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DESIGN PROCESS SUMMARY: TRADITIONAL DRIVETRAIN

DJH Engineering Technical Newsletter

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Introduction

This is the first of a two-part newsletter examining the design process for a tractor drivetrain. For this discussion we are assuming the manufacturer is targeting a machine power level and wanting to market the tractor across several regions. The drivetrain requirements have been derived based on the target market segment. The manufacturer desires to leverage the design to market in several global regions with minimal incremental investment. This newsletter will focus on a traditional diesel tractor drivetrain. A future newsletter will describe how a similar approach can be used for an electric drivetrain.

Background:

For the example used in this discussion, DJHEC was provided vehicle-level requirements which were used to derive drivetrain requirements. The drivetrain requirements in conjunction with the engine power / efficiency map were used to generate the following specification / feature list for the transmission which met the vehicle requirements. This feature list along with the speed and torque requirements function as a high-level functional requirements for the drivetrain team:

Standard Features:

Manual shift

16 forward and 16 reverse (4 speed main transmission with 4 ranges)

Full synchronized shifting range, main, and shuttle

Planetary final drive (inboard)

Fail safe wet brakes

Differential lock

Brakes – individual or simultaneous activated with travel lock

Optional Features:

Creeper Gear – doubling the number of speeds with manual engagement

4-Speed PTO, manual engage 540/750/1000/1250

Front PTO

Front 3-point hitch

The Optional Features can be used by marketing teams to differentiate between regions as well as for options available to customers within a region. The final decision on standard features, optional features, and feature availability within regions normally falls to the manufacturer's marketing organization.

DJHEC is versed in working with the various engineering standards (ISO, SAE, DIN, JIS) and will help ensure the design satisfies the standards for the relevant regions. For world wide products we work to minimize the differences across regions while balancing the cost / complexity penalty against inter-regional commonality.

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Design Process:

Initially, the DJHEC drivetrain team worked with the vehicle team to package several options for arrangement of gears, shafts, bearings, and clutches with rough castings on the vehicle. During this early layout stage it is critical to evaluate the concepts' effects on visibility, serviceability, manufacturability, cost, weight, weight distribution, industrial design, operator access, auxiliary system packaging, etc. For efficiency during this phase it is crucial to have good processes in place to quickly evaluate these parameters to use as a framework to make design decisions. During all phases of any design project "engineering knowhow" is important, however it is critically important during this early concept selection stage. An experienced engineering team providing critical feedback will help the team save months of expensive iteration. One of DJHEC's core strengths is our decades of experience working on new product development from the first sketch on a napkin through production.

Once a layout is selected, the detailed engineering begins. The gears, shafts, splines, clutches, and bearings are finalized and packaged. The models for the castings are created. The lubrication and cooling passageways and lines are modeled. The assembly sequences are modeled and manufacturing processes are simulated. FMEAs and DFMEAs are completed. The geartrain analysis and lubrication analysis are completed. The structural housings and bolted joints are analyzed. DJHEC recommends "Design to Cost" approach where cost is tracked during design process and evaluated throughout this process. This allows our team to identify features that add significant cost during the design phase. It is often possible to eliminate these features easily during the design phase when great time and effort would be required to make the change after design is complete. Final drawing packages are created and final quotes for cost are procured and scrutinized against should-cost data used during design. As part of DJHEC's ISO 9001 Certification, we evaluate the cost models after every project to make sure the data we utilize during the design process are continually improving.

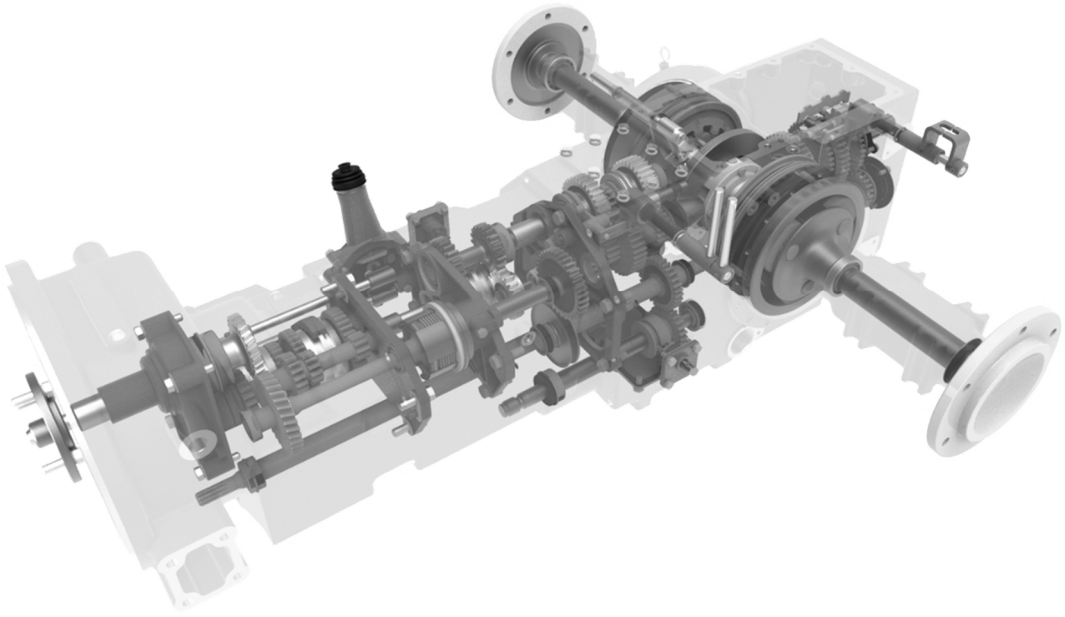

FIGURE 1: Example drivetrain layout for tractor used in this Newsletter.
See also LINK to YouTube video showing details of how the drivetrain is assembled.

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Conclusion

The design process described above (although abbreviated and simplified) has been developed over decades of successful projects and continues to evolve. The example used in this newsletter is a 25 year old tractor drivetrain. Although Physics has not changed, the tools (particularly computing power), processes, and nomenclature have been updated over the decades to allow faster design development timelines and opportunities for engineers to more quickly optimize the parts and systems incrementally leading to incredible improvements in equipment.

With emerging trends toward electrification gaining market share in the automotive sector, many manufacturers of Agricultural and Construction Equipment have begun to evaluate the potential competitive benefits of electrified equipment in their industries. How, if at all, does the design approach differ for electrified equipment? We will evaluate how the same requirements for a tractor drivetrain could be designed using an electrified drivetrain in an upcoming newsletter.

About DJHEC

DJHEC is an Engineering Firm specializing in new product development of mobile equipment. Our experience lies primarily in Construction, Agricultural, Off-Road Heavy Equipment, Oil / Gas Industry, Aerospace, and Automotive Industries. Our firm was founded in 1987 with offices located today in Salt Lake City, UT and Martin, Slovakia.

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