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Meander-Effect® turns into engineering of agriculture

All over industrial applications the transport of different substances (e. g. gaseous, liquid, solid, viscous) in pipelines is a common and proved technique. Therefore also agriculture techniques are involved with stationary and mobil machinery, farm equipment and many more objects. The transport of substances cause – in any way – energy losses. Most of the users don't know about these cost effective losses they buy with the equipment.
The new bionic elements called „tube bends with meander-effect®" support an effective and efficient pipeline transport of air, seed, fertilizer, food, water and other agricultural used stuffs.

Keywords
Bionics, systemic, tube bend, meander-effect®, energy-efficiency, cost-reduction

Abstract
Landtechnik 64 (2009), no. 5, pp. 343 - 346, 5 figures
7 references

The financial, economic and social crises have almost succeeded in eclipsing existential problems. But there are other factors much more influential for our future. These include energy efficiency, environmental compatibility and climate change. Agriculture is not unimportant in this context: The production and delivery of sufficient amounts of foods, their processing and preparation, including packaging and transport, requires multiple technical applications.

Important in such processing chains are pipelines. Examples in farming:

- Pipeline transport in energy transformation systems such as biogas plants
- Air and material transport in livestock production
- General building climate systems in farming
- Pipeline transport systems for milk or wine processing industries
- Air transport systems for belt driers
- Seed transport in drill machines
- N solid or liquid fertiliser distribution equipment

The breadth of technical applications in agriculture for efficient pipeline or tube systems with the patented Meander-Effect ® can only be touched upon here.

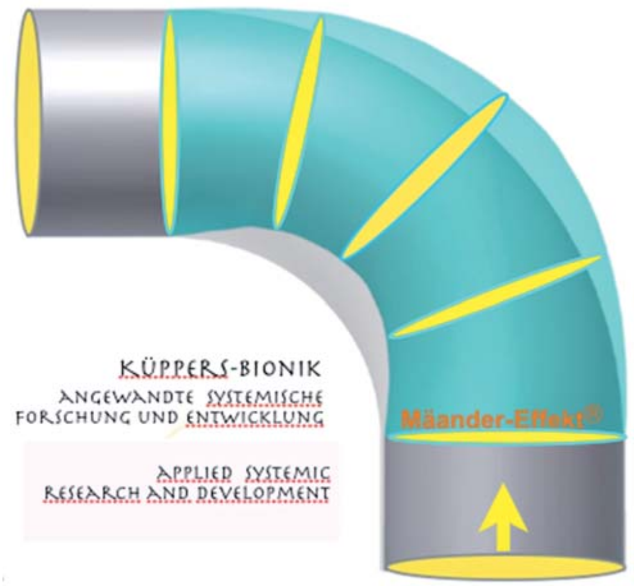
Motion energy is lost if material rub against each other as is the case with transport in pipes. These losses are caused by velocity, friction, redirection, turbulence, cross flow or so called „dead zones" in currents etc. Such losses work against the forces needed to transport material from one location to another. Relating thereto especially is the field of ventilation and air conditioning, also in agriculture technology. Transport losses of 30 to 40 % in pipe form pieces are not unusual – that costs cash. Also expensive is the acquisition of over-dimensioned equipment necessary to overcome such losses. Most users are often not even aware of especially this aspect because transport pipe components – especially those structural elements – have preprogrammed transport losses due to geometries that have remained unchanged over decades. But there are new, valuable, energy-efficient and environmentally friendly product and process innovations, previously hardly known. The bend pipe with Meander-Effect® is such an innovation. Asymmetrically designed pipe bends with Meander-Effect® significantly reduce the transport energy losses in the pipe bend; depending on bend angle and diameter by 20 %, 30 % or more.

Figure 1 shows the difference between a conventional, symmetrical circle pipe bend with high losses and an asymmetrical bend as a 90°-moulded body. They both are overlayed in order to show clearly the geometrical difference.

