DEPRAG, Inc.
640 Hembry Street
Lewisville, TX 75057
(800) 4 DEPRAG
www.depragusa.com

Interview: Doubling engine output while reducing air consumption

The turbine: the air motor packing maximum efficiency

Great power-weight ratio while also delivering high revolution rates in continuous operation

What happens when the power from your drive unit simply isn't enough? When the motor for your robot-controlled plant has to supply maximum power yet has to be physically very small? When it has to produce very high revolution speeds, yet be fit for continuous operation? The automatic processes used to manufacture today's modern materials place heavy demands on the equipment that drives them. Plant engineers often anguish over the choice of motor to carry out the job. Technical journalist and editor Trixy Schmidt talked to two prominent plant engineers to find out more. During the interview the Managing Director of DEPRAG, Dr. Rolf Pfeiffer, and air motors product manager, Dagmar Dübbelde, provided an intriguing answer: in applications which require a pneumatically driven turbine with excellent power-weight ratio the ideal solution to the problem is motor selection.

Trixy Schmidt: If I am a plant engineer in search of the ideal motor for my application I basically have to decide whether the drive for my motor should be pneumatic or electric? DEPRAG boasts decades of experience in the production of air motors but in the screw fastening sector it also makes use of electric screwdrivers. What are the advantages of compressed air as an operating fluid?

Test facilities Technical University Amberg-Weiden

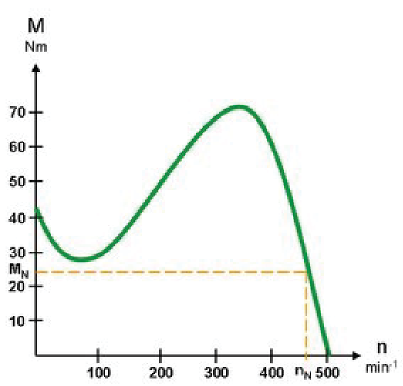
Dr. Rolf Pfeiffer: Ever since the days of mining and tunnelling operations in the 19th century air tools have represented a great success story. In atmospheres at risk of firedamp where a single spark could cause an explosion it would have been unthinkable to use an electric motor. The same is true today. Wherever there is a risk of explosion - for example in the bulk materials handling systems as used in the chemicals industry - the air motor will come into its own. The other side of the coin is that air motors can also be sterilized and are therefore used within the medical technology industry.

Dagmar Dübbelde: Furthermore, due to their simple structure air motors and pneumatic tools are immune to dirt and humidity and can be operated under full load down to standstill without damage. However the most significant advantage is that for the required drive output they are a third to a fifth lighter and are more compact than their electric counterparts. Air motors can also be found carrying out automated tasks, for example fastening screws.

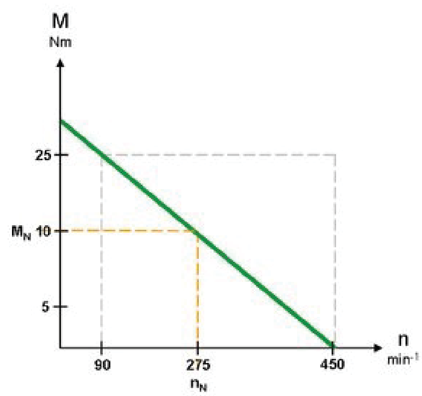
Trixy Schmidt: It is most often a vane motor that forms the basis of an air drive. Critics of the vane motor point out that it makes inefficient use of the volume expansion properties of the compressed air, so uses more electric energy than an electric motor.

Dagmar Dübbelde: To counter that suggestion properly, we need to dig more deeply. You cannot make a direct comparison between air motors and electric motors. Ultimately it is the application that is the deciding factor in the choice of drive. For example: take a look at the torque graph for an air motor compared with an electric motor in a packaging machine. For this application the required speed is approximately 450 rpm. However, for an extended period the torque is at 25 Nm at a reduced speed in order to seal the packing tape. Electric motors cannot withstand overload for extended periods because they overheat. So for this application an electric motor would need to be designed for torque under load, requiring an output of 1170 W (25 Nm x 450 rpm, divided by 9550).

However, the calculations for an air motor are completely different. With the air motor’s superior torque graph and the way it deals with increased temperature, the smaller motor solves both problems. The final choice for this



Characteristic curve electric motor



Characteristic curve pneumatic motor

application fell to an air motor with a nominal torque of 15 Nm and a nominal speed of 275 rpm. Since the working torque is below the nominal torque, at low load the motor revolves at close to the no-load speed of 450 rpm. The output required from the air motor is therefore 430W. If all is needed is a mere third of the power of an electric motor, the air motor’s efficiency appears in a completely different light.

Dr. Rolf Pfeiffer: In addition to the frequently used vane motor there are also other drive types that use compressed air more efficiently. This is where our innovative turbine technology steps in: A turbine is a fluid dynamic machine which uses the volume expansion properties of compressed air much more efficiently than vane motors do. They use a third of the amount of compressed air.

The power-weight ratio (kilowatts/kilograms) is unrivalled, just half the size of the vane motor. An example: if we replace a vane motor the size of a man’s fist with a turbine drive of the same size, we can almost double the amount of power produced.

