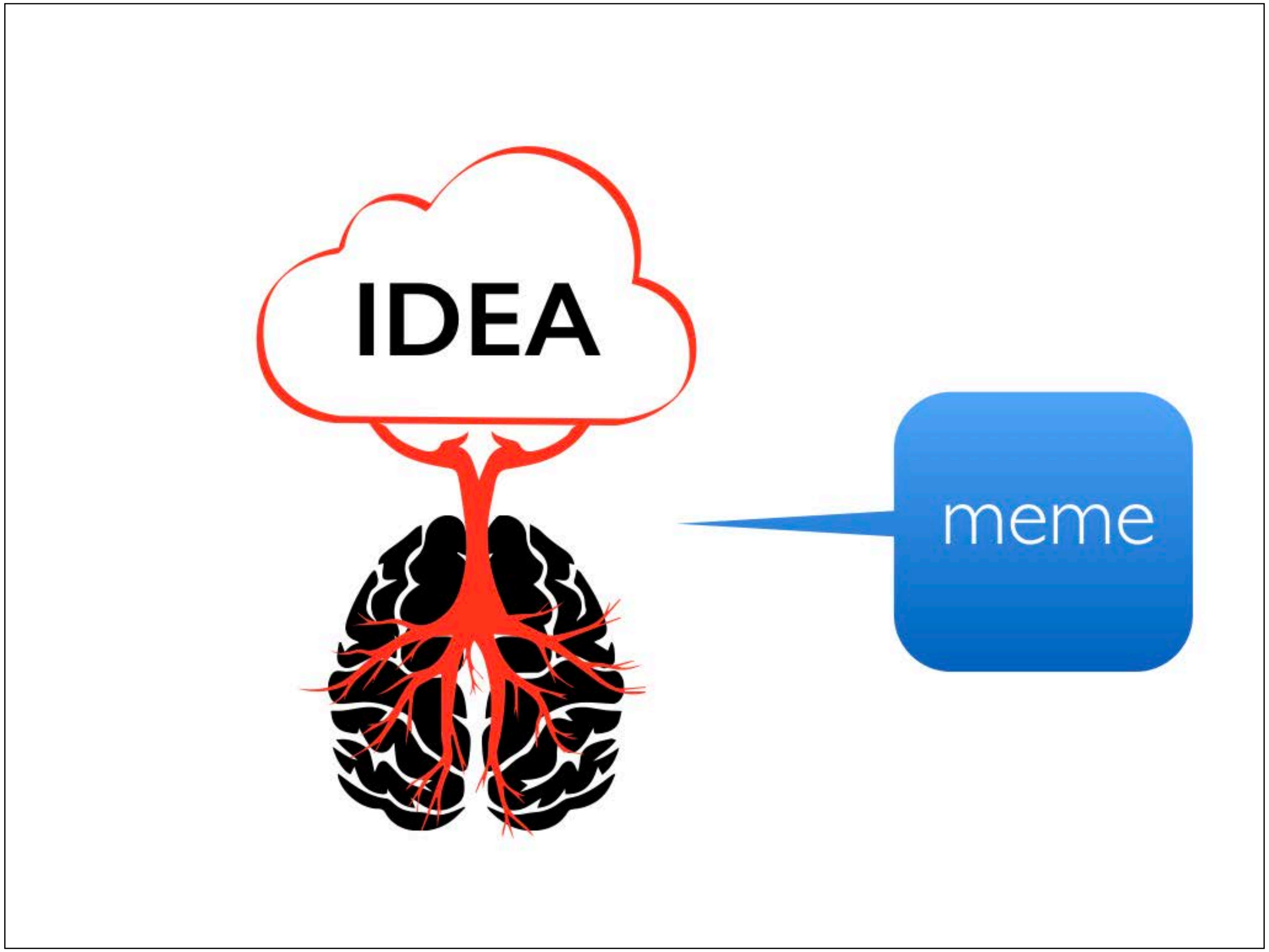
You all know that I like to tell stories, but this story will involve some killing and bloodshed. The story will also have an open end. It can be a happy end, but it all depends on you. You can make it a happy end.

And no, you are not in the wrong lecture. This is not a lecture on ichthyology, mammalogy or ornithology. My speech will not be about fishes, rodents or birds. But I will show you some photographs, some images, of these animals.

Images have always been strong instruments in conveying messages: they can get implanted in your head.

This is what happened to me some time ago when I saw this photo: this image has taken root in my head. It is a young albatross chick, and it is not in very good shape.

I will show you the same photo again at the end of this lecture, and tell you why this picture got ingrained in my brain, and also how this albatross is related to the topic of this conference



An idea, which gets deep-rooted in your head is called a meme. It comes from the Greek word mí-me-ma, which literally means ‘imitated thing’.

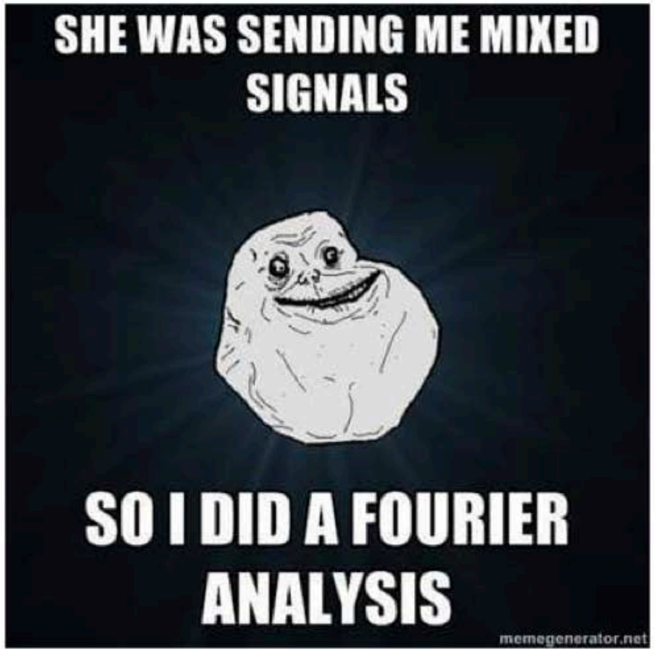
Memes creep in your head. Often without knowing or realizing it yourselves, they influence your decisions and your behaviour. They are strongly contagious: they can become ‘viral’ as it’s called. Memes are often used by internet trolls, but also in marketing and journalism.

Now, you probably all know memes, or at least ‘internet memes’.

internet meme

Such as this one. Internet memes can be funny, but at the same time they are often cruel and unjust.

engineering memes



There are internet memes about everything, …
also about engineers…

memes about Finland

…and even about Finland.

The internet has made a caricature, a travesty of the term ‘meme’. Memes are much more serious than internet memes suggest.

Richard Dawkins

Genes determine an organism's physical characteristics.

Memes determine the behaviour of an organism

The term was coined in 1976 by this guy, Richard Dawkins, an Oxford professor and evolutionary biologist.

Whereas "genes determine an organism's physical characteristics", he says, "memes determine the behaviour of an organism".

Richard Dawkins

Genes determine your physical characteristics.

Memes determine your behaviour

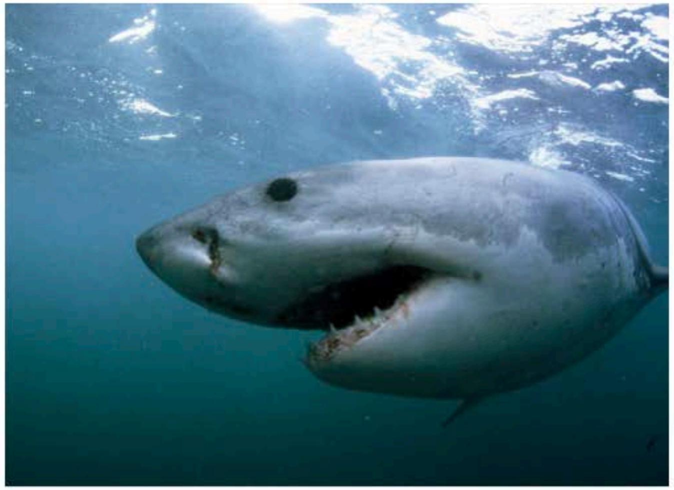
Or to rephrase this. Whereas “genes determine your physical characteristics”, …, “memes determine your behaviour”.

As I said before, memes are much more, and also much more serious, than internet memes. They can be: tunes, ideas, catch-phrases, clothes fashions, oneliners, slogans…

They propagate themselves by leaping from brain to brain by means of imitation

some examples

Humans are superior to animals



≈ 8 humans/year are killed by sharks

Let me give you some examples: This is a first example of a meme:

'Humans are superior to animals'.

Now I know you don't get up every morning, look in the mirror and tell yourself that you are superior to animals. But without telling, you accept it as an indisputable truth.

Let me explain this by means of an example. Each year there are about 8 persons being killed around the world by a shark. Four of them because the shark has been provoked. Whenever you hear or read about a shark which has killed a diver or a tourist at a beach you know that this is a nasty and vicious animal.

some examples

Humans are superior to animals

≈ 8 humans/year are killed by sharks

≈ 100.000.000 sharks are killed by men every year

But there are more than 100 million sharks killed by humans every year. In many cases, the sharks are caught for their fins, which are cutoff, after which the heavily injured shark is thrown back in the water to die a cruel death. So, who is the nasty, vicious animal?

some examples

Humans are superior to animals

White people are superior

Let me give you another example of a meme:

"White people are superior."

I know that you don't think this way, but don't be mistaken. White supremacy is flourishing again.

But, white supremacy is not genetic, it's behaviour. It's a meme.

some examples

Humans are superior to animals

White people are superior

White man are superior

And then you have ‘White masculinity’. Forget about woman, white man are superior

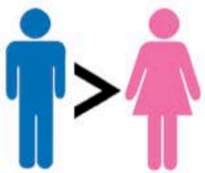
some examples

Humans are superior to animals

White people are superior

White man are superior

Man are superior



Or, simply, man are superior. Now you are supposed to say: “Owww…” or “Boohh……;”. But the majority of the human population still lives by this cornerstone in their paradigm.

But how do you get ‘infected’ by such a meme?

Well, the pub is not only a good place to catch the flue, but also to get infected by memes. Amidst your peers it is easy to accept thoughts, which are often hidden as jokes or funny statements.

And then of course we have the social media, such as twitter, instagram, and facebook. Yes, you are being manipulated constantly. Be aware of this!

Fluid power genes and memes

Now, if you think that we don’t have our own memes, about our own fluid power discipline, then you are wrong.

Let me take you on a small mental tour.

in this presentation

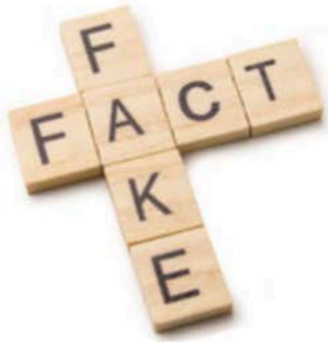
- what are our genes?
  - what is inherent to fluid power, both good and bad?

First of all, I want to define our own fluid power genes. What is really inherent to fluid power?

What are the things we have to accept, both good and bad?

in this presentation

- what are our genes?
  - what is inherent to fluid power, both good and bad?
- what are our memes?
  - what is tradition, what is superstition, what is a fact or what is fake?



But also, what are our memes? What is tradition, and superstition? What is a fact, and what is just fake or an illusion we live by?

in this presentation

- what are our genes?
  - what is inherent to fluid power, both good and bad?
- what are our memes?
  - what is tradition, what is superstition, what is a fact or what is fake?
- what does it mean for the future of fluid power?

And finally, what does it mean for the future of fluid power? In the end, I want us to have a discussion about research priorities. What things should we work on in the next years, let's say between now and in four years time, when there will be another conference here in Tampere?

But first, our genes.

The essence of hydraulics: The fluid

- fluid transmits power
- fluid controls power
- fluid stores energy
- fluid transports heat
- fluid flushes

The quintessence of hydraulics is the fluid. Fluid transmits power, it control power, and you can store energy in fluids.

Furthermore, it is very convenient that fluids transport heat, for example from internal losses, to another place where it can be cooled again.

And fluids can flush systems and take the debris and particles to a filter, where the fluid can be cleaned again.

advantages

- robustness
- flexibility
- high power, force and torque density

Because of the characteristics of fluid:
- we can make robust machines,
- have flexible power transport,
- and have an unparalleled power, force and torque density.

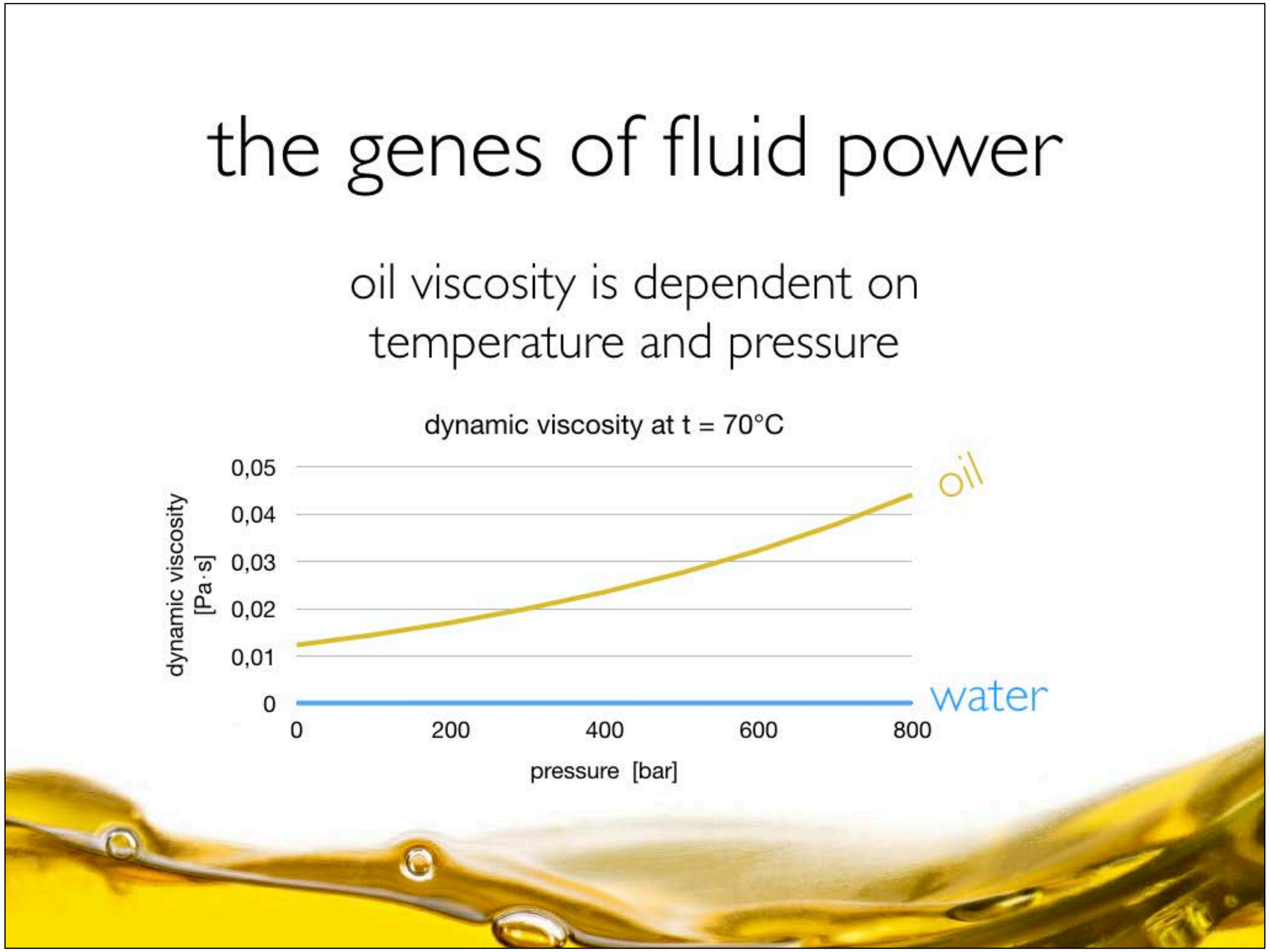
the genes of fluid power

fluids are compressible

- oil: 100 to 1000 times more elastic than steel
- below 50 bar:
  strongly dependent on the air content

It should not be a surprise that the characteristics of fluids also define the genes of hydraulic systems and its components.

