HYDRAULIC HYBRID TECHNOLOGY

DIESEL-DOWNSIZING OF ASPHALT ROLLERS SAVES FUEL

How can I use my machines with even greater economic efficiency? A central question for all machinery owners. In collaboration with HYDAC, HAMM AG has developed asphalt rollers with hydraulic hybrid drive for their customers which save 15% on diesel fuel in practical applications.
The minimisation of operating costs continues to be of central importance for mobile work machines. Machines with hybrid drives represent a possible solution in this connection. No matter which machine category is in question, one finds both electrical and hydraulic series solutions which have established themselves on the market in a process which is evolutionary to a certain extent. In such cases, it is often a downsizing of the diesel engine that has enabled significant fuel savings with the aid of a hybridisation. Depending on the machine and the work process involved, energy recovery functionalities can also make a contribution to energy efficiency.

HOW DOES AN ASPHALT ROLLER ACTUALLY COMPACT?

In the case of tandem rollers with applications in asphalt construction, the motivation for hybridisation lies in the typical operating cycle which is characterised by significant performance peaks for the diesel engine during reversing procedures. In this connection it is worthwhile to take a somewhat more detailed look at the topology of the drive system of the machines. So-called dynamic compaction systems are regarded nowadays as state-of-the-art technology. Depending on the machine version, vibration or oscillatory movements of the roller drums are created thereby as the result of rotating centrifugal weights powered by hydraulic motors. The necessary compaction power is applied by driving over the hot asphalt that was laid down shortly beforehand with activated vibration or oscillation.

Fig. 01 shows the simplified drive topology of a tandem roller. The traction drive is realized by a hydrostatic closed circuit with variable displacement pump and fixed displacement motors in the drums. The propulsion of the vibration/oscillation systems in the front and the rear roller drums also takes place in the closed circuit.

LOAD CYCLE WITH DOWNSIZING POTENTIAL

During a reversing procedure, the machine is decelerated and the vibration/oscillation is stopped at the same time, for which the temporal progressions of these two procedures must be tailored precisely to one another in order to achieve an optimum compaction result in the asphalt. When starting up the machine in the opposite direction, the roller must be accelerated by the traction drive and the vibration/oscillation drive is started up once again in parallel or with a slight time offset. This results in considerable load peaks for the diesel engine, as is displayed schematically in Fig. 02. The performance class of the required internal combustion engine (ICE) is determined essentially by the manifestation of the load peaks explained. During the compression process with constant travel speed, e.g. of 6 km/h, the necessary performance of the diesel unit is by contrast considerably less than the requirements which are called for by the referenced load peaks.

The load cycle manifestation type described suggests hybridisation measures which enable a downsizing of the diesel engine. A smaller-sized diesel unit covers the basic load in such cases, while performance peaks are provided by a hybrid drive. This way, fuel consumption and the CO2 emission can both be reduced. If necessary, the complexity of the devices for exhaust gas aftertreatment can also be reduced considerably, thus achieving a reduced amount of maintenance and/or a lowering of operating costs in this connection.

A large downsizing potential is available in this context, for example the mid-sized machine weight class with around 9 t working weight. In the present solution, HAMM AG was able, in collaboration with the HYDAC, to use hybridisation to replace an 85 kW diesel unit with a 55.4 kW motor. An additional factor which enabled the significant downsizing of the diesel engine was HAMM’s replacement of the hydraulic fan drive with a more energy-efficient electrical version. Further additional measures for the optimisation of the energy efficiency of the drivetrain and a revised steering unit resulted in a lowered power requirement.

HYDRAULIC HYBRID TECHNOLOGY PROVIDES ADVANTAGES

In principle, it is not only in the area of mobile work machines that various different technologies are available for hybridisation approaches. In addition to electrical solutions with batteries or double-layer capacitors, disc flywheel storage systems can also be used. In the context of the present application of “Tandem roller for asphalt construction”, hydraulic solutions do however bring with them decisive advantages. Hydraulic drives have been state-of-the-art technology for these mobile working machines for decades. Corresponding know-how with respect to the handling of hydraulic components is consequently available. The high level
of service friendliness was also decisive for HAMM’s selection. The high volumetric power densities of the hydraulic accumulator and of the hydostatic unit were a clear advantage in view of the limited installation space available. It is primarily two aspects which are of particular significance: the readily amortisable system assembly and the particular robustness of the hydraulic accumulators, which are able above all to withstand without difficulty strong, permanent vibrations and high temperatures.

