Tutorial - Fracture Design and Optimization

**Background**

* **Starting input filename**: ***High perm optimization tutorial-start.inp***
* **Final input filename**: ***High perm optimization tutorial.inp***
* **Tutorial focus**: Fracture treatment design
* Selecting fluids and proppants
* Selecting flow rate and treatment size
* Determining proppant schedule

This example represents a relatively simple reservoir with two sandstone payzone separated by shales and a nearby water-bearing sandstone. The operator wants to design the best treatment for this well that will maximize production performance while preventing hydraulic fracture growth into the water-bearing interval.

**Step 1: Load Input File**

Load file ***High perm optimization tutorial-start.inp*** from the ***C:\Program Files\Fracpro\Fracpro 2019\Tutorial\Fracture Design&Optimization*** folder by using the ***Retrieve Input File*** tool-bar button (or the menus).

**Step 2: Review Necessary Inputs**

This file does not have to be set up from scratch. If you are not familiar with the design module, the easiest method to find you way around is by using the ***Next*** button at the bottom of every screen. Your starting point is to select the ***Fracture Design*** button on the ***[Main Screen - F2](mk:@MSITStore:G:\\Fracpro\\Program\\FracproPT.chm::/HTML/_navigation/Main_Screen_-_F2.html)*** screen. We have already filled out some of the vital information in the following screens:

* ***[Wellbore and Treatment Information - F3](mk:@MSITStore:G:\\Fracpro\\Program\\FracproPT.chm::/HTML/Well_and_Treatment_Information_-_F3/Well_and_Treatment_Information_-_F3_-_General_Information.html)***
* [***Fracture Design Options - F4***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/_Options/Fracture_Design_Options_-_F4/Fracture_Design_Options_-_F4_-_Main_Options.html)   
  you can select ***3D Calibrated*** or ***3D User Defined*** model settings here, which allow you to import a certain type of hydraulic fracture growth behavior that may be typical in a certain area. Please select the ***3D Shear-Decoupled (Default)*** model.
* [***Wellbore Configuration - F7***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/Wellbore_Configuration_-_F7/Wellbore_Configuration_-_F7_-_Drilled_Hole.html)
* [***Reservoir Parameters - F9***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/Reservoir_Parameters_-_F9/Reservoir_Parameters_-_F9_-_Layers__Lithology-Based_.html)(LithologyBased)   
  Showing a simple shale-sand-shale sequence on the Layer tab. we have estimated a 0.1 psi /ft stress gradient contrast between the sands and the shales, visible in the [***Rock Properties***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/Reservoir_Parameters_-_F9/Reservoir_Parameters_-_F9_-_Rock_Properties.html) tab. Also, we know from direct hydraulic fracture diagnostics in this area that hydraulic fracture height growth is more confined than what we see based on stress contrast only, so there is also a ***Composite Layering Effect*** of 10 set in the zones outside the pay zone on the [***Rock Properties***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/Reservoir_Parameters_-_F9/Reservoir_Parameters_-_F9_-_Rock_Properties.html) ***tab***.

**Step 3: Selection of Fluid and Proppant**

Once these input screens are filled out, you can select the appropriate fluids and proppants for this design. For the fluids, the operator has selected ***Halliburton*** for the propped hydraulic fracture treatment, so limit ***Vendor Selection*** to ***Halliburton***. A typical criterion is to obtain 200 cP apparent viscosity at 40 s-1 (estimated shear rate in the hydraulic fracture) after about 2 hours of exposure to the reservoir temperature. Once these criteria are set, you will see that a 40# Guar Borate (HYBOR G) fluid fits this profile, amongst others. Highlight the row with the ***HYBOR G*** fluid and ***Add*** ***Fluid*** to ***Selected Fluids*** list. The selected fluid will now be highlighted in yellow. If a fluid is selected that does not qualify to the selection criteria, for example when a fluid is added manually from the library, the property that does not qualify will be highlighted in red.