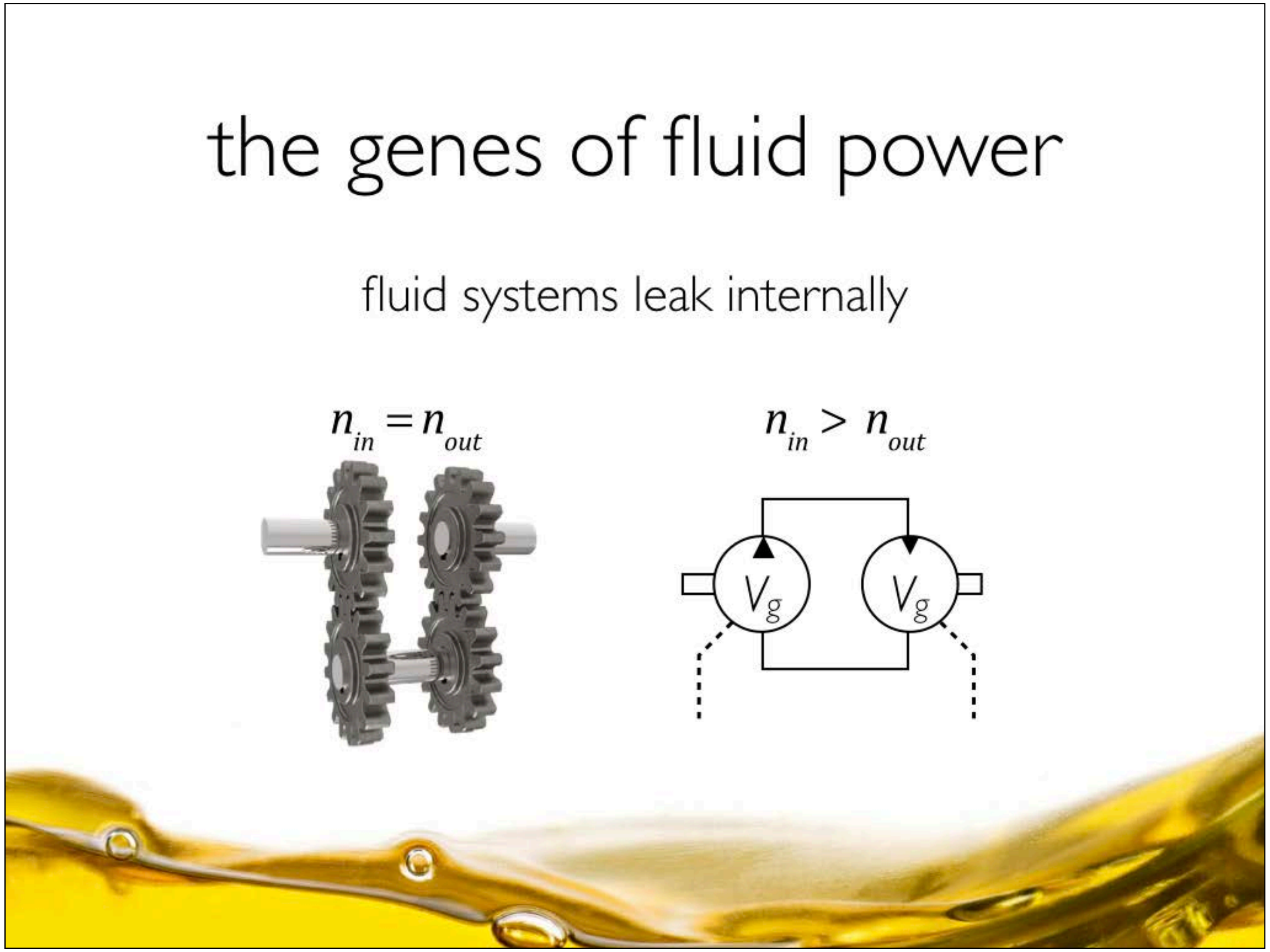
Our first ‘gene’ is, that we have to accept that fluids are compressible. Oil, for instance, is 2 to 3 orders of a magnitude more elastic than steel. And especially below 50 bar, the bulk modulus is strongly dependent on the air content



Another key characteristic is that fluids are viscous, and that the viscosity is not a constant but is dependent on temperature and pressure.

This diagram, for instance, shows how the viscosity of oil increases when the pressure is increased.

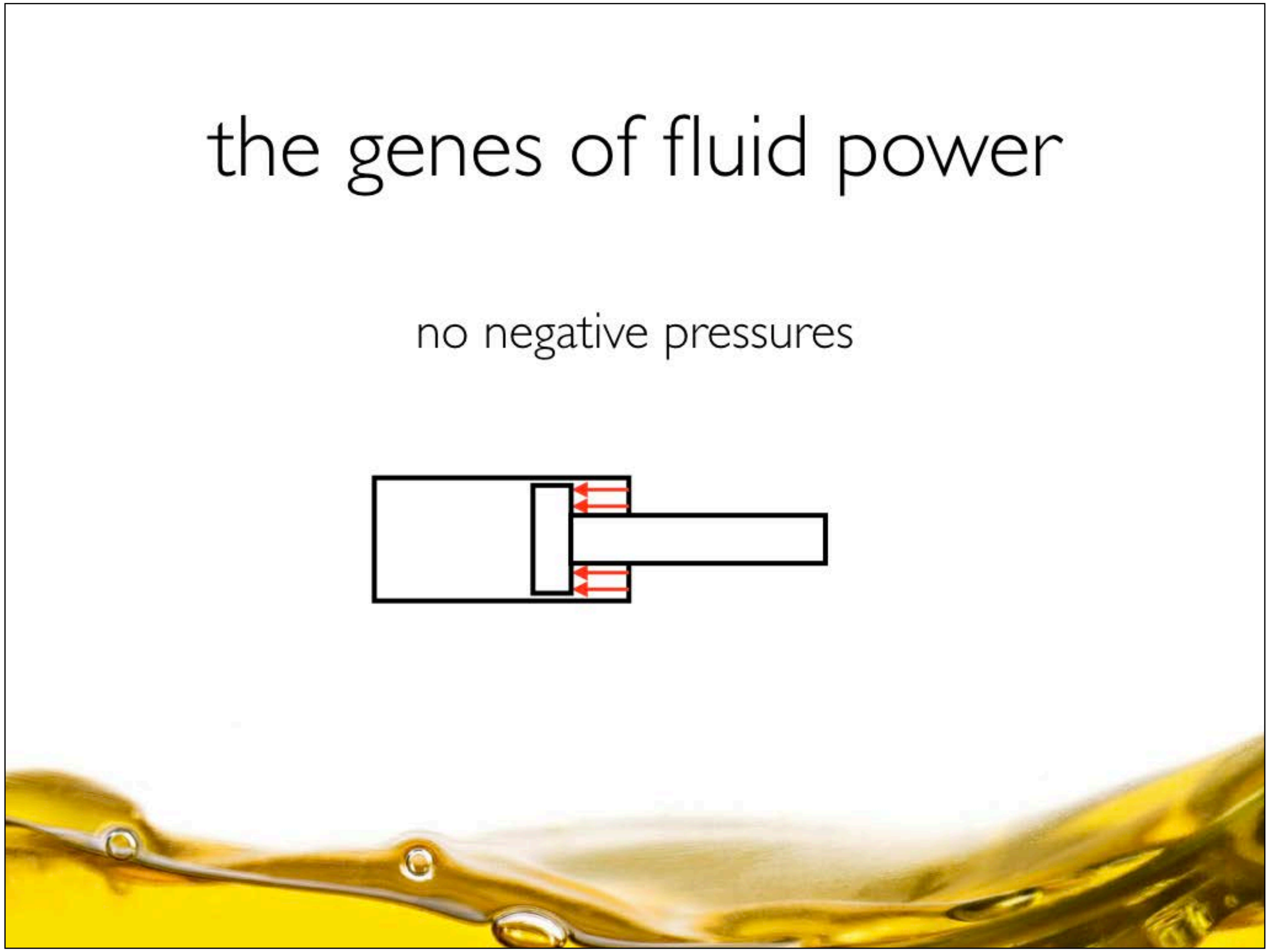
This behaviour is typically for oil. The viscosity of water is not only much lower, but the viscosity is not increased at higher pressure. This characteristic of oil is the reason why oil has such good bearing characteristics, and why water hydraulics has a problem.



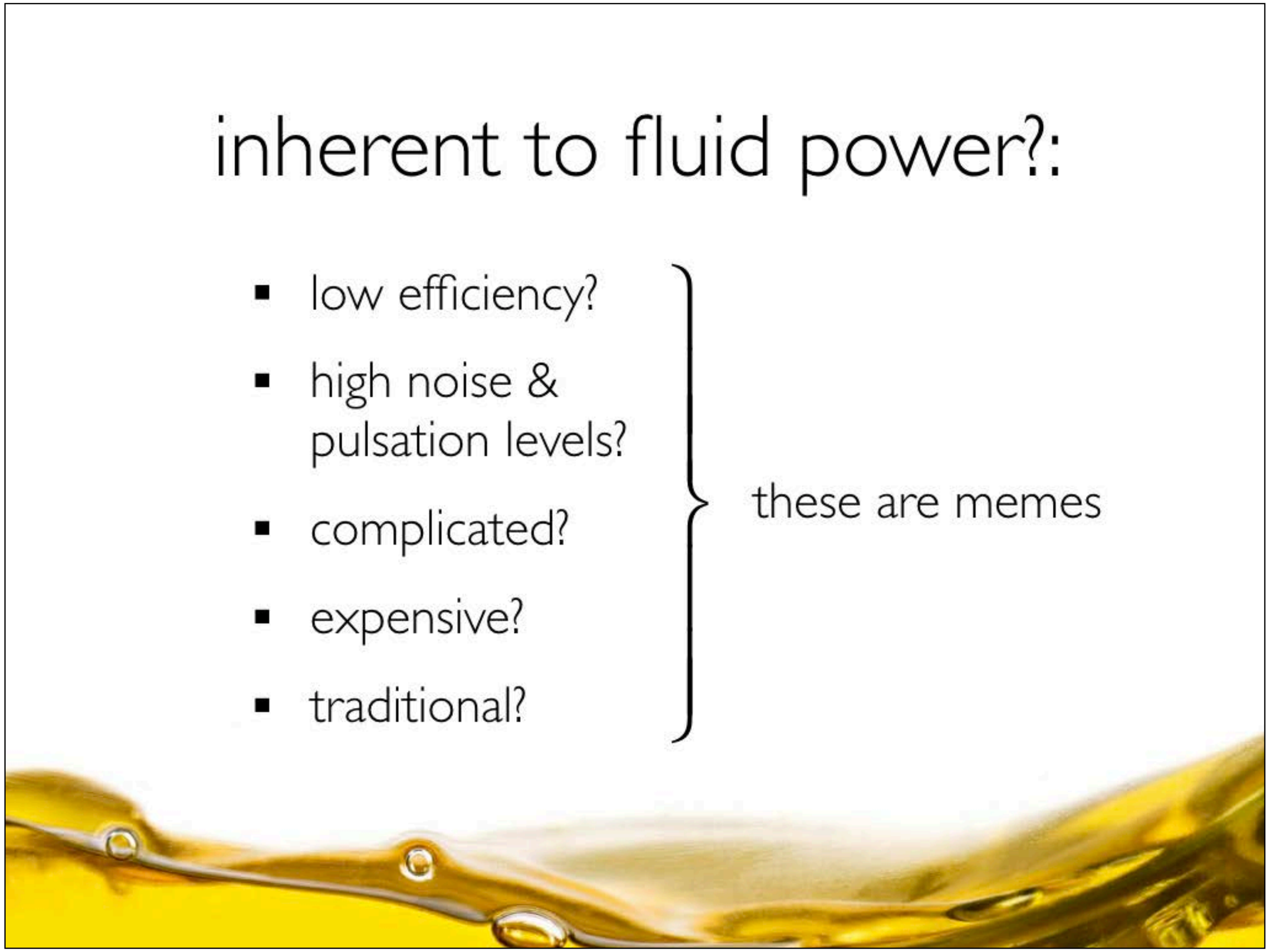
The third inherent characteristic of fluid power is that there is always some amount of leakage. I am not talking about exterior leakage, but about internal leakage.

This is something you won't have in a gear transmission. In this simple transmission with equal gears, the output speed is exactly equal to the input speed. You don't have any leakage of teeth in a gear transmission.

This is different in a hydrostatic transmission. Although the displacement of the pump equals the displacement of the motor, the output speed is always lower than the input speed. This is especially important for low rotational speeds when the internal leakage can result in control issues, such as dead band.



Finally, we can't have negative pressures. Well you can, at specific conditions, but not in the real world. A practical consequence is that cylinders can't pull, unless they are double acting, having two surfaces to create a pushing force in opposite directions.



But how about the efficiency, the high power losses. After all, we have not been able to make any improvement in the past 30 years that I am visiting these conferences. Surely, this must also be inherent to fluid power!

And also noise and pulsations must be unavoidable.

And we cannot help it, our systems must be complicated and expensive.

And finally, I always hear that the industry is extremely conservative and traditional. So we can’t help it that there are no innovations.

But…these are all memes! There are no fundamental physical reasons why any of this is true.

These are the genes of fluid power systems. This is our DNA:

- compressibility
- viscosity
- internal leakage
- only positive pressures

These are the things that make hydraulic systems different from mechanical systems. The rest are memes: mental mindfucks, similar to the believe that vaccines can cause autism.

memes about hydraulics

Allow me to examine some of these thoughts in more detail. I won't have the time to discuss everything, but let me choose three memes:

❶
Hydraulic systems have high power and energy losses

❷
Hydraulic systems and components are expensive

❸
The hydraulic industry is traditional and lacks innovation

The first statement I want to investigate is that hydraulic systems, by definition, have high power and energy losses.