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Trixy Schmidt: So pneumatic turbine drives score points for energy efficiency and an outstandingly low power-weight ratio.

Dr. Rolf Pfeiffer: Indeed they do. But other features also come into play here. We have already talked about their small size. It means that turbines are particularly suited for robot-controlled applications or where space is at a premium, for example inside the fuselage of an aircraft, but they are also used in high quality manual machinery. We market a turbine grinder which is able to exert as much as 2.2 kilowatts of power onto the grinding wheel, yet it weighs only 1.8 kilograms. A comparable device to deburr, polish or cut using a vane motor and weighing the same would produce only 1 kilowatt of power. Compared with an electrically driven tool the advantage derived from this low power-weight ratio is even more pronounced: To produce the same power an electro-grinder would weigh 5.7 kilograms.

Dagmar Dübbelde: At this point we should again highlight the turbine drive's low air consumption figures. On average it uses a third less compressed air than a vane motor. With a centrifugal governor to govern the speed of the turbine motor, air consumption can be reduced further by 50 percent. No other air motor works as efficiently! The turbines do not need oil, and there are no wear parts. And let us not forget the low noise level. This is another point in favor of using a turbine.

Trixy Schmidt: Turbines "live" off high speeds, so they have a reputation for high speed - a term explained by the way these fluid dynamics machines function. Their operating principle ensures that they are ideal for continuous operation. Which applications benefit most from these properties? In which industrial sectors are they of most use?

Motor - size comparision

Dr. Rolf Pfeiffer: Primarily they are ideal for stationary applications: grinding, milling, deburring or drilling metals, as well as wood. In short we recommend using a turbine-type drive wherever a constantly high motor speed is required to produce excellent machining quality. Turbines can also be deployed in manual tools where maximum power is required from a lightweight tool.

Dagmar Dübbelde: And of course they are also ideal for use where there is very little mounting space available. I'm thinking here of drill feed units, where with a turbine I can achieve much greater power from the same size of motor.

Trixy Schmidt: The design of a turbine drive involves more complicated configurations than occurs in a vane motor. The geometry of the blade, for example. Does it actually make economic sense to buy a turbine drive?

Dr. Rolf Pfeiffer: The engineering design work involved in producing a turbine is much greater than the actual manufacturing process. But if you look closely you find that at DEPRAG we have already made many turbine drives. We are able to produce turbine drives in a power range of between 500 W to 50,000 W.

Dagmar Dübbelde: And because we have also designed and developed the innovative turbine grinder in our Green Energy range, where we have developed a completely new gas expansion turbine to convert unused process gases into electricity, we already have a lot of software tools that we can use to design turbines to customers' own requirements.

Trixy Schmidt: So does that mean that DEPRAG is in a position to implement turbines to customers' special requirements quickly and without complication?

Dr. Rolf Pfeiffer: Yes, our many years of excellent collaboration with the University of Applied Sciences at Amberg-Weiden in testing and developing these turbines has paid off. The calculation and design work for the turbines for the DEPRAG turbine grinder took place under the leadership of Professor Dr. Andreas Weiß. The university has a test facility for pneumatic drives and compressed air technology, which we used to verify the design calculations and CFD flow simulations for the Curtis turbines used in the grinder. The intensive work of the materials that this involves means that, together with the university, we have gained an enormous amount of expertise in the design and manufacture of turbines.

Trixy Schmidt: So, if I may sum up: DEPRAG has already worked very intensively on turbine projects and as a result their experts have a considerable edge over other suppliers. In DEPRAG, designers who are thinking about using a turbine as the drive solution for their application will find experts who are able to offer comprehensive advice on implementing their project.

Dr. Rolf Pfeiffer: And there's more: I venture to suggest that none of our competitors could carry out a similar project as quickly and as expertly as DEPRAG can. Our company philosophy is to cover the entire value chain, from planning through to after sales servicing - and all with the utmost skill.

Trixy Schmidt: Thank you very much for talking to me today.

DEPRAG SCHULZ GMBH & CO. has its headquarters in Amberg, Germany. Employing around 600 staff, the medium-sized enterprise has a presence in some 50 countries. Besides air motors, the core skills at this mechanical and plant engineering company also include screw fastening technology and automation, in which it also supplies many feeder options. Moreover, it is also active in the Green Energy sector, having developed an innovative gas expansion turbine (GET - Green Energy Turbine) which is able to convert small amounts of residual gas into economically viable electricity.

Press contact:

Dagmar Dübbelde
DEPRAG SCHULZ GMBH u. CO.
Carl-Schulz-Platz 1
D-92224 Amberg
Tel: 09621 371-343
Fax: 09621 371-199
Email: d.duebbelde@deprag.de
Internet: www.deprag.com

US-Contact:

Ms. Lori Logan
Marketing Manager
DEPRAG Inc.
640 Hembry Street
Lewisville, TX 75057
(800) 433-7724 (800 4 DEPRAG)
(972) 221-8731 Local Phone
(972) 221-8163 Fax
l.logan@depragusa.com
www.depragusa.com