Use of the Universal Energy and Meander Design Principles of Nature

During evolution organic structures, forms and functions adapted as best as possible to their dynamic environment. For example, Meander windings or effective flow distributors support effectively the transport energy efficiency in flow systems of organisms (blood circulation, gas circulation, food circulation systems). Similar, fluid-dynamically optimal solutions can be seen in the interlaced, inanimate nature in adaptive bends – Meanders – in free running waters. This structure forming process by self organistaion of free flow-meanders leads to a minimum of energy dissipation rate eg in transport losses. What could be nearer than trying to use these natural forms of direction as best as possible energetically and technically? The border-crossing science of Bionik (biology and technology) collects, analyses, measures ie evaluates such natural solutions and transfers them finally into valuable technical products and processes with the help of engineering tools [1;2]. Systemisation of processes is a further key for lasting futuristic technologies. It is the aim to systematically acquire and totally optimise interrelations, similar to the very efficient circulation systems of nature. In this field the optimisation processes of agriculture technology are still in the beginning of their innovative development.

Fig. 1



90° tube bend with meander-effect® (follow yellow ellipses) and conventional 90° tube bend underlayed

Model agricultural engineering applications

Practical example with climate and ventilation systems. In livestock production pipeline systems help ensure a good climate within the animal housing (fresh air intake, temperature regulation, withdrawal of dust and pollutant gas) and also supply of feed and water and more.

Large and small ventilation systems, in particular, with usually quadrangular cross sectional channels represent worthwhile cost-saving opportunities for application of tube form pieces with Meander-Effect®. Various experimental optimisations with 90° tube bends in flow lengths identical to practical situations have clearly confirmed this. Depending on tube bend cross sectional area, increases of almost 25 % were achieved in this context in first energy efficiency increasing trials (minimising of tube bend pressure loss) [3]. In favourable situations existing larger power aggregates could be replaced by aggregates with less electrical power.

Using experimentally applied evolutionary optimisation algorithms [4; 5] a 90° round tube bend in a practically-relevant climate-ventilation flow length was successively reformed into a new optimum „meanderbend geometry“ and the throughflow measured until the optimum geometry gave minimal flow loss. **Figure 2** shows a family of tube bends with classic round forms applied – with substantial energy losses – in various agricultural appliances. For minimising pipeline system losses, evolutionary optimisation processes were applied in experiments. This brings us nearer to the widely used standard geometry involved in the optimisation of a 90° tube bend. With the 90° tube bend in **figure 2** the signified directional changes are added, their local radial displacement leading to an asymmetrical directional-change geometry as finally realised through the Meander-Effect® bend in **figure 3** right.

For efficiency improvement through pressure loss in the tube bend, a so-called multi-element evolutionary strategy was applied. The appropriate basic algorithm is:

Basic algorithm of the (μ, λ)-evolution strategy

$$
\begin{aligned}
x^{g}_{N1} &= x^{g}_{Ei} + \delta \cdot z_1 \\
x^{g}_{N2} &= x^{g}_{Ej} + \delta \cdot z_2 \\
&\vdots \\
x^{g}_{N\lambda} &= x^{g}_{Ek} + \delta \cdot z_\lambda
\end{aligned}
\qquad z_1, z_2, \cdots z_n = (0, 1/\sqrt{n}) \text{ - normally distributed} \tag{1}
$$

The x-values interpret thereby the variable number of radii lengths distributed over the tube bend directional change angle from 0 to 90°. These radii lengths – which are constant in the case of a standard tube bend although variable with the Meander-Effect® tube bend – were varied per random value (z) and various strategy values (i. a. ∂) until achieving the measured optimum, giving step-by-step matching of the tube bend geometry to the desired optimum form. For further details on optimisation please refer to the literature list. The target is defined as optimum radii positioning of the 90° tube bend along the redirectional length with associated minimal tube bend loss. Accordingly, the target function is:

Target = OPT (Long radius R1...Rn) = MIN Δp (tube bend) (2)

The flow loss as total pressure loss in tube bend follows the empirical approach:

$$\Delta p = (\zeta_\lambda + \zeta_u)\frac{1}{2}\rho v^2 \text{ [Pa]} \tag{3}$$

with ζ_λ = resistance figure for friction loss
and ζ_u = resistance figure for directional change loss
ρ = density of flow medium air [kg/m^3]
V = flow velocity [m/s].