With regard to the hybridisation topologies, serial, parallel or even power-split approaches can for example be selected. In the case of the present drive system with two hydraulic main consumers (traction drive and vibration/oscillation drive, see Fig. 01), a central input/output of energy at a mechanical interface with
During the development stage of the hydraulic hybrid system, FOCUS ON OPERATOR ACCEPTANCE was also able to determine the same fuel savings as in the test cycles. After the comparison runs, the fuel consumptions were compared between a conventional machine (9t, 85 kW) and a hybrid machine (HD+ 90i PH, 55.4 kW). Depending on the defined cycles, the hybrid machine consumed around 15% less fuel.

SUCCESSFUL VALIDATION IN TEST FIELD AND AT END USERS

Intensive trial and measurement runs have been carried out for validating the hybrid drive that was developed. For this, a conventional machine of the 9 t class (85 kW diesel engine) was compared with a “hybrid machine” HD+ 90i PH (55.4 kW diesel engine). Fig 04 shows examples of measured cycle data. The operating phases were marked in correspondence with Fig 02.

In Phase a2, the performance peak is smoothed by the energy feed of the hybrid drive and the load on the diesel engine is reduced. During the compaction process at constant travel speed (Phase b), considerably less performance is required in the hybrid machine by comparison, even though the hydraulic accumulators (pressure increase) are simultaneously loaded.

In addition to the trial and measurement runs, fuel consumption measurements were also carried out with realistic test cycles. After the comparison runs, the fuel consumptions were compared between a conventional machine (9t, 85 kW) and a hybrid machine (HD+ 90i PH, 55.4 kW). Depending on the defined cycles, the hybrid machine consumed around 15% less fuel.

In order to obtain an extended data basis, both the comparison machine and the hybrid machine were equipped with a field data recording device. The fuel consumptions were recorded thereby under real operating conditions over a period of approximately 230 hours at the construction sites and compared with one another. This method was also able to determine the same fuel savings as in the test cycles.

FOCUS ON OPERATOR ACCEPTANCE

During the development stage of the hydraulic hybrid system, particularly also in connection with the software and function connection to the diesel engine is an advantage. The boost function required for load-peak smoothing was able to be implemented using the hybrid topology presented in Fig 03 without major modifications to the drive concept.

The tandem rollers with “Power Hybrid” drive (HD+ 90i PH) are equipped with a transfer gearbox (TG) to which the traction drive and vibration/oscillation pump are connected. In addition, a hybrid motor pump (HMP) is connected with the 55.4 kW diesel engine via the TG. The HMP is an axial piston variable displacement pump (28 ccm) from Bosch-Rexroth. The hydraulic accumulator unit with 20 l nominal volume (two bladder accumulators from HYDAC, each with 10 l nominal volume) are loaded and unloaded via a HYDAC control block.

The loading and unloading cycle is implemented with different swivel angles of the hybrid hydromatematical unit. Energy is buffered in pump operation. The HMP is swivelled into the motor operation for the boost function. With a diesel engine speed of 2300 rpm, a boost power of a maximum of approx. 20 kW can be made temporarily available at a pump speed of approx. 3000 rpm, full swivel angle and a maximum accumulator pressure of 280 bar. The hybrid functionalities are controlled with the HY-TTC 30 HYDAC controller, which is connected to the machine ECU.

The tandem rollers with “Power Hybrid” drive (HD+ 90i PH) are used between a conventional machine (9t, 85 kW) and a hybrid machine by comparison, even though the hydraulic accumulators (Phase b), considerably less performance is required in the hybrid machine compared with the conventional machine ECU.

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