The second ‘meme’ is that hydraulic systems and components are expensive and that costs can’t be reduced. Our production volumes are too small, and the number of different applications is endless, so we can’t help it.

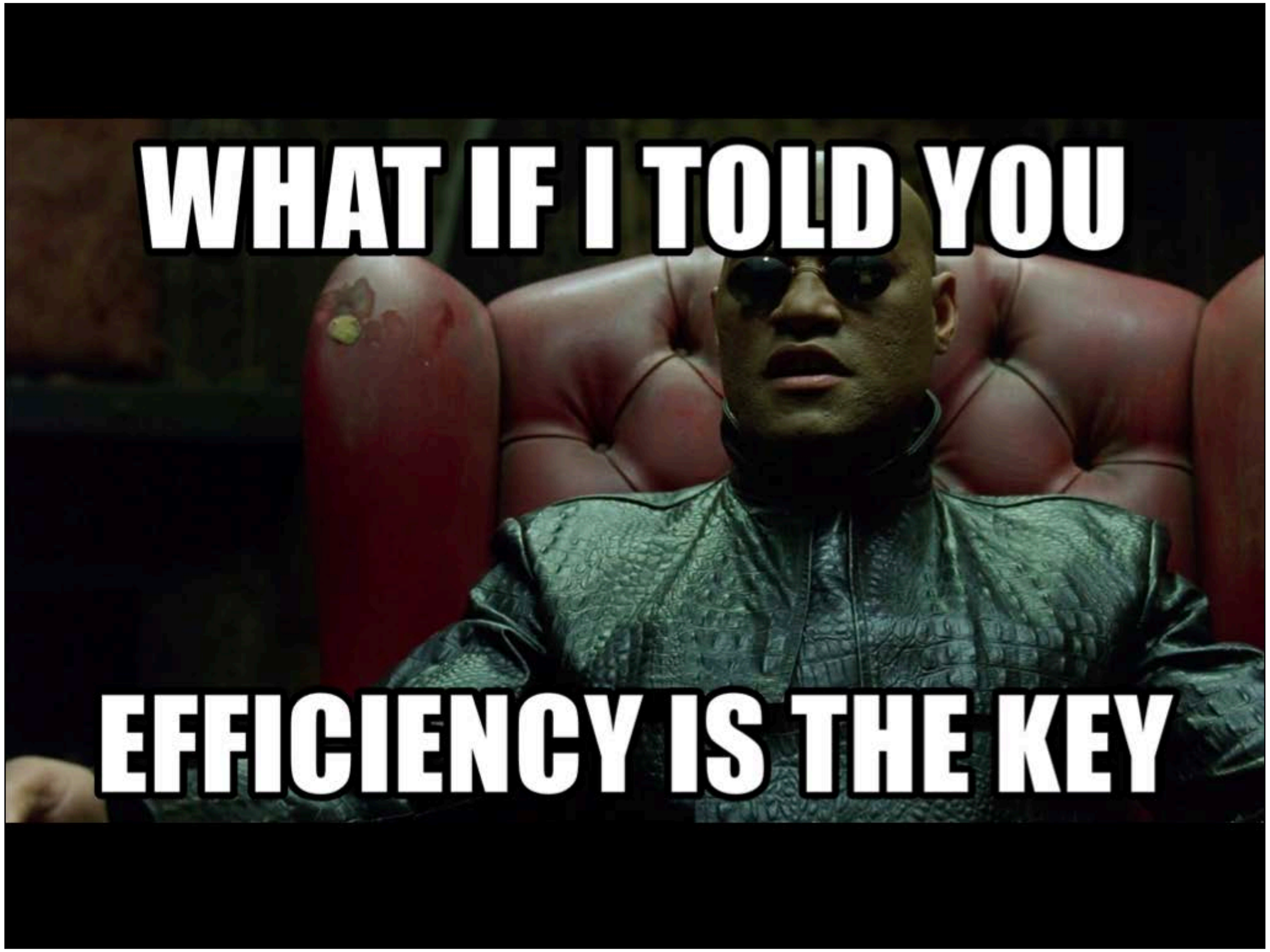
And then of course, we have to deal with a market that doesn’t want to innovate. We have to accept this. Period

1. Hydraulic systems have high power and energy losses

2. Hydraulic systems and components are expensive

3. The hydraulic industry is traditional and lacks innovation

Is it? … Let’s first take a closer look at the power losses.

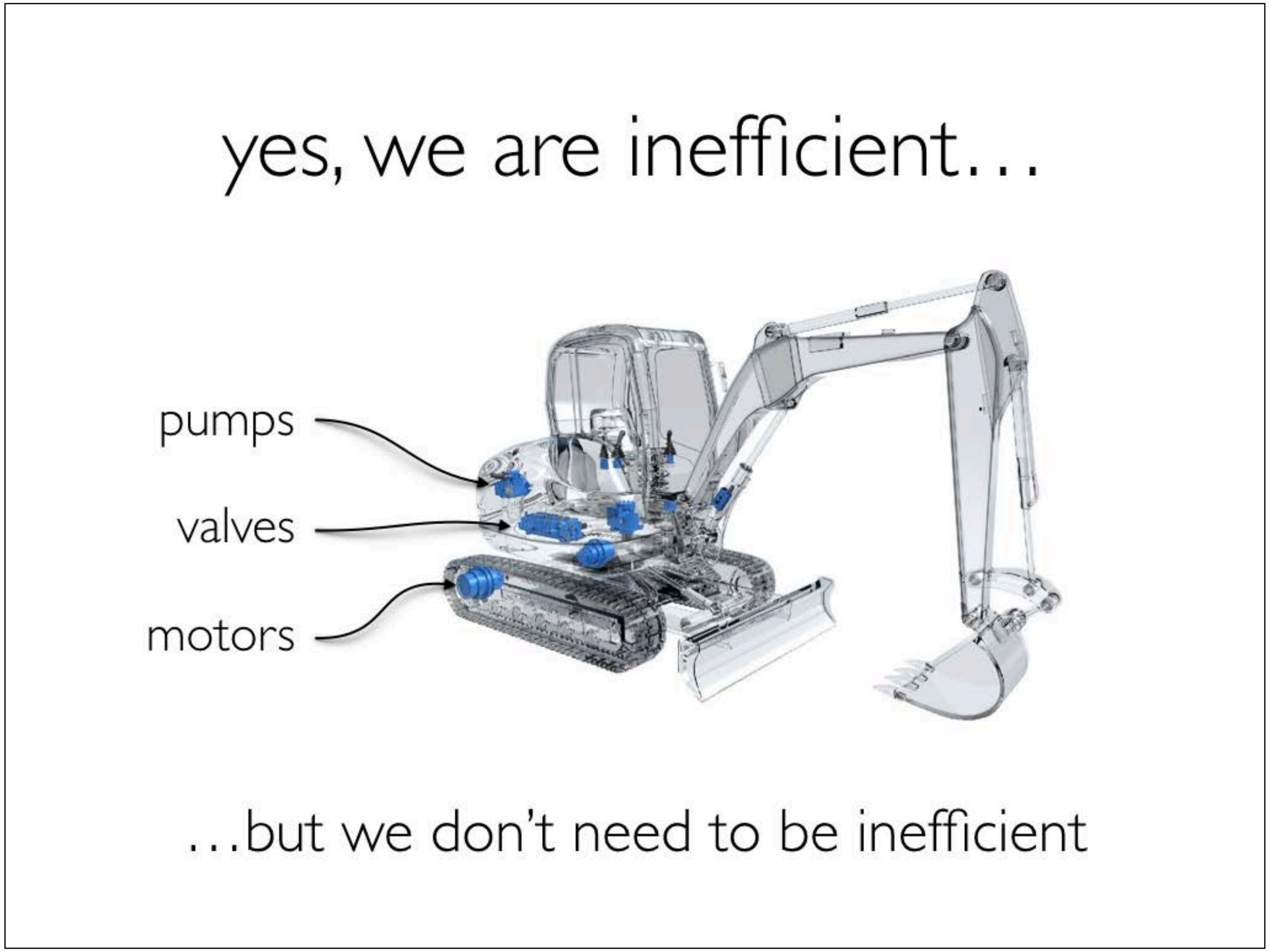


So, welcome in the world of energy efficiency. Considering the worldwide concerns about climate change and the urgency of an energy transition, this is of course an important topic.

But efficiency is not only related to CO2 and global warming. It is also about fuel costs. A poor efficiency also means more cooling. And coolers are big, heavy and expensive.

Furthermore, a poor efficiency is often caused because of high friction losses, and is thus going hand in hand with strong wear.

Efficiency, ladies and gentleman, efficiency is the key.



And yes we are inefficient. Often even extremely inefficient. It is almost unbelievable that we still exist on the market.

Our pumps and motors suck. Most pumps and most motors don't make the 90% efficiency point. In normal, average conditions, the efficiency is often below 70%.

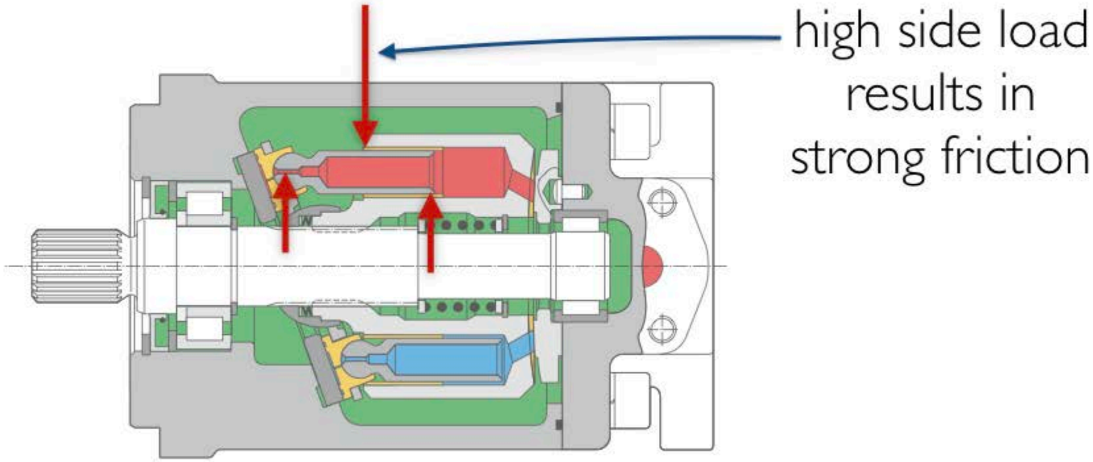
And then we have the valves. Valve control is simply control by means of energy dissipation. By definition.

But does this mean that this inefficiency belongs to hydraulic systems? That there is nothing we can do about it?

No, we don't need to be inefficient. There is no physical law, such as Carnot's law for heat engines, that tells us that we have to accept high losses. We don't need to be inefficient!

But there is no easy solution. There is no silver bullet, not just one single innovation which will suddenly make hydraulics systems efficient. There is no magic spell that will solve this issue. We need to come up with a whole range of innovations.

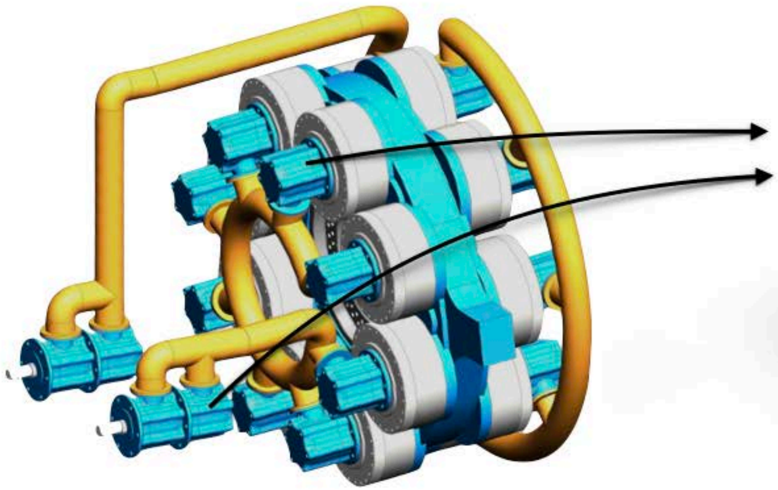
piston friction in a pump



Let me give you one example of such an innovation we are working on. The most dominant loss in swash plate pumps and motors is in the contact between the piston and its cylinder. The strong lateral forces are the main cause for high friction losses. We believe we have solved this issue.

We are currently working on behalf of a consortium called Hydrautrans, which is developing the next generation of wind turbines. The aim is that the costs of electricity produced by wind energy should be lower than produced by oil or coal. To achieve this goal, Hydrautrans has decided to replace the conventional gear box by a hydrostatic transmission.

Hydrautrans

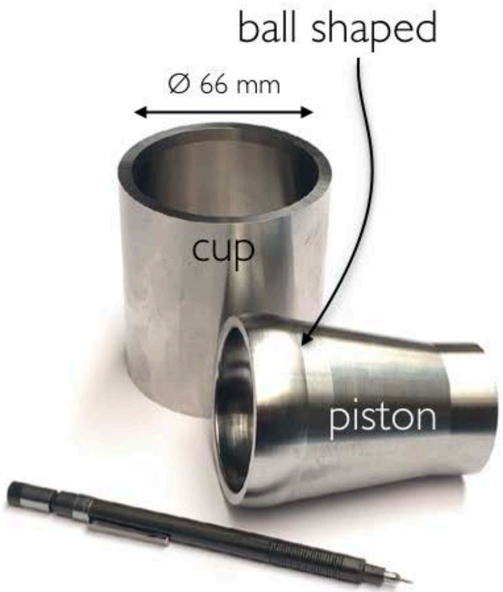


All pumps and motors in this transmission will be floating cup machines. The peak power rating of each motor is 4,2 MW. The pumps and motors have a displacement of about 5 litres per revolution.

Hydrautrans

Here you see one of the pistons and a cylinder, or cup as we would call them. Each pump and motor has 28 of these cups and pistons.

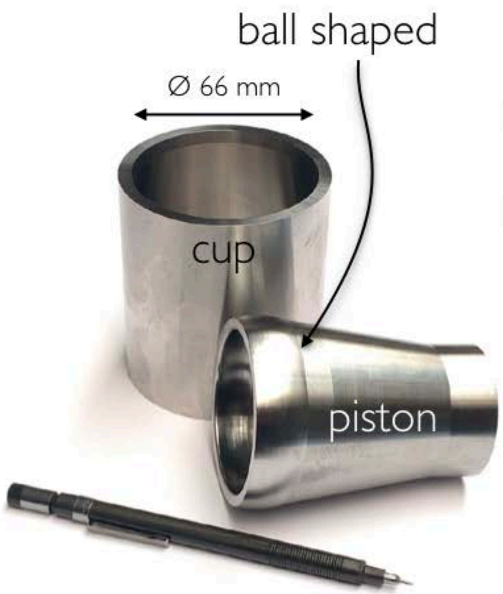
Hydrautrans



The cups have an inner diameter of 66 mm, and the pistons are about the size of a normal beer glass. The top part of the piston, the crown, is ball shaped.