Under consideration of the positions of the pressure measurement points M1 (approx. 3D before entry cross section of 90° tube turn) and M2 (approx. 15D after exit cross section 90° tube turn, **figure 2**) in the flow canal, the resistance value for the directional change loss in the tube bend and the additional pressure loss effected through throughflow of the tube bend is determined through the measuring of pressure difference:

$$\Delta p_{\text{tube bend sum.}} = p_1 - p_2 - \lambda\left(\frac{l_{\text{straight channel length}}}{d}\right)\frac{1}{2}\rho v^2) - \lambda\left(\frac{l_{\text{straightened tube bend length}}}{d}\right)\frac{1}{2}\rho v^2) \text{ [Pa]} \tag{4}$$

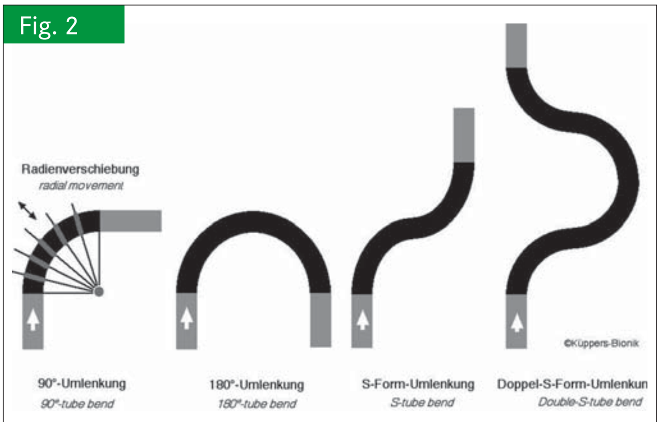
p1, p2 = pressure on the flow cross sections M1 and M2

l total length = length of straight tube piece + straightened tube bend length

λ = tube friction figure [-]

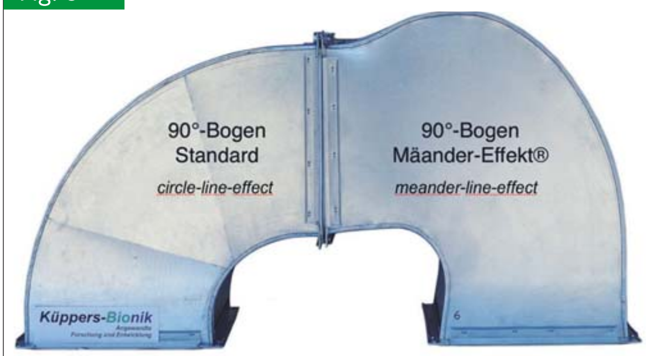
d = hydraulic diameter

Fig. 2



Different tube bends within technical pipelines produces high energy loss

Fig. 3



Comparison of conventional and optimized 90° tube bend (for example channel area 300 mm^2)

$$\zeta_{\lambda \text{ tube bend}} = \lambda\left(\frac{l_{\text{straightened tube bend length}}}{d}\right)\frac{1}{2}\rho v^2) \text{ [-]} \tag{5}$$

and

$$\zeta_{U\ 90°\text{-bend}} = \frac{(p_1 - p_2) - \lambda\left(\frac{l_{\text{straight channel length}}}{d}\right)\frac{1}{2}\rho v^2)}{\frac{1}{2}\rho v^2} - \frac{\lambda\left(\frac{l_{\text{straightened tube bend length}}}{d}\right)\frac{1}{2}\rho v^2)}{\frac{1}{2}\rho v^2} \text{ [-]} \tag{6}$$