Change to the ***[Fluid and Proppant Selection - F5](mk:@MSITStore:G:\\Fracpro\\Program\\FracproPT.chm::/HTML/Fluid_and_Proppant_Selection_-_F5/Fluid_and_Proppant_Selection_-_F5_-_Proppant_Selection_(Design).html)*** screen, ***Proppant Selection*** tab. We are expecting that multiphase and non-Darcy flow issues play some role in production response, as the well will not only produce oil, but also a small amount of gas. Select the ***Proppant Perm Damage*** function where you can specify non-Darcy and multiphase flow effects: the operator has experience that wells typically come in at about 250 bopd. If we assume gel damage of about 50%, the ***Total Damage Factor***, which includes apparent damage from non-Darcy effects, is as high as 20% depending on the selected proppant. Back to the Proppant Selection tab, the table with ***Proppant Selection Results*** shows a number of proppant choices. A 12/18-mesh CarboLite qualifies best for this purpose, providing high conductivity at the lowest cost per mD -ft. Highlight this proppant and click ***Add*** to move it to the Selected proppant list.

## Step 4: Treatment Selection

The next step in the design process is to select an appropriate pump rate. Based on the selected fluid and other settings, ***Fracpro***can calculate wellbore friction and expected surface pressures to automatically select the maximum feasible pump rate. In this case, the maximum surface pressure at the wellhead is 10,000 psi. After entering this information, select the ***Determine Rate*** button, and ***Fracpro***suggests a maximum ***Injection Rate*** of 14 bpm to stay within this surface pressure limitation.

We will now determine the treatment size versus length in 25-foot ***Fracture Half-Length Increments***. Set ***FcD Goal*** to 1.6 for the main hydraulic fracture. Leave the ***Max Proppant Concentration*** at 14 ppg and the ***Max TSO Net Pressure Increase*** at 1,000 psi. After selecting the ***Determine Treatment Size versus Length*** button, the table on the top half of the screen is populated. You will see that it is impossible to obtain the required ***FcD*** for this high perm well once the hydraulic fracture becomes very large, despite the fact that we have selected the highest conductivity proppant for this case and have used a high maximum proppant concentration at the end of the treatment and an aggressive tip screen-out design. ***Fracpro***lists the highest possible ***FcD***'s that can be achieved under these circumstances in this well.

You can now look at the various plots that are generated, most notably the hydraulic fracture***Geometry*** plot, and see that the hydraulic fracture will grow into the water-bearing sand when the hydraulic fracture exceeds a certain size. Now, you can set various criteria to determine the required hydraulic fracture length. As the first criterion, select ***NPV*** under ***Select*** ***Size using Criteria*** to obtain the treatment size for maximum ***NPV*** . Secondly, select a criterion that Mother Nature is imposing on our design to avoid hydraulic fracture growth into the water-bearing sand. If we set ourselves a 5 ft spacer with the bottom of the water-bearing zone, the ***Fracture Top Depth*** should not become smaller than 6,084 ft.

Now, we can ***Select Size Using Criteria***, and if the economics have not been evaluated before, it will be necessary to select the ***Economic Analysis*** button first.

## Step 5: Define Economics

The next step in the design process is to define treatment cost and production revenues. First, hydraulic fracture treatment cost can be defined in the [***Optimization Economic Data - F8***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/_HTML/_screens/Optimization_Economic_Data_-_F8.html) screen. Costs are already provided for all entries on this screen. Select ***Next*** to advance to the ***[Well Production - F6](mk:@MSITStore:G:\\Fracpro\\Program\\FracproPT.chm::/HTML/Well_Production_-_F6/Well_Production_-_F6_-_Production_Constraints.html)*** screen ***Production Constraints*** tab. To populate the ***Production Constraints*** table, set the ***Total Production Time*** to 730 days, the ***Maximum HC Rate*** to 10,000 bbl/day and the ***Minimum Pressure*** to 500 psi and select the ***Set Up Table*** button. For high perm well, economics are typically evaluated over a relatively short time period, for example 2 years. The ***Maximum HC Rate*** is set rather high using the assumption that the wellbore tubulars impose no significant limitation on production response for very large hydraulic fractures. Select ***Next*** to advance to the ***[Optimization Control - F10](mk:@MSITStore:G:\\Fracpro\\Program\\FracproPT.chm::/HTML/_Control/Optimization_Control_-_F10.html)*** screen.

