| Worksheet HW3 & Training Record<br>Bore Drilling Rig Motor Specification | | Equipment Sizing |
|---|---|---|
| Email: | Course: | Provider: |

## Expected Outcomes: (60-120mins)

Understand how to perform calculations to size hydraulic motor and match the hydraulic motor power to the engine that drives it. Consideration will also be given to the circuit requirements and design.

## Previous Knowledge Required:

Students should have completed worksheet FB1 'formulas and fundamentals' and HP1 'hydraulic pump basics' plus have a good working knowledge of hydraulic equipment.

## Certificate of Achievement Requirements:

Complete and return a worked example with notes detailing the decisions you have made.

*Customer Enquiry*

A company wants to upgrade their direct drive, bore hole drilling rig with hydraulic power to generate extra torque and drill more quickly.
The enquiry comes in the following form.

> We need the drilling FORCE of HYDRAULIC MOTOR, the ENGINE HP will power the PUMP.
>
> The DESIGN of the rig should be able to drill through ROCKS and HARD SOIL FORMATION to a depth of 120 METRES.
>
> Here is just what I need:- The Hydraulic motor, the PUMP, the hp of the Engine that will power the PUMP, the Hydraulic TANK, the CONTROL VALVE, the HOSE SIZES. Hydraulic piston is not needed, because I will make use of a mechanical winch.

*Drilling rig performance requirements*

| | |
|---|---|
| QUESTION 1 | What are the first things we need to know?<br>Write down a list of the questions we should ask. |
| SAMPLE ANSWER 1 | Request the maximum performance figures to make your scoping calculations.<br>We need specific values to size the equipment. We are hydraulic engineers not drilling experts so we must rely on what the client tells us or we will be liable for the redesign costs if it does not work. The customer must therefore specify:<br>• Maximum torque required?<br>• The maximum speed required?<br>The above will allow us to calculate the rough initial sizes and product types. To help us to understand how the equipment will work will also be useful to know: |

| | |
|---|---|
| | • Will the maximum torque need to be adjustable e.g. for different rod sizes or as the rod length increases? Or for different drilling heads?<br>• Will the speed need to be changed?<br>• Is reverse direction required?<br>• Is a freewheel mode required?<br>It's also important to know about the industry sector and environment:<br>• What are the environmental conditions e.g. day and night temperatures, dusty, marine or other environments, storage conditions, is it enclosed in a dry house, etc.<br>• Operating duty and life e.g. How long will it operate to drill one hole? How many holes or years of operation is expected?<br><br>Complete with your own requirements list |

## The customer feedback was:

1. TORQUE REQUIREMENTS FOR DRILLING RODS:- 900 N/m.  Adjustments for different rods or head is not required.
2. DRILLING RODS SIZE IS:- 1.'75inch OD, 5ft long, weight of rods 420kg.
3. REQUIRED SPEED IS:- 60-70 RPM.
4. SEEDED CHANGE NEEDED:- yes.
5. FREEWHEEL MODE REQUIRED:- yes
6. ENVIRONMENTS CONDITION:-  Wet and dry
7. STORAGE:- Enclosed in a dry House.
8. HOW LONG TO DRILL A HOLE:- It depends on the soil formation been drilled, Average of 6 - 8 hours. It should last for years, 15-20years or more.

*Maximum design limits of the machine*

| | |
|---|---|
| QUESTION 2 | Identify any limiting factors in the machine design and add these to the performance limits of the machine. |
| SAMPLE ANSWER 2 | The maximum torque the customer wants must not exceed the strength of the drilling rods so we will first make a calculation to check this.<br><br>**Example - Shear Stress and Angular Deflection in a Hollow Cylinder**<br>A moment of *900 Nm* is acting on a hollow cylinder shaft with outer diameter *50 mm (0.05 m)*, inner diameter *40 mm (0.04 m)* and length *1 m*. The shaft is made in steel with a maximum shear stress for the material might be 80-160 MPa but don't forget you need a good safety margin against fatigue stress and other drilling loads. The drilling rig should have a shear pin fitted so this breaks above ground long before the drilling rod breaks below ground.<br>Maximum shear stress can be calculated as<br>$\tau_{max} = T\ r / J$<br>$= T (D / 2) / (\pi (D^4 - d^4) / 32)$<br>$= (900\ Nm) ((0.05\ m) / 2) / (\pi ((0.05\ m)^4 - (0.04\ m)^4) / 32)$<br>= <u>62.1 </u> MPa<br>This shows we are below the breaking point of the rod with an acceptable safety margin in the ultimate stress for the rod. |