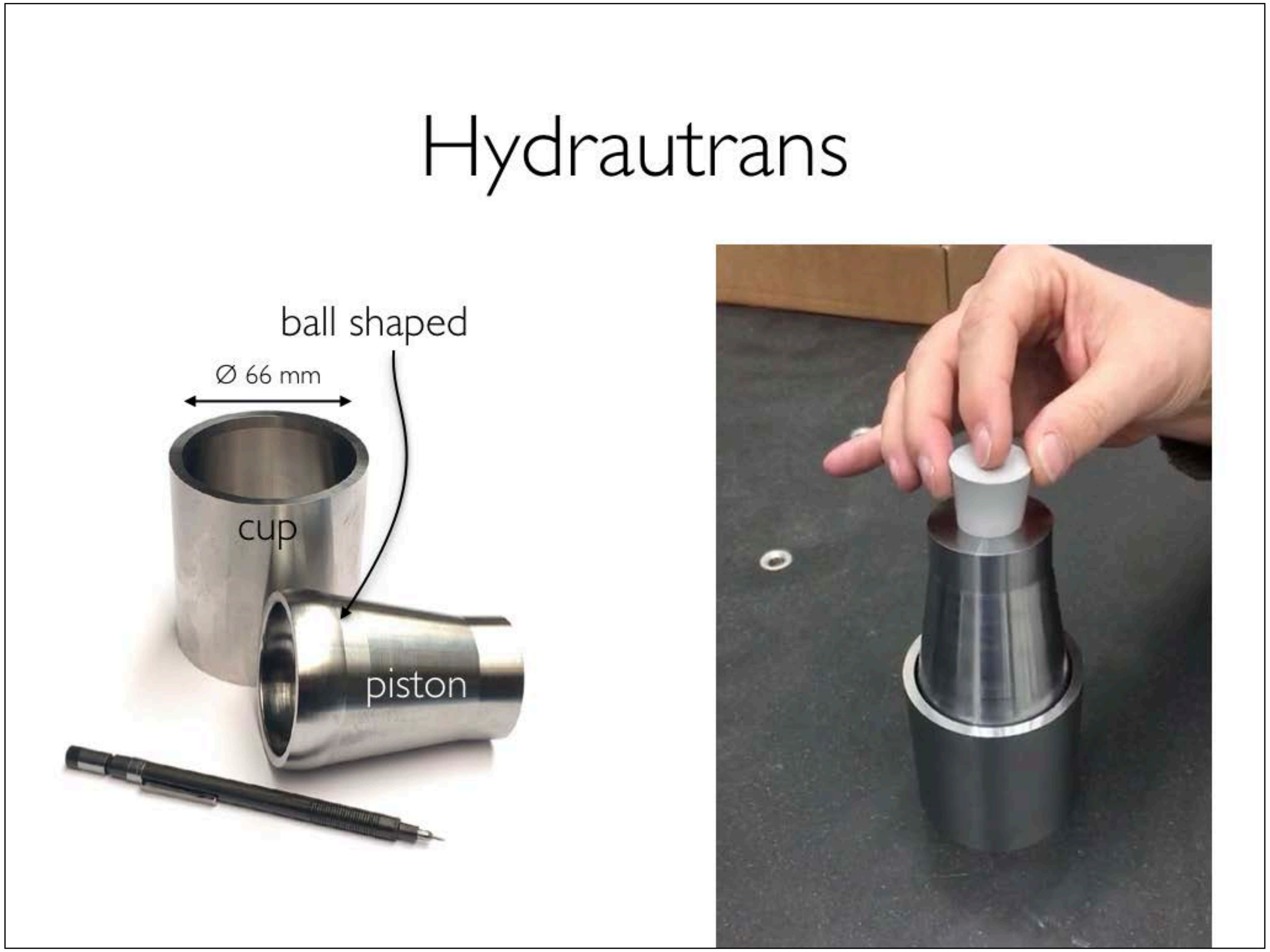
There is no piston ring: the piston is directly sealing on the cylinder wall. This only works if the sealing gap, between the ball shaped crown and the cylinder is small, about 3 micron. Also, when the components are deformed because of the oil pressure, or because of thermal deformation.

Hydrautrans



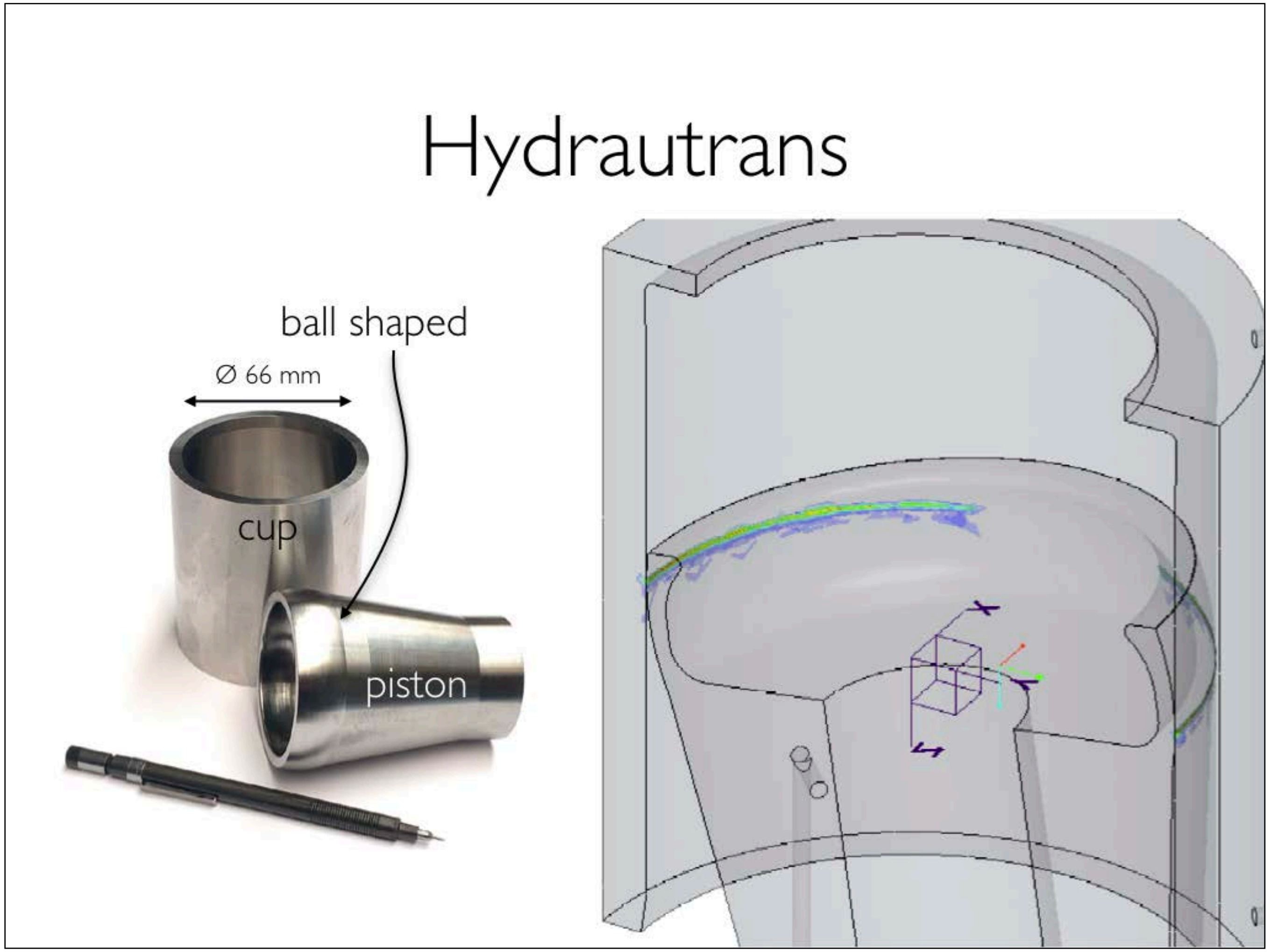
- hardened steel (62 HR)
- precision manufactured
  - inner cup cylindricity: < 2,6 µm
  - piston form deviation: < 3 µm

These parts are produced from 100Cr6-steel, which is hardened to 62 Rockwell. Despite this hardness, these parts can be machined nowadays with extreme precision:
the production tolerance was better than 3 *µ*m, in terms of roundness, cylindricity, and form shape.



This is a small movie which the manufacturer proudly showed after production: a piston is slid into the cylinder without any friction.

Then, the central bore is plugged, and the piston is now drifting of an air cushion, despite the gap between the bal shaped crown of the piston and the cylindric wall of the cup.



The next question was how this construction would behave when being pressurised. What happens if the parts get deformed by as much as 30 micron due to the pressure load?

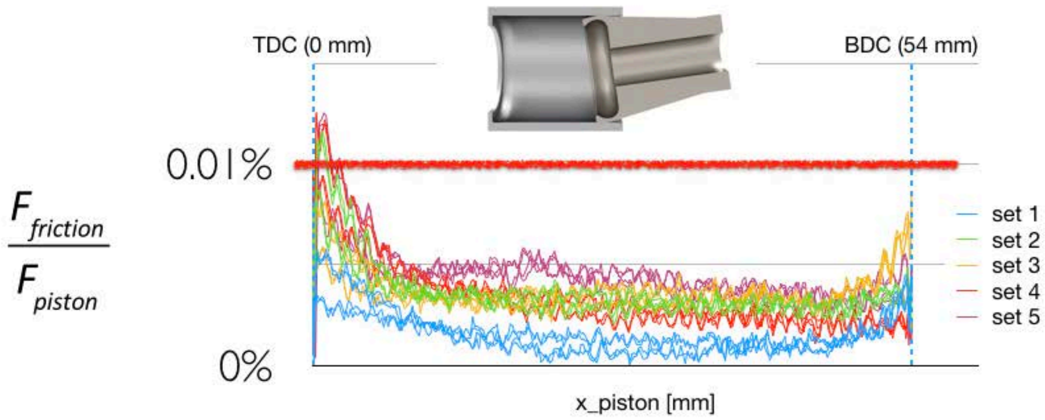
Won't the deformation of the piston crown become larger than the local deformation of the cup, which would then result in excessive friction and wear?

Test bench for measuring friction between cup and piston

We have build a special test bench to measure the friction force between the piston and the cup.

Be aware that, with a diameter of 66 mm, the piston force becomes as large as 120 kN at 350 bar

Measured friction force between cup and piston at 300 bar, 50°C



conclusions:

Friction force is negligible (≈ 0.005%)

No wear

This diagram shows the measured piston friction when the piston moves between the two extreme positions, the top and bottom dead centre. This diagram shows the traces of 5 different sets.

The friction force was around 6 N. Compared to the hydrostatic piston force, the friction is less than 0,01%, on average even below 0,005%.

These friction forces are negligible. And that is extremely good news, not only for the efficiency of the entire drive train, but also for the lifetime and maintenance costs. No friction is the essential pre-condition for eliminating maintenance costs.

I am not often proud about what we achieve, but I can't deny that I felt very proud a few weeks ago, when, at the Bauma, Bucher Hydraulics presented their new pump and motor line. Based on our floating cup principle.

They call it a revolution.

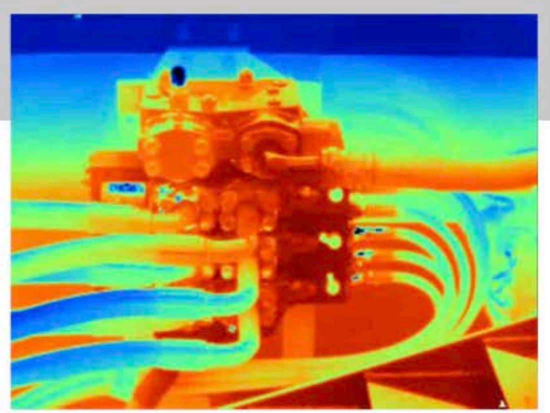
applications of floating cup pumps

Electro-hydraulic actuators

And at the same Bauma, the first applications of these machines were also presented.

Both machines are fully electric and battery driven. The new floating cup pumps from Bucher were applied in the electro hydraulic actuators

What about valve losses?



But the losses in pumps and motors are peanuts when compared to the losses in our valve blocks, our load sensing valves and pressure compensators. So what to do about these losses?

Valve control
needs to be replaced by
displacement control

The answer is simple. There is only one solution, and that is that valve control needs to be replaced by displacement control.

displacement control

- Electric power distribution
  - electro-hydraulic actuators
- Mechanical power distribution
  - individual pump control
- Hydraulic power distribution
  - secondary control and hydraulic transformers

There are three ways of doing this, by three different means of power distribution:

The first option is by means of electric power distribution. Hydraulic systems are reduced to the minimum. Sometimes this system is referred to as zonal hydraulics.

The second option is based on mechanical power distribution. Instead of having one pump supplying oil to several loads, in this system, each load is controlled by its own variable displacement pump. The power to drive these pumps is distributed through mechanical transmissions, or by stacking pumps in line.

In the third and last option, the energy is distributed via a hydraulic power line, a common pressure rail. This system needs so called secondary control and hydraulic transformers.

Now, I won't discuss the mechanical option any further in this presentation. I simply have no confidence in using multiple variable displacement pumps to compete with the other two options.

displacement control

- Electric power distribution
  - electro-hydraulic actuators
- Hydraulic power distribution
  - secondary control and hydraulic transformers

So that leaves us with two choices: one based on electric power distribution, and one based on hydraulic power distribution. Let's look a bit more in detail at these two options.

Electro-hydraulic actuators

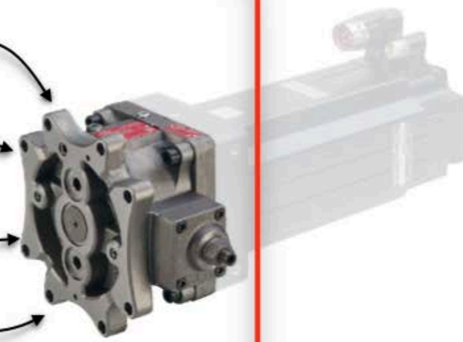
Operation 0…6000 rpm

low friction, also at n ≈ 0 rpm

low leakage

low noise and pulsations

four quadrant operation



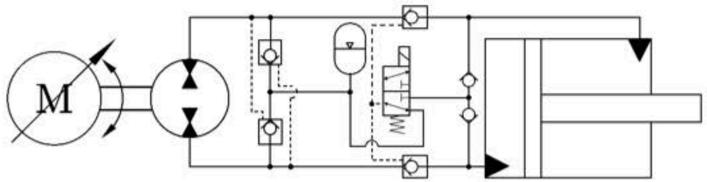
needs to be developed

First the system with electric power distribution. This option needs electro-hydraulic actuators, which need a special kind of hydrostatic unit, which should be able to fulfil these demands:

- The pump should be able to run in a wide range of operating speeds
- The friction losses should be low, also at close to zero speeds
- The leakage losses need to be low as well, in order to reduce the dead band and non-linear behaviour
- The pump must have low noise and pulsation levels
- and if possible, it should be able to work in all four quadrants, that is in both rotational directions and also as a pump and as a motor

These machines are not yet available on the market: they need to be developed

Electro-hydraulic actuators



- Each actuator needs its own cooler and filter
- Accumulator is needed
- Complicated control

What I like about this system is that it is a modular approach. This development will for sure benefit from the main trend to electrification.