This screen shows almost the same table as the previous [***Treatment Selection - F8***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/_HTML/_screens/Treatment_Selection_-_F8.html) screen, but various columns have been added to show economic criteria. ***Fracpro***will populate the values in these columns after you select the ***Run Simulator*** button. After all economic indicators have been calculated based on the defined cost and revenues from the forecasted production response, ***Select Size Using Economic Criterion*** to ***NPV***, and the treatment with maximum ***NPV*** will be selected for a hydraulic fracture half-length of 225 ft.

Now select the ***Treatment Selection*** button to return to the [***Treatment Selection - F8***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/_HTML/_screens/Treatment_Selection_-_F8.html) ***screen*** for a final reconciliation of the most favorable economic hydraulic fracture half-length and avoiding growth in the water-bearing zone.

## Step 6: Creating the Final Treatment Design

Use the ***Select Size using Criteria*** button again, and now that the economics have been evaluated, ***Fracpro***will select the hydraulic fracture half-length that honors both economics and growth limitations imposed by Mother Nature. This results in an optimum hydraulic fracture half-length of 225 ft, so the hydraulic fracture half-length with the best economics for our assumptions still remains below the water-bearing zone.

The selected yellow line illustrates what approximate treatment size is required to obtain the correct proppant conductivity at the wellbore. The last step is to determine the rest of the schedule to obtain the ideal conductivity profile along the entire hydraulic fracture length. Select a ***Standard*** profile and set ***Max Error*** to 15% and set the number of iterations to 15 (or less, depending on your patience). Have ***Fracpro***next ***Fit Conductivity Profile*** by selecting that function, and ***Fracpro***will iterate to get a proppant profile that fits the ideal schedule in the best way. You have now created a design requiring about 1000 bbl of fluid and 250,000 lbs of proppant, and this is the time to view your work using ***Generate Report***.

Once this is done, select ***Next*** to go to the [***Treatment Schedule - F6***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/Treatment_Schedule_-_F6/Treatment_Schedule_-_F6_-_Design_Treatment_Schedule.html) screen to check the design treatment stages and totals.

You can now also run the model for this schedule by going to the [***Main Screen - F2***](mk:@MSITStore:G:\Fracpro\Program\FracproPT.chm::/HTML/_navigation/Main_Screen_-_F2.html) ***screen***, selecting ***Fracture Analysis***, and then running the model in that mode.

教程-断裂设计与优化

背景

起始输入文件名：High perm optimization tutorial-start.inp

最终输入文件名：High perm Optimization tutorial.inp

教程重点：骨折治疗设计

选择流体和支撑剂

选择流速和处理量

确定支撑剂时间表

该示例代表了一个相对简单的储层，其中有两个由页岩隔开的砂岩产层和附近的含水砂岩。 操作员希望为此井设计最佳处理方法，以在不使水力压裂增加到含水间隔的情况下最大化生产性能。

步骤1：加载输入文件

使用``检索输入文件''工具栏按钮（或菜单）从C：\ Program Files \ Fracpro \ Fracpro 2019 \ Tutorial \ Fracture Design＆Optimization文件夹中加载文件High perm Optimization tutorial-start.inp。