Complete with your own shaft sizing and loads

*Drilling rig hydraulic motor sizing*

| | |
|---|---|
| QUESTION 3 | Calculate some approximate (scoping) sizes for the hydraulic motor<br>Calculate the motor size required including the flow rate and maximum drive power required. As a guide, the current system has a direct engine drive of 25 hp at 1000 rev/min. From basic sizing we can say this will give around 130 Nm of torque. We need more! |
| SAMPLE ANSWER 3 | To provide 900 Nm at 60 rpm we need to determine a number of variables. The system pressure, flow rate and motor displacement. We will be designing the power unit so we have a certain amount of control over the flow rate and pressure that will be available.<br>We have two ways of delivering this torque.<br>1. Using a low-speed high torque motor (LSHT)<br>For 900 Nm at 130 bar = 900 * 20π / 130 = 430 cc/rev<br>2. Using a standard motor and a gearbox (say 10:1) to make sure we maintain a minimum speed of over 600 rev/min<br>Again for 900 Nm at 130 bar = 900 * 20π / (130 * 10) = 43 cc/rev<br>This initial scoping size information was passed back to the client who said they would prefer the LSHT motor option and they already have an engine with a 25hp output power that they would like to use to drive the pump.<br><br>Complete with your own performance values |

*Select motor type*

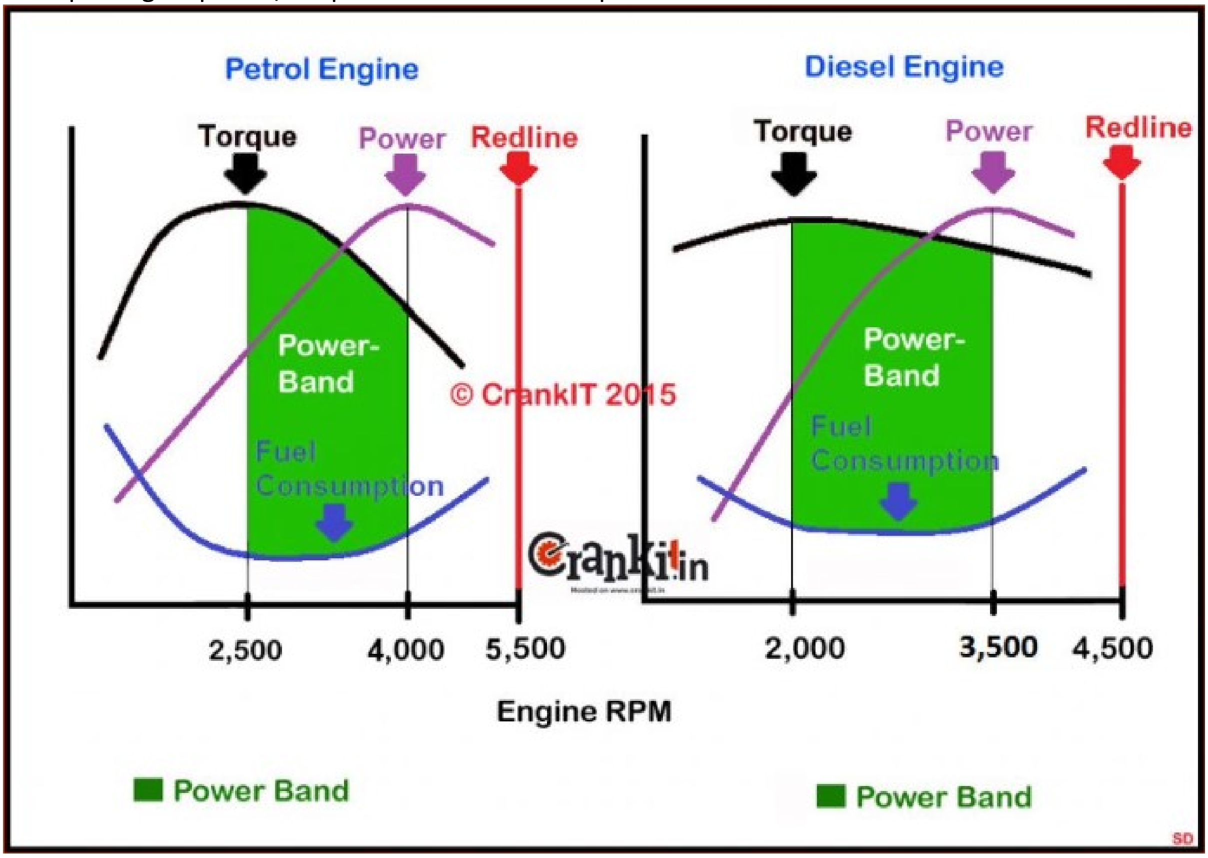
| | |
|---|---|
| QUESTION 4 | What motor would you select for this application and why? |
| SAMPLE ANSWER 4 | Demonstrate you have selected a particular motor from a datasheet and explain why. You should also be thinking about budgets at this stage and whether this will limit the component selection in any way.<br>There is no definitive correct answer to this. Different machine builders, with different requirements and different local suppliers, may select different motors. In this application, the client would like to use an MLHV 800B hydraulic motor manufactured by M+S Hydraulics. This is a larger motor than perhaps would be required but the client was keen to build in sufficient capacity to increase the performance later, if required.<br><br>Complete with your own motor recommendations |