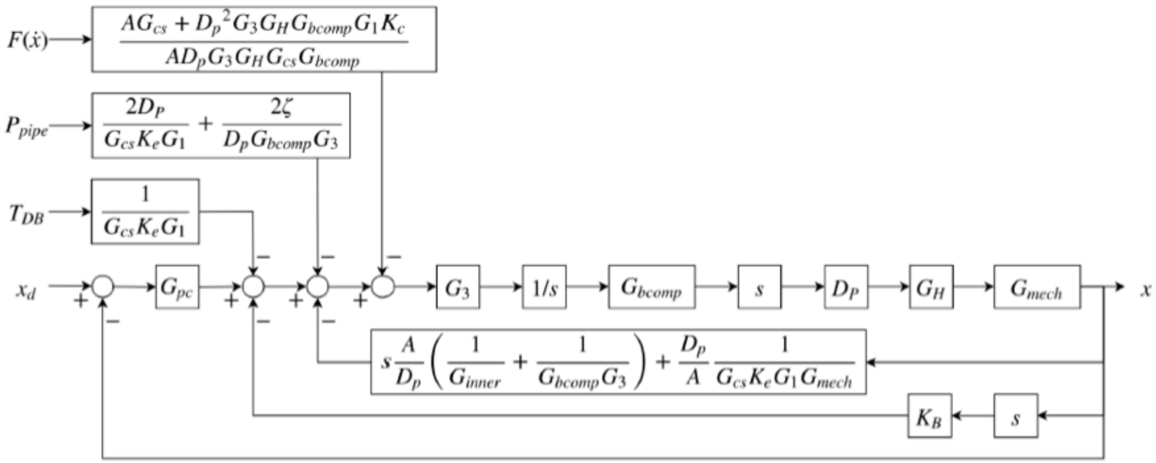
But electro-hydraulic, speed controlled actuators are by no means simple.

Each actuator has its own miniature hydraulic circuit, being isolated from the others. So each actuator needs its own reservoir, filter and cooler

The reservoir is often an accumulator, not for energy recuperation, but to avoid cavitation for the 4 quadrant pump/motor operation

And since we have friction and leakage, the system is often non-linear and suffers from dead band

Electro-hydraulic actuators



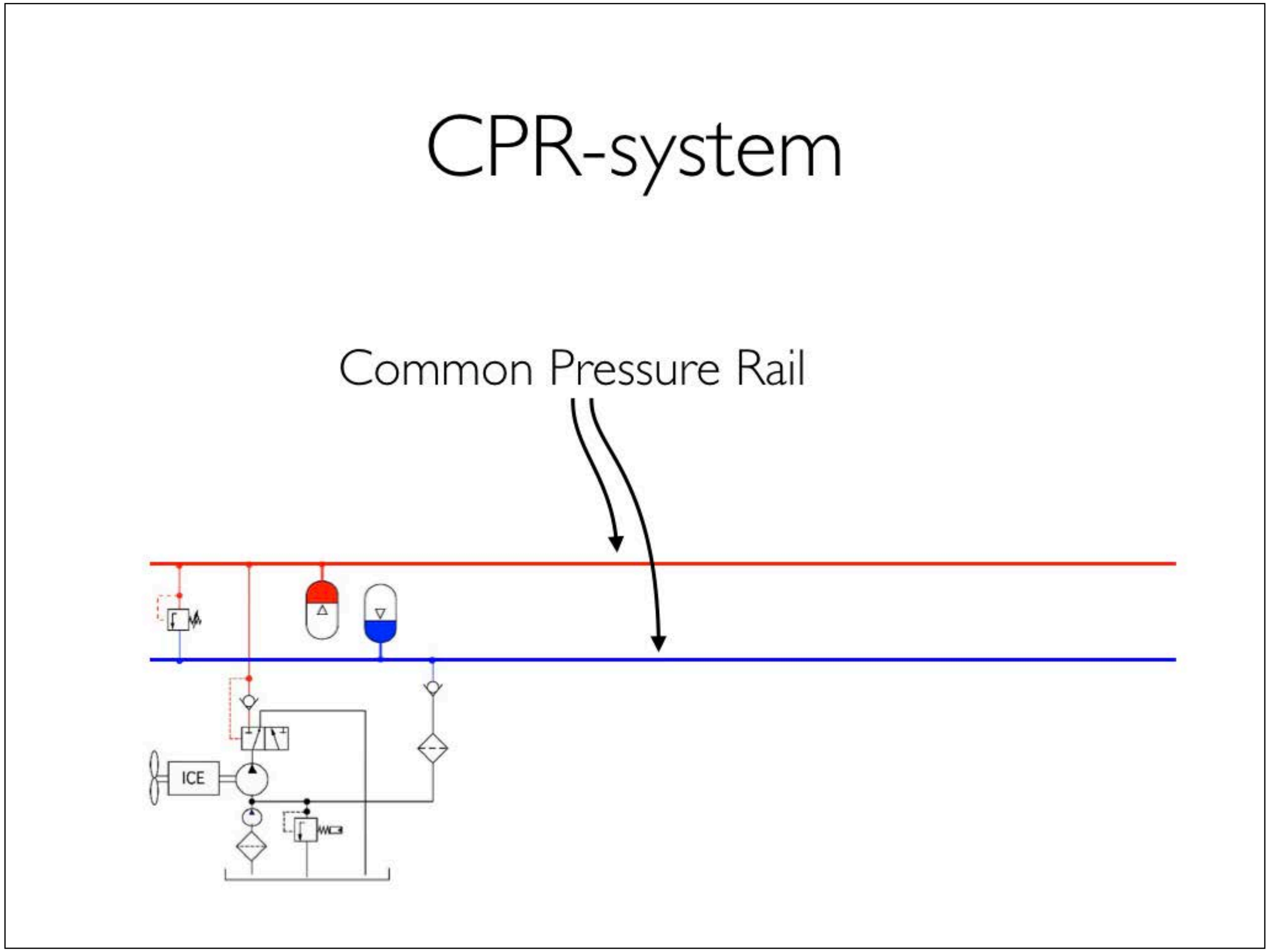
The control system can be rather simple, at least if you don't need a fast controller, and if accuracy is not an issue.

But the market demands accuracy and high dynamic performance. And thus you will need multiple inner- and outer loop controllers, backstepping sliding mode controllers, … and other advanced control technologies.

My main concern about these systems is, that the system essentially is velocity controlled or speed controlled, which makes the system jerky.

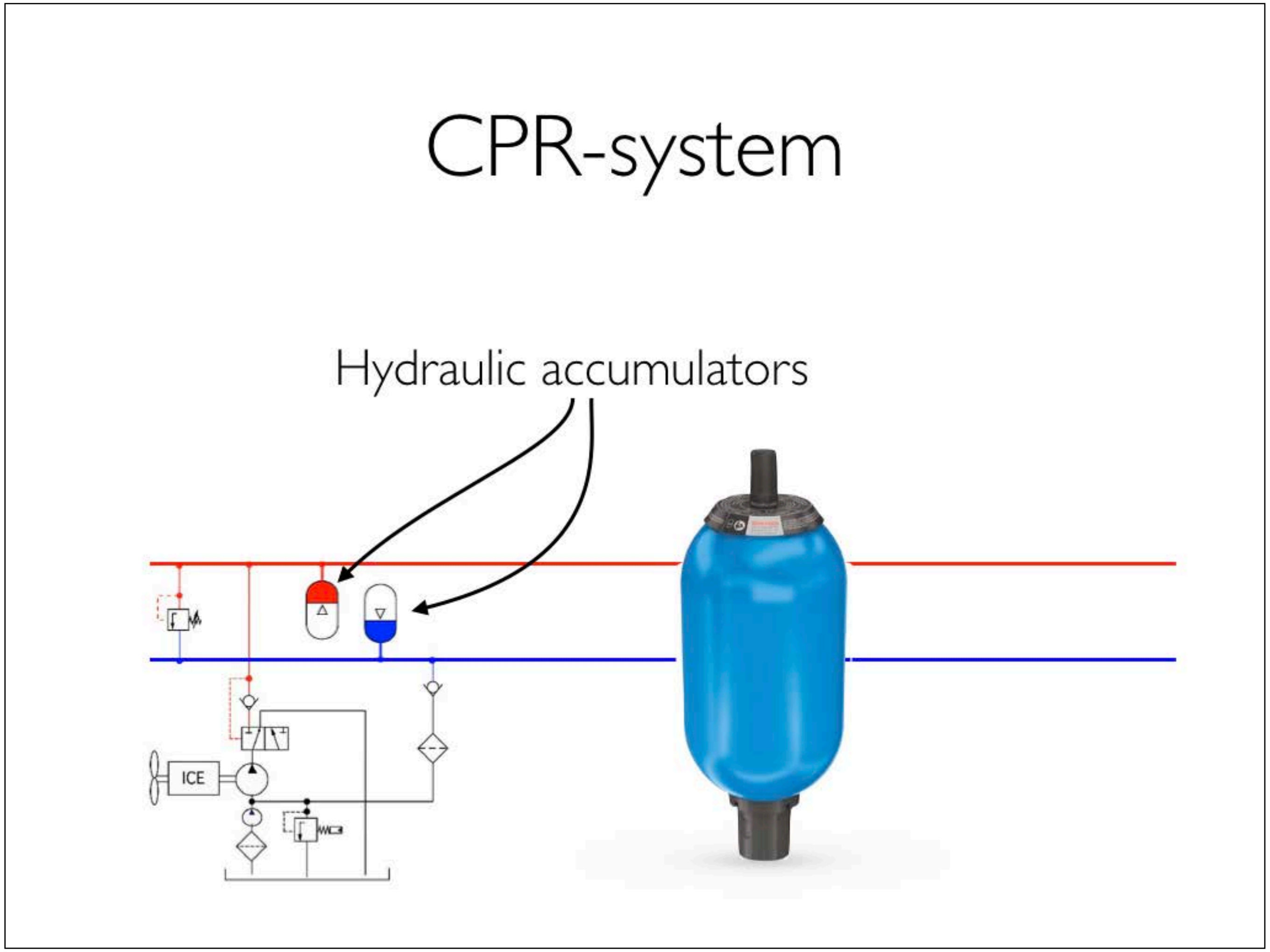
In the case of a hydraulic power distribution, the power is supplied via a common pressure rail, or CPR.

Some years ago we performed a study together with Volvo CE, in which this loader was evaluated as an application for such a CPR-system.



The common pressure rail is the backbone of this system. You can compare it to the electric power grid in you home, which has the same voltage at all plugs. In this system, all loads receive the same common pressure.

This picture shows an internal combustion engine as the main power supply. This doesn't need to be. By separating the loads from the power supply, you have complete freedom in choosing the power source. It can also be a battery driven electric source.

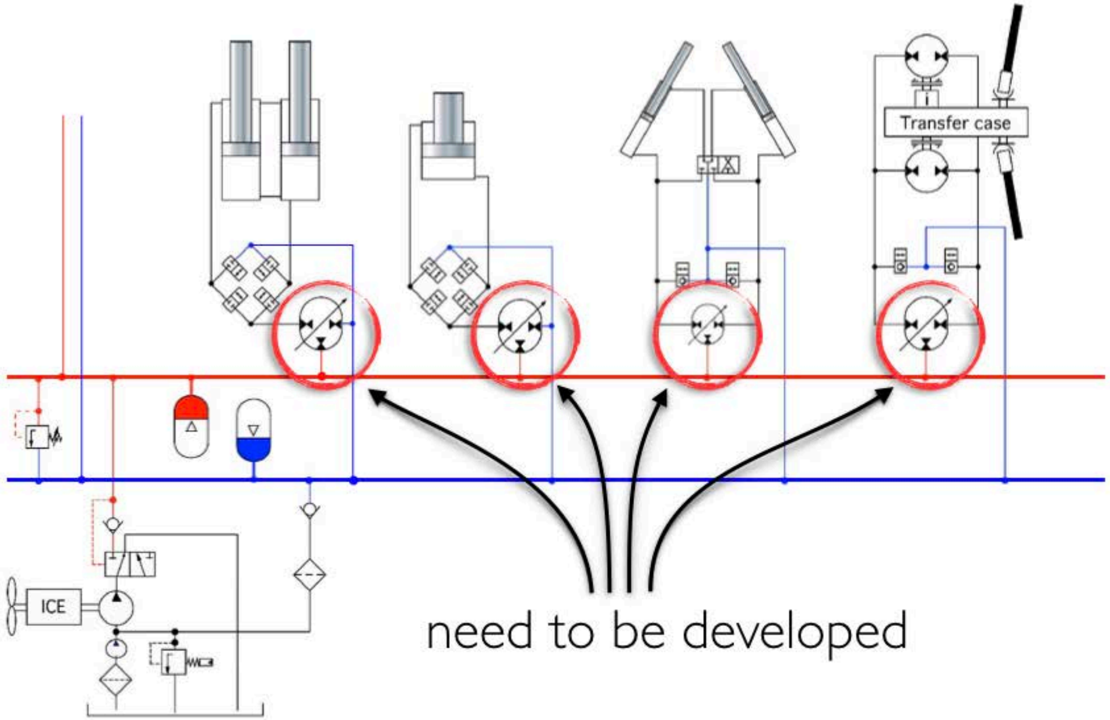


It is not a constant pressure system. Essential for this system are the hydraulic accumulators. And since the pressure level in the accumulator varies, the CPR-system is not a constant pressure system.

Whenever I make a SWOT-analysis for companies on hydraulic systems, the hydraulic accumulator is my favourite asset. You can't store much energy, but for many applications you don't need a lot of energy to be stored.

What most applications need is power management. And the hydraulic accumulator is the best super-capacitor in the world.

CPR-system



CPR-systems need hydraulic transformers. And they are not readily available on the market. We have a job to do.