ζ_U = additional loss value of tube bend

Figure 4 shows first practical-relevant results from optimisation experiments for climate and ventilation systems with different flow cross-sections. The conclusion from the described and comparative experiments with tube form pieces is: Nature analogue curve forms and computerised optimisation of more energy-efficient tube bend directional changes lead to similar optimisation solutions. This result confirms conjectures over energy-efficient flow meanders, because:

1. Self-organised naturally optimised meander curves in free flowing waters contribute to the transportation of material with minimum entropy.
2. Evolutionary optimised tube bend systems consequently show similar meander geometries. To number 2 belongs pipeline system optimisation experiments with atmospheric air, technical compressed air, agricultural equipment with pipeline systems for transport of corn material, and more.

Just as efficient – if not even substantially more efficient – can be the effect of tube bends with Meander-Effect® in compact tube systems, whether these be for transport and distribution of seed during sowing, for the transport and environment-friendly placement of crop fertiliser in soil, for the transport and distribution of air in multiple band drying systems or for other applications in farming (**figure 4**)

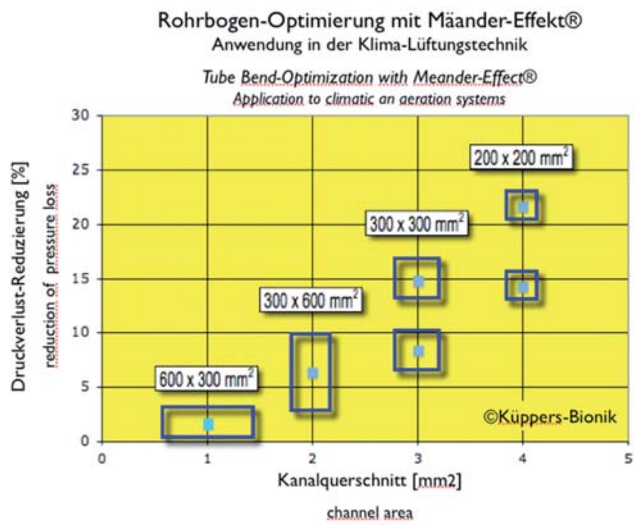
For the above mentioned agricultural uses, and those discussed initially, other not insignificant opportunities open up in the form of sustainable innovations around the Meander-Effect®. In special cases it can without doubt come to advantageous multiplication effects through which the new product tube bend with Meander-Effect® is a additional solution bringer for one or more complementary innovations within applied agricultural engineering. This has been clearly demonstrated by valuable bionic solutions, e.g., from flight, material or packaging technology [6; 7]. Also demonstrating this point is not least the factual and interdisciplinary bionics subject with its system-oriented orientation for solution solving.

Conclusions

Nature represents a large and very experienced experimental field in which solutions for particular problems and adaptive methods are optimised. Technical product developments nowadays go several ways. For economical reasons the solving of problems often has computer controlled simulation models in the foreground. The more complex a challenge turns out to be, the greater the investment needed to solve it. Here, development limits are often formed through cost and benefit getting out of proportion and threatening expected cash flow. Often, however, the warning signs that a development is not sustainable are, for various reasons, overseen. Increasingly apparent, however, is that particularly for business targets involving highly complex problems, experimental bionic solutions are, and can be, definitely more economically efficient in the light of sustainable business targets. One example of many is presented here.

The optimisation of flow systems which are low in losses or energy efficient is not limited, however, to only climate and ventilation systems. In the broader application of pipeline or flow systems the classic form of tube bend elements with its avoidable losses is also present. Those who reflect on energy efficiency find a direct route to this through energy saving. The identification and sustainable exploitation of savings potential in technical pipeline systems and associated surroundings requires, however, a view over and beyond the factual horizon. Keys to this are bionic methodology and systematic thinking and action.

Fig. 4



Results of energy optimization processes with different channel areas of 90° tube bends. From greater to smaler channel area an exponential trend in increasing values of energy gain can be observed

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Books are signed with ●

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