*Pump and power unit sizing*

| | |
|---|---|
| QUESTION 5 | Calculate the approximate (scoping) power unit and pump size and pressure? |

| | |
|---|---|
| SAMPLE ANSWER 5 | The MLHV 800B hydraulic motor is 800 cc/rev<br>To achieve 70 rev/min we need a flow rate of 800*70/1000 = 56 L/min<br>Pump power = 130 bar * 56 L/min / 600 = 12 kW<br>Power unit size should be approximately 1.15 * 12 = 14 kW<br>(Although with an engine drive system we still need to ensure the maximum drive power corresponds to the speeds at which we need it, so we must also check the engine power characteristic.)<br><br>Complete with your own performance values |

*Select the power unit type*

| | |
|---|---|
| QUESTION 6 | Identify a suitable drive system? |
| SAMPLE ANSWER 6 | In this case, the client already has an engine drive as follows. It is also unlikely that mains electricity will be available where the boreholes need to be so we can assume this is the most appropriate.<br><br>The client's engine power is 26 HP but there is no power characteristic available.<br>The RPM is 2500 continuous.<br>Our calculated requirement of 14KW is approximately 19 HP, so this should be fine to drive our pump. We would need around 15% over capacity to cover losses so the extra power gives us more confidence that the engine power characteristic will be appropriate.<br>Example engine power/torque characteristics are provided below.<br> |

*Pump sizing calculation*

| | |
|---|---|
| QUESTION 7 | What size of pump do we need? |
| SAMPLE ANSWER 7 | For 56 L/min at 2500 rev/min we will need a 56/2500 = 22.4 cc/rev pump<br><br>Once the engine and pump data is available we can use the design guide at www.e4training.com/design_guides/designpu1.php to help evaluate the combined system performance.<br>Complete with your own performance values |

*Pump type selection*

| | |
|---|---|
| QUESTION 8 | What type of pump do we need? |
| SAMPLE ANSWER 8 | There are three options for pumps, gear, vane, or piston. The piston would be preferable to achieve a long life, provided good fluid cleanliness can be maintained. A piston pump would be recommended if continuous, full load drilling (through rock) was required for over 1000 hours. However, if most of the drilling will be through softer soil (lower pressure) then a gear pump could be recommended. Its' contamination resistance should be more appropriate to the environment and its' pressure range is similar to the motor being used, plus it's reasonably cheap to replace.<br><br>Complete with your own product specification |

*Hydraulic circuit component type selection*

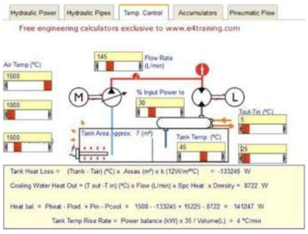
| | |
|---|---|
| QUESTION 9 | What other components and circuit layout do we need?<br>Our client has now informed us that they would also like to use the motor as a winch to lift the drilling rods from the ground once they have finished. They will attach a gearbox to achieve this but what components will they need for the circuit to provide these functions. List all components required and state why. |
| SAMPLE ANSWER 9 | Pressure relief valve for safety protection of the power unit and limit the maximum torque seen by the drilling rods.<br>A better solution would be a fixed relief valve for safety and pressure compensated pump to set the maximum torque.<br>A directional valve will control the stop/start, forward and reverse rotation of the drill.<br>Centre condition must allow freewheeling when the pump is stopped. |

No speed control is required as minimal losses and low heat generation are important. Speed will be adjusted with engine speed revs. Pressure will depend on the load on the drill head.
Keep it simple!
An example circuit can be found in the in the hydraulic circuit simulation program at www.e4training.com/simulate/simulate2.php

Complete with your own product specification

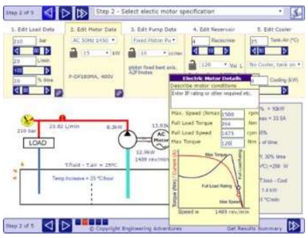
*Further reading and experiments*


A full range of lessons covering all aspects of hydraulic system design and maintenance can be found at www.e4training.com/menusummary1.php
Of particular importance will be understanding the control of fluid contamination and good filter selection.
See also our power unit and reservoir design details.



Enter calculated results into the ‘hydraulic system design calculator’ at www.e4training.com/hydraulic_calculators/hydraulic1.php

- Compare the motor torque and pump sizing.
- Compare the input power requirements.
- Compare the predicted pipe sizes for your supply and return line flow rates.
- Review the temperature balance figures for all possible operating and standby conditions.



Experiment with a hydraulic power unit design guide at www.e4training.com/design_guides/designpu3.php :

- Confirm the reservoir size based on flow rate.
- Confirm reservoir size provides stable temperature with expected duty cycles.
- Review the engine characteristic vs output torque required.

## And Finally:

Complete this worksheet and keep for your records. Submit the written coursework to e4training.com or your training course provider. Application result postings will be collated automatically by the course provider; e4training.com will also receive a copy of the results to include in the certificate assessment process.

## Related Worksheets:

Visit www.e4training.com/hydraulic_courses/worksheets1.php to find the next worksheets related to your course.