CPR-system

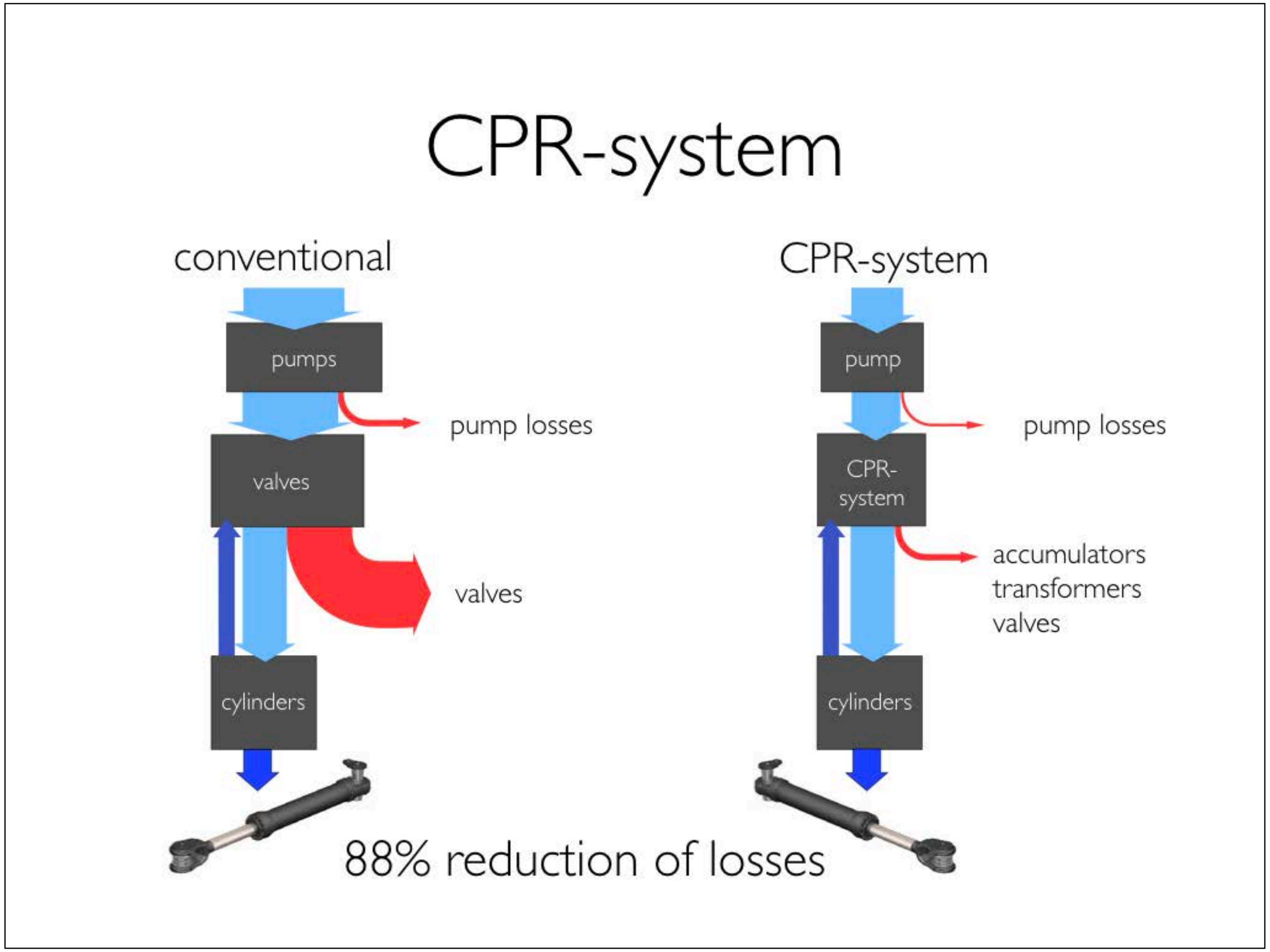
- one cooler, filter and reservoir for the entire system
- hydraulic energy recuperation by means of hydraulic accumulators
- pressure control
- acts on the acceleration, not on the velocity

Unlike the systems with electric power distribution, the CPR-system has a common hydraulic system, which basically needs only one reservoir, one cooler and one place to filter the oil.

The CPR-system offers excellent opportunities for energy recuperation and power management.

The control is not based on velocity or flow control, but on pressure or load control.

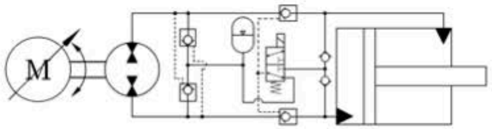
You are controlling the acceleration, not the speed, which greatly enhances the accuracy



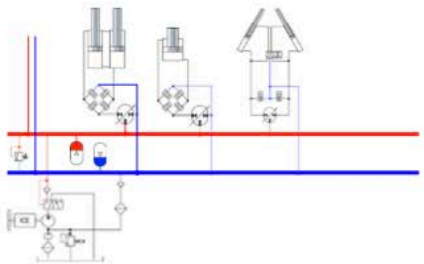
CPR-system are extremely efficient. Compared to the conventional valve control, the losses can be reduced by nearly 90%.

displacement control

- Electric power distribution



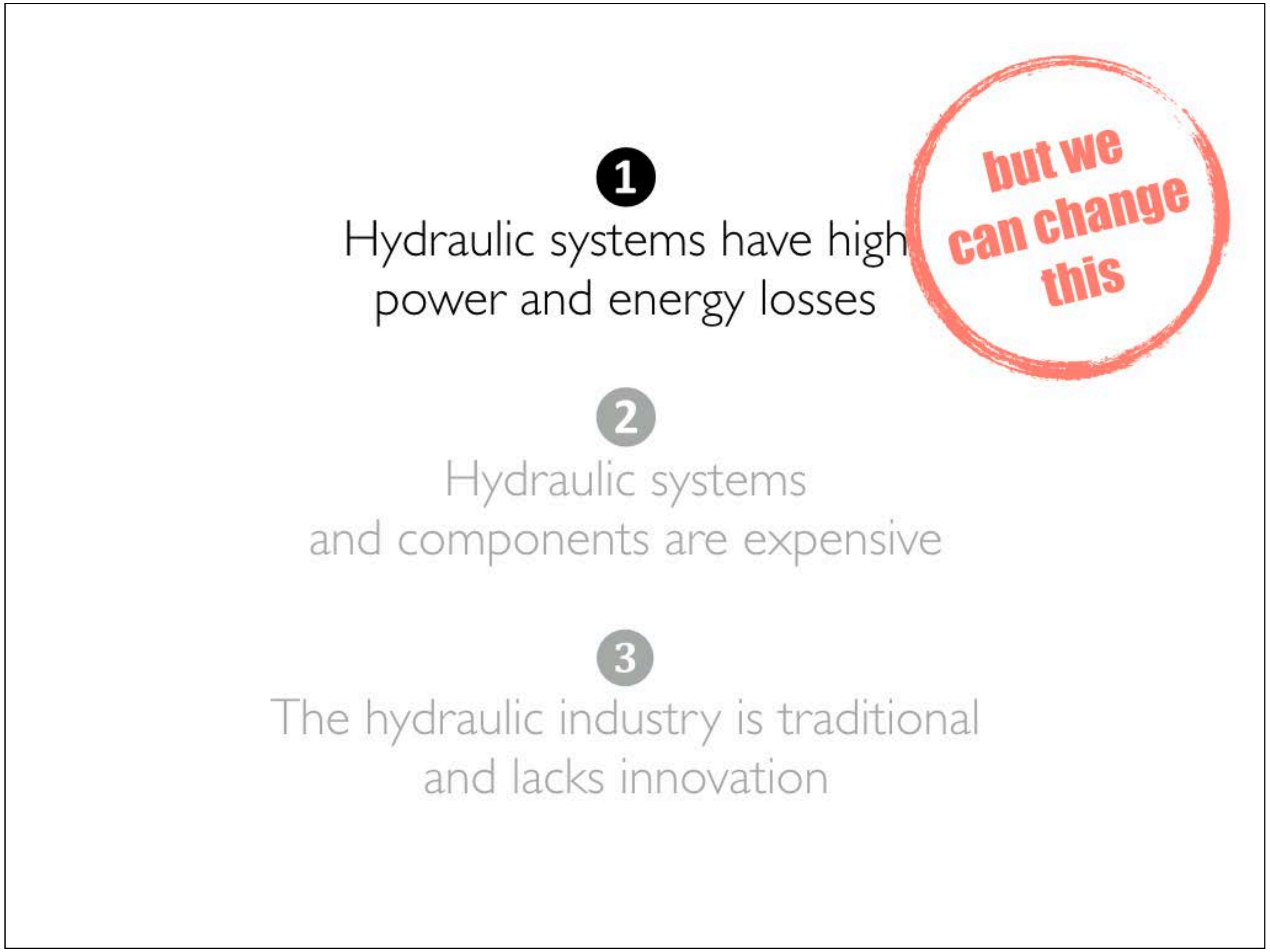
- Hydraulic power distribution



I don't know which system approach will win in the future: the one with electric power distribution, or the one with hydraulic power distribution.

Whatever system you choose, both offer tremendous advantages in terms of energy efficiency and power losses.

Actually, I don't care which system wins. But I care about the OEM-industry. I care about solving their problems. They will make the choice.



Indeed, most hydraulic systems and applications suffer from poor efficiencies and high power losses.

But, one conclusion is certain: the poor energy efficiency is not a necessary evil. It is not a law which is carved in stone.

We know we can change this. Inefficient hydraulic systems are a meme. Just like the meme that says that climate change is a hoax.

How about the second topic on this list?: costs.

Now most engineers, at least in academia, don’t know anything about costs. But without economic feasibility, nothing will be accepted by the industry. Unless you are selling electric vehicles I guess.

This is the best internet meme I could find about costs. Aside from being funny, it emphasises that economic decisions are not only about procurement or investment costs, but that costs are also related to quality.

Why are hydraulic systems expensive?

- Poor efficiency results in high energy costs

For instance, quality in terms of energy costs. We discussed this before: hydraulic systems are inefficient, and therefore result in high energy costs.

Why are hydraulic systems expensive?

- Poor efficiency results in high energy costs
- Poor designs result in strong wear and high maintenance cost

We think that hydraulic systems are robust, but the high friction losses also result in strong wear and high maintenance costs.

Why are hydraulic systems expensive?

- Poor efficiency results in high energy costs
- Poor designs result in strong wear and high maintenance cost
- convoluted system designs

Trouble shooting is often almost impossible, because many hydraulic systems are so convoluted.

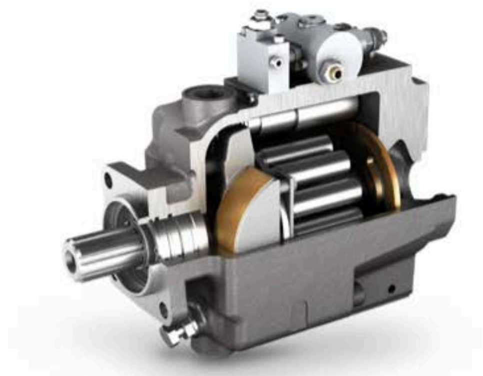
Why are hydraulic systems expensive?

- Poor efficiency results in high energy costs
- Poor designs result in strong wear and high maintenance cost
- convoluted system designs
- High labor cost in manufacturing

And then, finally, our component costs are high, for a part because of the high labor cost to manufacture these components.

High labour cost

In my career I have been visiting many hydraulic industries around the world. Some very modern, most rather old fashioned. And all of them, including the new factories, had one thing in common: high labour costs.



housing	housing
bearings	bearings
shafts	shafts
highly stressed precision parts	highly stressed precision parts
13 €/kg	>40 €/kg

I have often shown this comparison between a gear transmission and a pump. Both are very similar from a construction point of view:

- both need a housing
- some roller bearings;
- one or more shafts;
- and both machines have some highly stressed precision parts

But, despite all these similarities, the gear transmission only costs 13 Euro per kilogram, less than one third of the specific production costs of a piston pump or motor.

The explanation is in the labour costs. The pump industry has much higher labour cost than the gear transmission industry or the automotive industry.

cost reduction potential

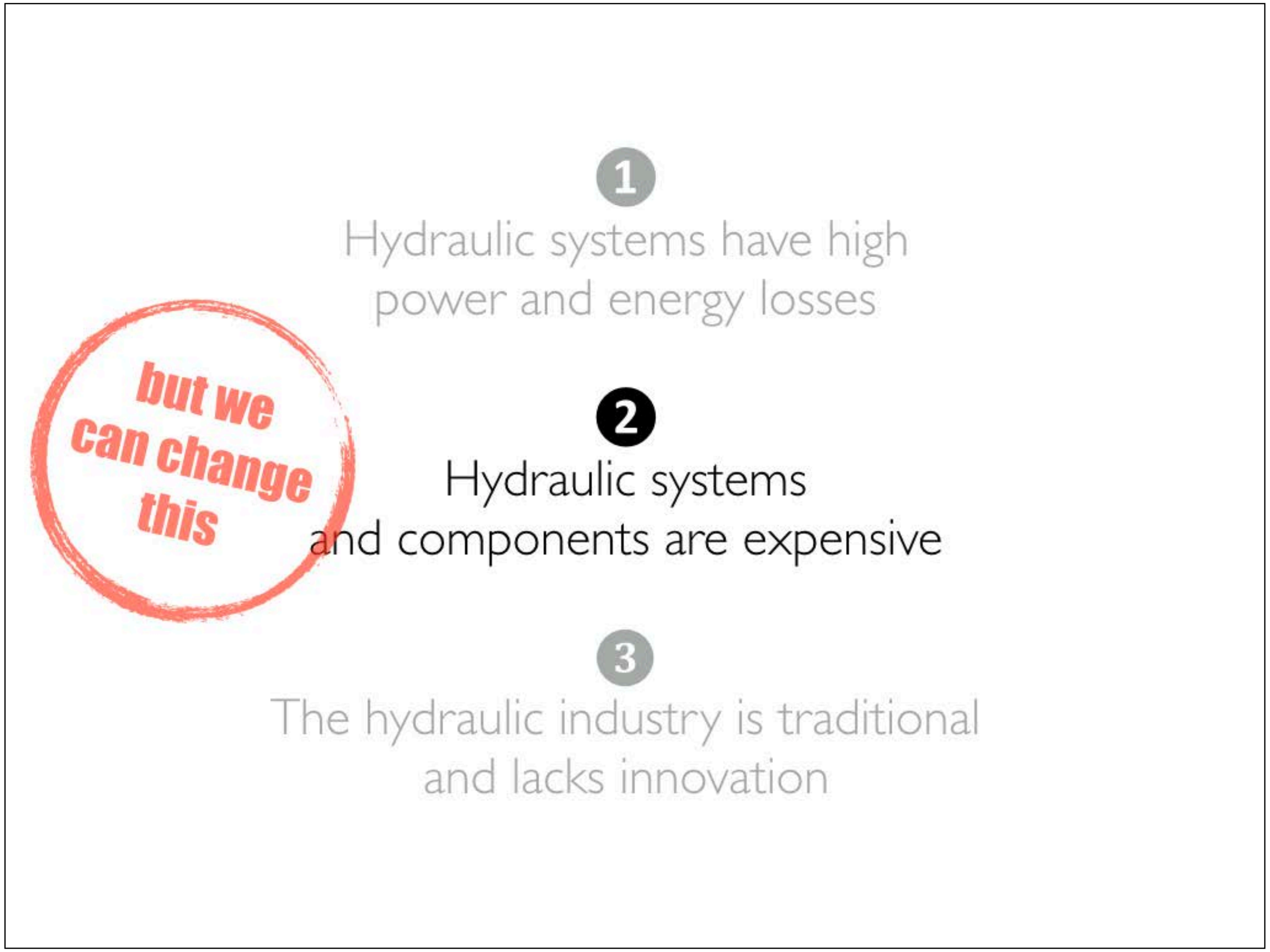
- new designs of components and systems
- reduction of coulomb friction and impact wear
- system design on the basis of modules
- distributed control on the basis of a power grid

The hydraulic industry has an enormous cost savings potential. But we need new systems and components to harvest this potential.

But, we also need to create new designs which have less coulomb friction and impact wear, thus reducing maintenance costs.

Furthermore we need to come with systems which have a modular design. Modules have the advantage that they have a clear definition, which allows to make larger production volumes.

And the only way to do this is by having distributed control systems on the basis of a power grid.



We can do this. And if we do, we will open up and create enormous market opportunities.

1

Hydraulic systems have high power and energy losses

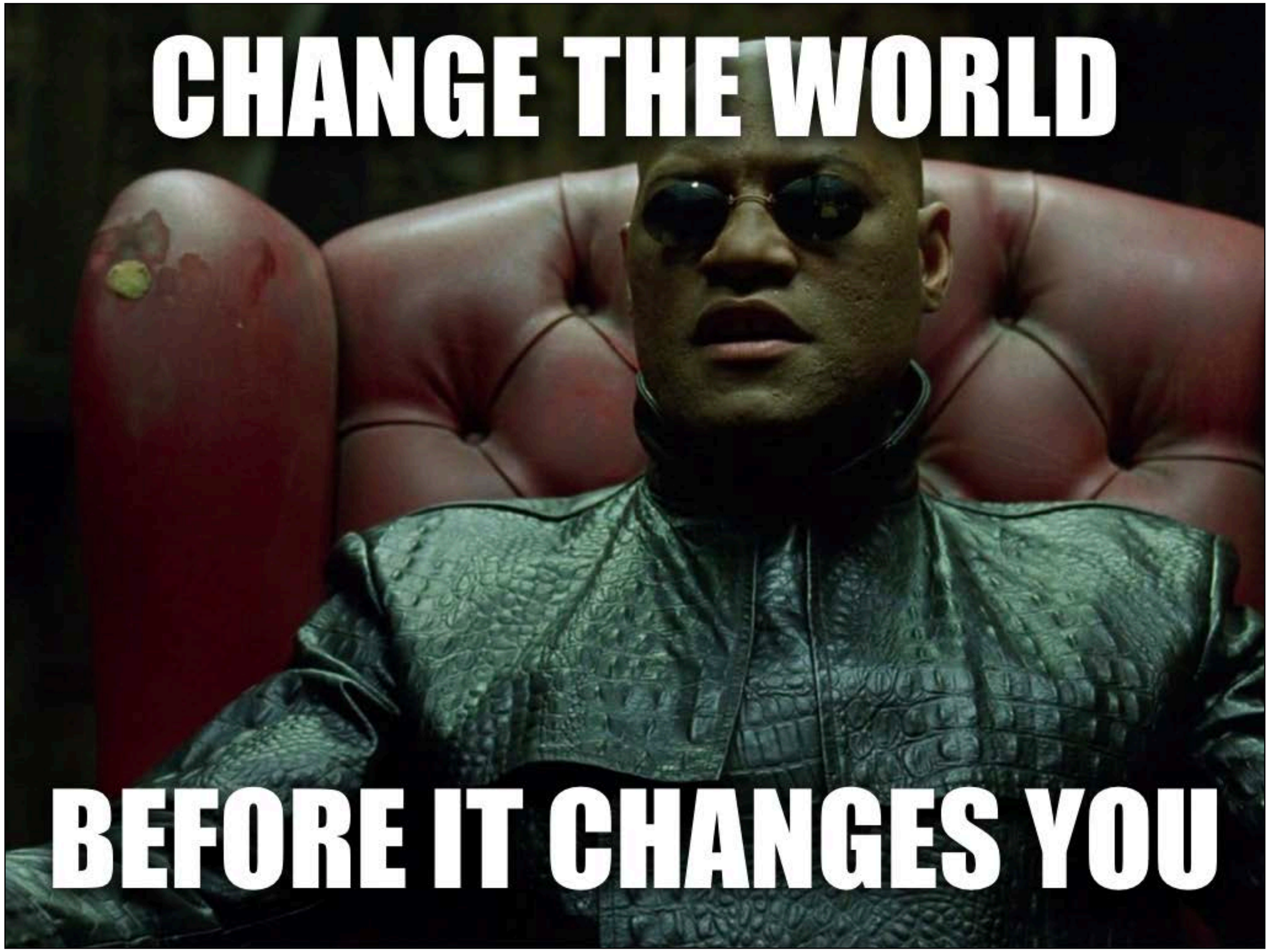
2

Hydraulic systems and components are expensive

3

The hydraulic industry is traditional and lacks innovation

And now, the third and most important meme.
It's the thought that we can't change.



But we have to. If we don't change, then the world will change us. Darwin didn't say that the strongest will survive, but the fittest, the one that can adapt to the changing environment.

This year I visited the Hannover Fair and the Bauma. Everywhere I saw new innovations and new products,…

No new products

…but only a few in hydraulics.

Let me give you an example. This is a pump we recently replaced in one of our test benches. It turned out to be 50 years old.

Now…in 50 years, we have seen many changes.

- Our phones have been transformed beyond recognition.
- Our TV-sets have become ultra-thin, colourful, multimedia, internet devices.
- Our cars still have 4 wheels, …but that's about the only thing that hasn't changed.

- In 50 years, gear transmissions have changed,
- washing machines have been revamped,
- and even prams have been completely redesigned.

When I started to study at the technical university, we were trained to make our designs and drawings on drafting tables, like this one.

My first computer programs were written on punch cards.

At the university, I started with a simple slide ruler, which was replaced in the second year by this wonderful pocket calculator, which you could even program.

My photo's were made an analog camera with a film which needed to be developed, and I listed to music being recorded on these cassette tapes

Nothing of this exists today. Everything has been replaced by new products and technologies.

in 50 years…

But then our pumps…. They stayed the same in the past fifty years…. Well… the colour has changed.

some promising developments

- Independent metering
- Digital fluid power
- Digital Displacement pumps
- Floating Cup pumps and motors

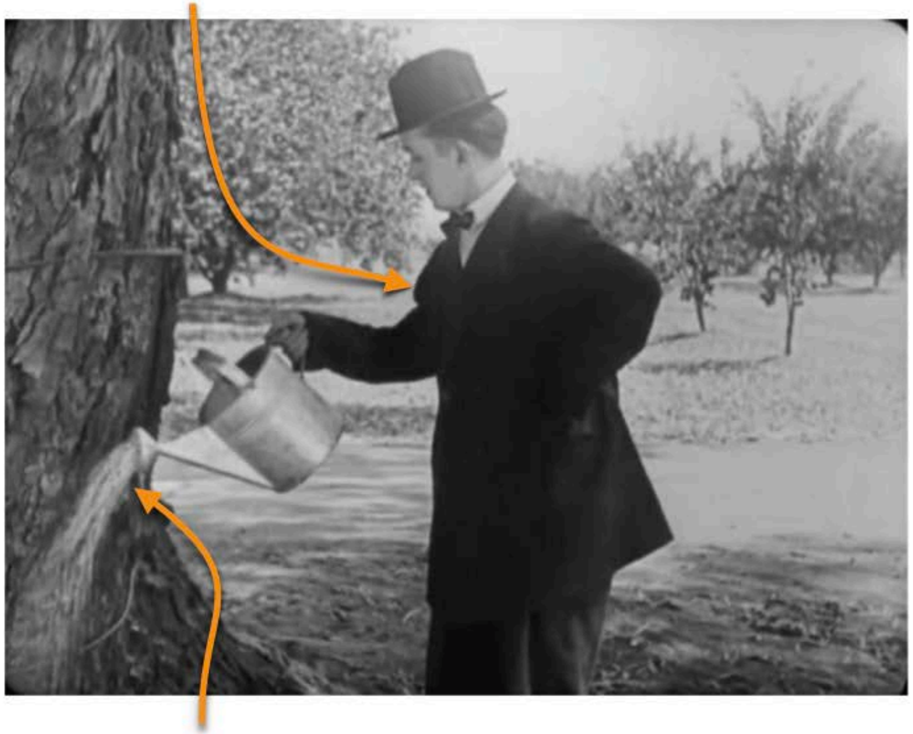
…but it's not enough

It is not that we don't do anything. There are some promising developments such as

- independent metering
- and digital fluid power
- I am also very pleased that Danfoss has decided to take the digital displacement pumps from Artemis into production
- and that Bucher Hydraulics is now producing floating cup pumps and motors

But… it's not enough.To illustrate what I mean, I want you to look at a small movie:

this is us



and this is our fluid power R&D-effort

This ladies and gentleman, this is us, and this is our R&D effort

… it's not enough

It is not enough. We need to come with a new plan to do more, if possible together.

At the beginning of this presentation, I mentioned that I want us to have a discussion about research priorities. Let me tell what I believe we can do. No, let me correct this: This is what I think what we need to do.

this is what we need to do:

- design and develop distributed control systems based on modules:
  - electric power distribution
  - hydraulic power distribution
- emphasis on
  - reduced power losses
  - reduced cost
  - improved control

We need to design new hydraulic systems and components. We have two flavours:

- systems based on electric power distribution
- systems based on hydraulic power distribution

It is absolutely clear that the emphasis should be on:

- reduced power losses
- reduced costs
- and improved controllability

The market needs and demands efficient accurate and stable control solutions, and especially faster controls.

this is what we need to do:

- Reduce the oil volume to be controlled
  - increased stiffness
  - improved control

In order to fulfill the need for more dynamic systems we have to reduce the amount of oil between the control actuator and the load. This is needed to increase the local stiffness of the hydraulic system.

this is what we need to do:

- Reduce the oil volume to be controlled
- Reduce the losses in components and systems
  - new pumps, new motors, avoid valve control

We will need to develop new, efficient components, and avoid valve control as much as possible.

this is what we need to do:

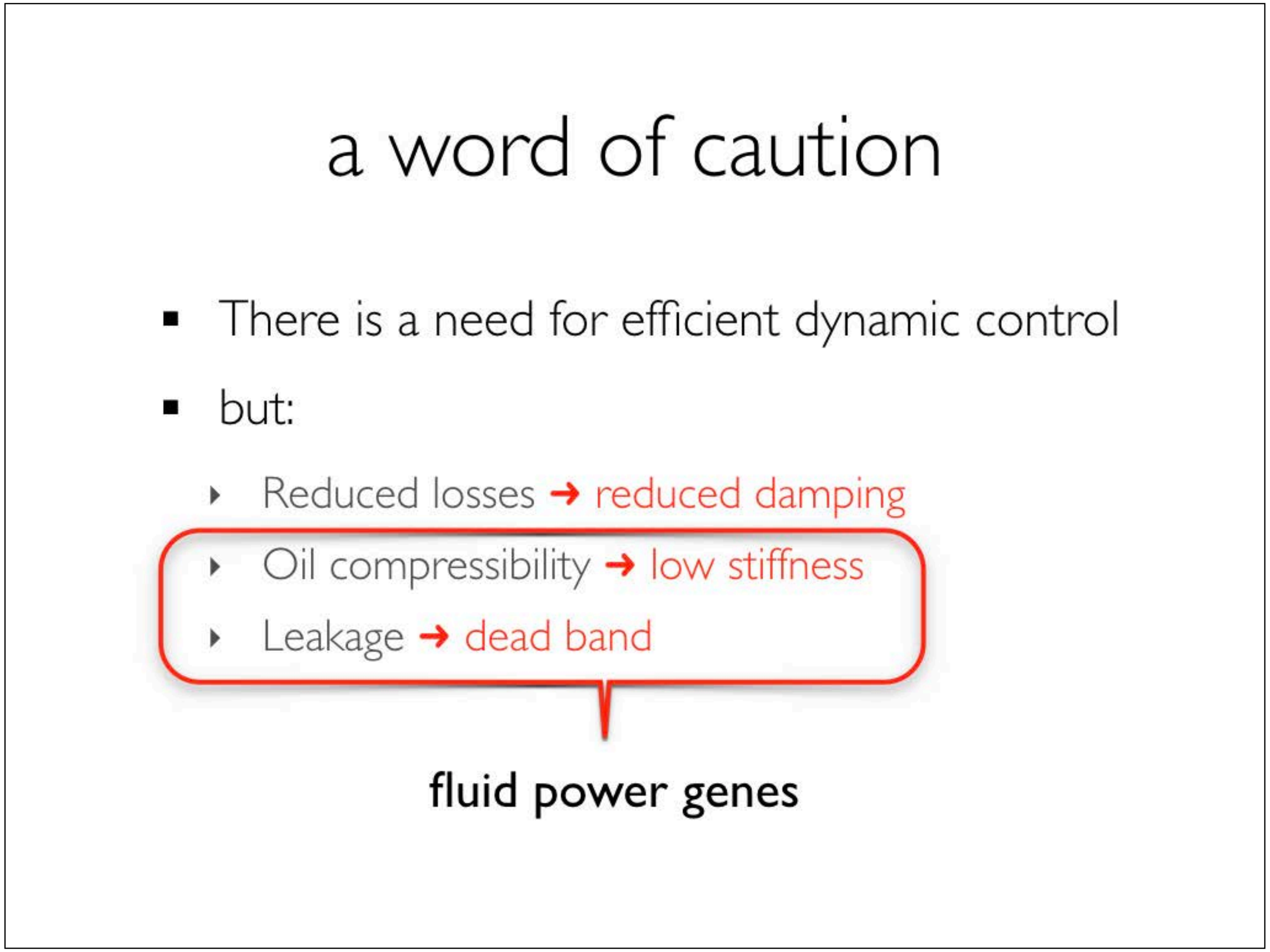
- Reduce the oil volume to be controlled
- Reduce the losses in components and systems
- Create modules
  - electro-hydraulic actuators
  - hydraulic transformers

And we have to think again in terms of modules: hydraulic cylinders having their own individual force and position control. This demands the further development of electro-hydraulic actuators and hydraulic transformers.

this is what we need to do:

- Reduce the oil volume to be controlled
- Reduce the losses in components and systems
- Create modules
- Utilize the strength of fluid power

If we can achieve all of this, then we simply have to utilize the strength of fluid power.



But, there is a word of caution. The world, our market, is looking for efficient dynamic control. I believe we can play an important role and offer many solutions, also for future demands. but there are some challenges, some caveats to deal with:

One of the advantages of valve control is that, with todays valve controlled systems, you have a lot of damping in the system. Once you replace the valve control by a more efficient system, you will miss the damping and the systems become much more prone to oscillations;

Furthermore, please remember that oil is compressible, and that this results in a reduced stiffness

And that we have internal leakage. Also this leakage often results in control problems and issues

This is were we have to deal with, this is the very essence, the genes of fluid power

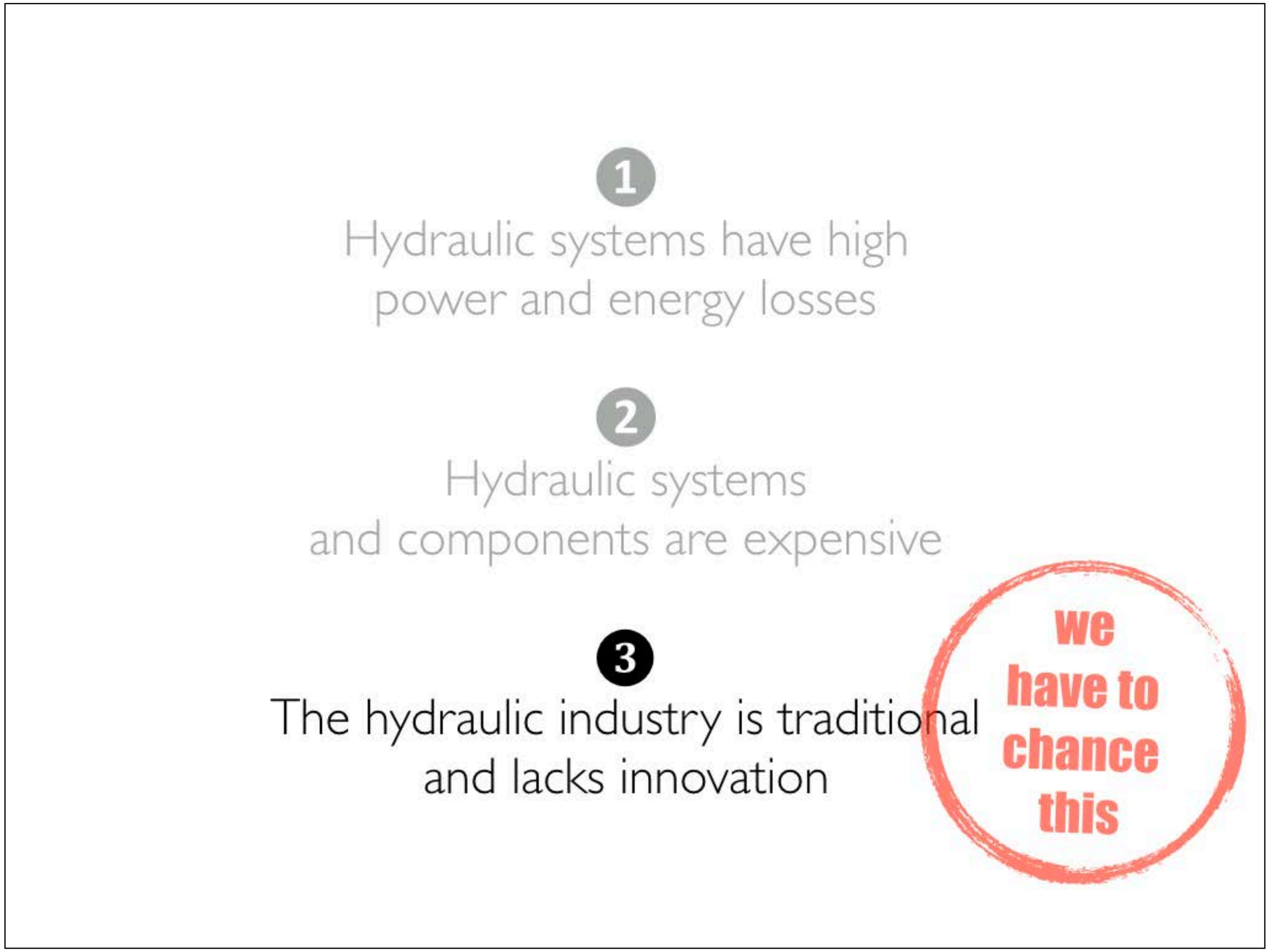
If we can achieve this renaissance of fluid power technology, then the hydraulic industry has an an enormous potential:

The current hydraulic market is a niche market. The pump and motor market has an annual worldwide turnover of around 7 billion.

The market of electric motors and generators is much bigger, around 112 billion Euro.

The biggest market is currently for mechanical transmissions, having a volume of around 160 billion Euro.

My opinion is not to compete with electric systems, but with mechanical systems. I am convinced that we can have a large part of this market if we can reduce the costs of our systems and components.



So let’s come back to our third topic on our list: the complain about the lack of willingness to innovate.

I don’t care about the question whether the industry is conservative or whether we are traditional. My response to this is rather simple: we can’t stay behind. We can’t afford being conservative or traditional. I care about change and innovation. The question is not if we can change this. No, it’s the certainty that we have to change this.

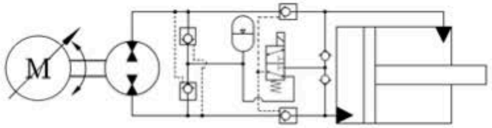
- GENES
  - The things we can't change and have to live with both good and bad
- MEMES
  - The things that we believe we can't change
  - but which we can change
  - and which we should change
  - Now

So where are we?
I have explained to you that hydraulic systems have some specific characteristics, which make them different from mechanical or electric systems. We have to accept these, and use them, if possible to our benefit.

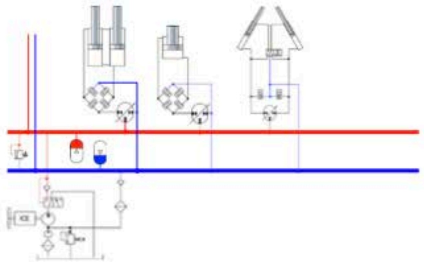
And then we have the memes: the things we believe we can't change, but which we can and should change. Now.

displacement control

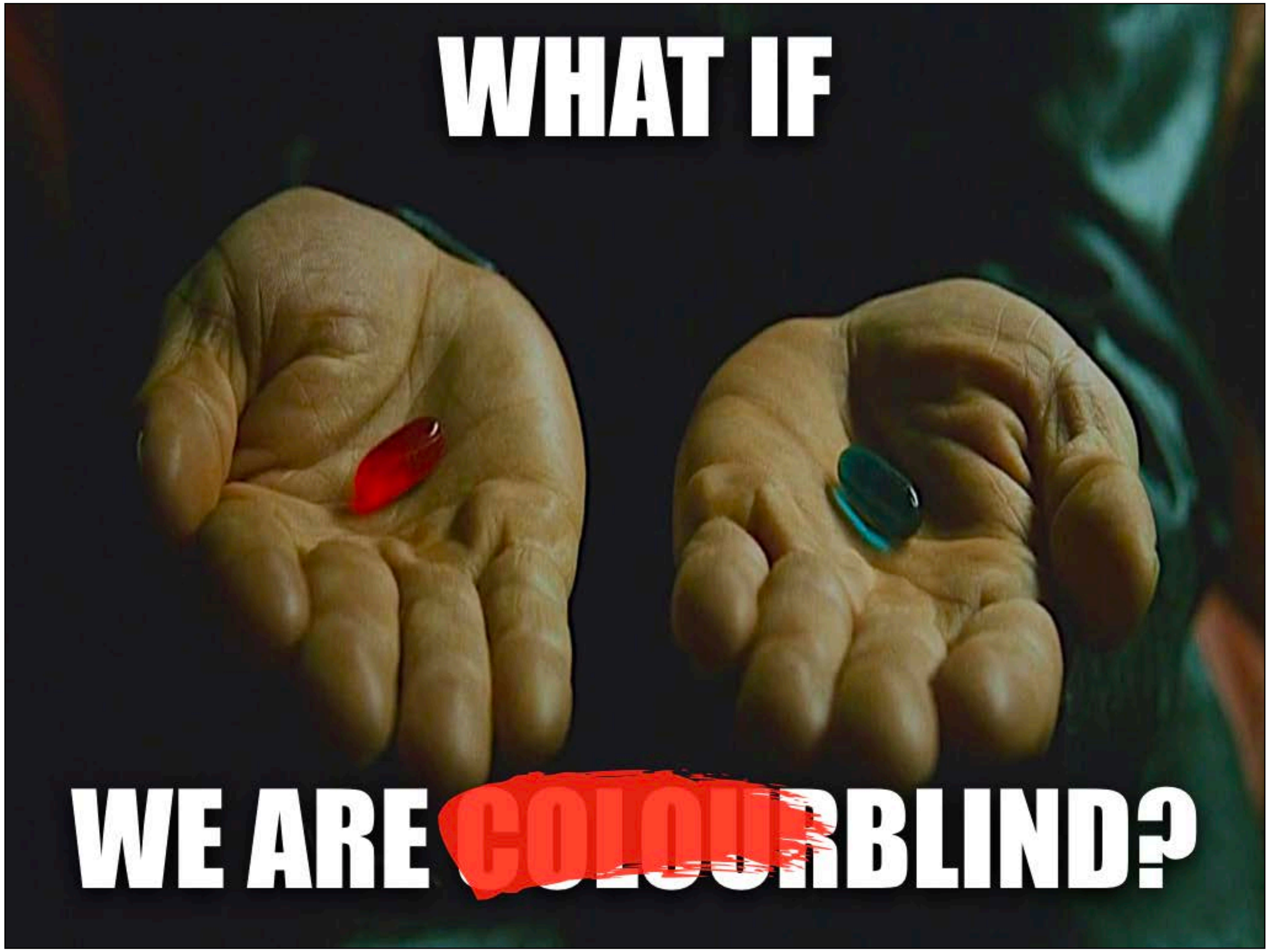
- Electric power distribution



- Hydraulic power distribution



Our future lies in displacement control, in a distributed control system based on modules. This is where we should focus on, simply because the market demands it. If we don't innovate, then the market will find another way, without us. We have no choice, we need to innovate.



But what if we are not just colourblind, but really blind?

This is where the story of the albatross chick needs to be told.

Let me first show you where this photo was taken: on Marion Island. The island is in the West Indian Ocean, about in the middle between South-Africa and Antarctica.

The islands were discovered on 4 March 1663 by Barent Barentszoon Lam of the Dutch East India Company. But he marked the wrong coordinates in his log, and the island could not be found again.

Until 1772, when a Frenchman, Marc-Joseph Marion du Fresne, rediscovered the island. After this visit he sailed to New Zealand, where he was caught by the Māori natives, by which he got killed and eaten.

After being rediscovered, the island was visited by seal hunters for some years. And with the hunters came the mice.

The mice were not a problem for many years. The strong winters killed most mice. But then, about 10 years ago, something changed. The researchers found that climate change is creating warmer winters that kill off fewer mice. As a result, the island's population has outgrown its supplies of the mice's normal food sources. Since 2009, the mice have begun feeding on birds at night.

But, why am I showing you this horrible story?

Because the birds don't fight back! Even the parents are sitting next to their offspring, and don't act. Having never dealt with these attacks in the past, the birds have no defenses. With no instinctual fear of this new danger, a bird will sit passively while mice nibble into its flesh, until it succumbs. The stunned parents simply watch the attacks happen. "It's like something out of a zombie apocalypse," the researchers report.

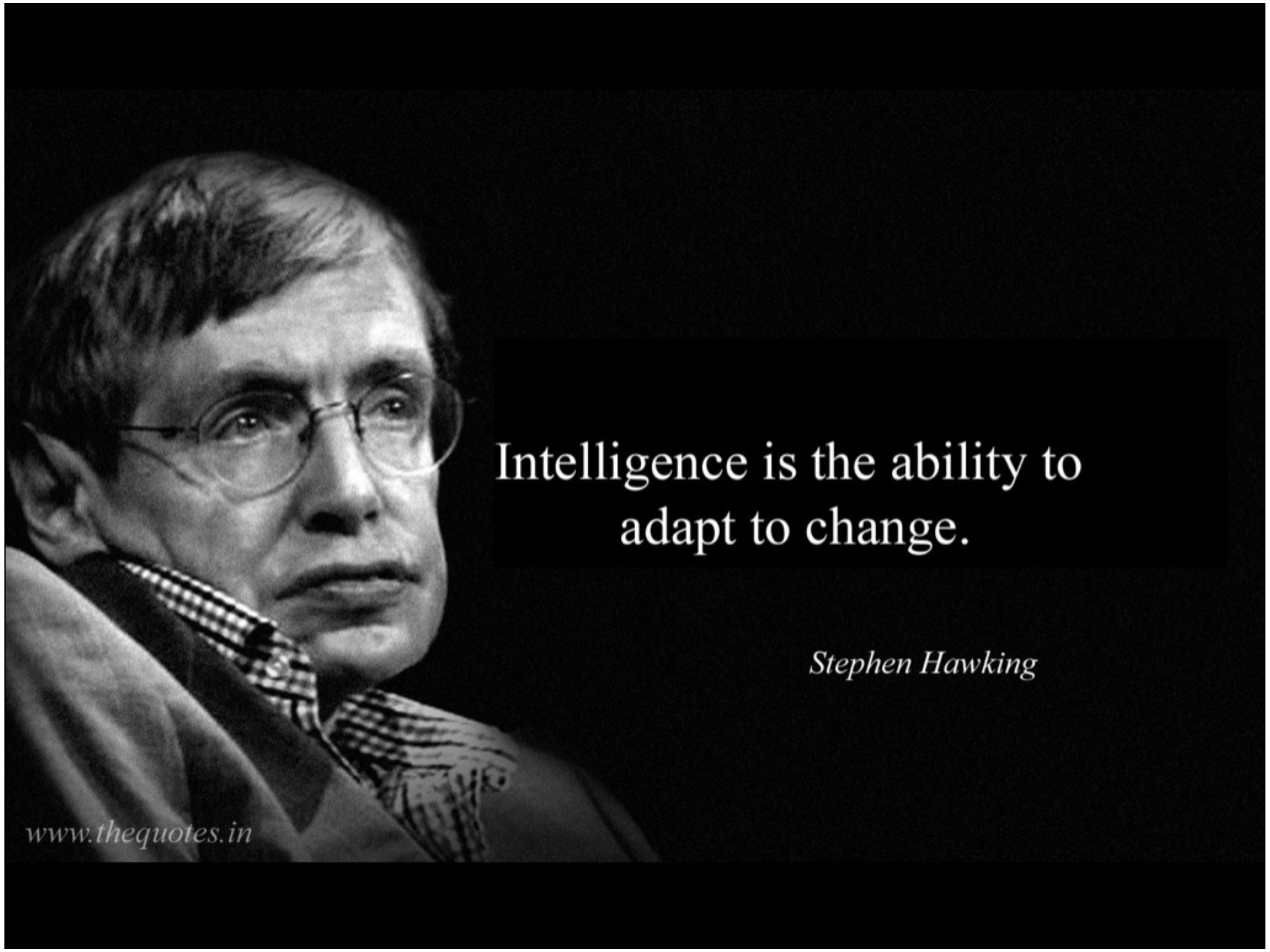
what if ?…

- We can’t see anymore what’s coming?
- We have forgotten how to innovate?
- We don’t see the threats…
- …and have no defence?

Now, what if we are like these birds?

- What if we can’t see what’s coming?
- What if we have forgotten how to innovate,
- don’t see the threats…
- …and have no defence.

What if we don’t belong to the fittest, the ones to survive?



This is the last meme I want to show to you. It is a quote from Stephen Hawking. And I don't think I need to read this to you, or explain why I show this.

it's up to you…

It is up to you.
Thank you

impotent fluid power

One last warning.
If I come back here in four years time, and nothing has changed, then this will be the first slide of my presentation.