步骤2：查看必要的输入

不必从头开始设置此文件。如果您不熟悉设计模块，那么最容易找到解决方法的方法是使用每个屏幕底部的“下一步”按钮。您的起点是选择“主屏幕-F2”屏幕上的“骨折设计”按钮。我们已经在以下屏幕中填写了一些重要信息：

井筒和处理信息-F3

骨折设计选项-F4

您可以在此处选择“ 3D校准”或“ 3D用户定义”模型设置，这些设置可让您导入特定类型的液压裂缝扩展行为，这在特定区域可能是典型的。请选择3D剪切解耦（默认）模型。

井筒配置-F7

储层参数-F9（基于岩性）

在“层”选项卡上显示一个简单的页岩-砂-页岩序列。我们估计，在“岩石属性”标签中可见，沙子和页岩之间的应力梯度反差为0.1 psi / ft。同样，从该地区的直接水力压裂诊断中我们知道，水力压裂高度的增长比仅基于应力对比所看到的要局限得多，因此，在该区域的产油区以外的区域也有10层的复合分层效应。岩石属性选项卡。

步骤3：选择液体和支撑剂

填写完这些输入屏幕后，您可以为该设计选择合适的流体和支撑剂。对于流体，操作员已选择哈利伯顿进行支撑的水力压裂处理，因此将供应商选择限制为哈利伯顿。一个典型的标准是在暴露于储层温度约2小时后，在40 s-1（水力压裂中的估计剪切速率）下获得200 cP的表观粘度。设置这些条件后，您将看到40＃瓜尔硼酸盐（HYBOR G）流体尤其适合此轮廓。突出显示带有HYBOR G流体的行，然后将流体添加到选定流体列表中。所选流体现在将以黄色突出显示。如果选择的流体不符合选择标准，例如当从库中手动添加流体时，不合格的属性将以红色突出显示。

切换至“流体和支撑剂选择-F5”屏幕，“支撑剂选择”选项卡。我们期望多相流和非达西流问题在生产响应中发挥一定作用，因为该井不仅会产生石油，还会产生少量的天然气。选择“支撑剂烫发破坏”功能，您可以在其中指定非达西和多相流动效应：操作员经验表明，通常井速约为250 bopd。如果我们假设凝胶损坏约为50％，则取决于所选支撑剂，包括非达西效应造成的明显损坏在内的总损坏因子高达20％。返回到“支撑剂选择”选项卡，带有“支撑剂选择结果”的表显示了许多支撑剂选择。 12/18目CarboLite最适合用于此目的，以最低的每mD -ft成本提供高电导率。突出显示该支撑剂，然后单击添加以将其移动到“选定的支撑剂”列表中。

步骤4：治疗选择

设计过程的下一步是选择合适的泵速。根据所选的流体和其他设置，Fracprocan计算井眼摩擦力和预期的表面压力，以自动选择最大可行泵速。在这种情况下，井口处的最大表面压力为10,000 psi。输入此信息后，选择“确定速率”按钮，然后Fracprosuggest建议最大注入速率为14 bpm，以保持在此表面压力限制范围内。

现在，我们将以25英尺骨折半长增量确定治疗尺寸与长度的关系。将主要水力压裂的FcD目标设为1.6。保持最大支撑剂浓度为14 ppg，最大TSO净压力增加为1,000 psi。选择“确定治疗量与长度”按钮后，将填充屏幕上半部的表格。您将看到，一旦水力压裂变得非常大，就不可能获得此高渗透率井所需的FcD，尽管事实是我们为此选择了最高电导率的支撑剂，并在最后使用了最高的最大支撑剂浓度的治疗和激进的尖端筛除设计。 Fracprolists在这种情况下，在这些情况下可以实现的最高FcD。

现在，您可以查看生成的各种图，最值得注意的是水力压裂几何图形，并观察到，当水力压裂超过一定大小时，水力压裂将长成含水砂。现在，您可以设置各种标准来确定所需的水力压裂长度。作为第一个条件，请使用条件在选择尺寸下选择NPV以获得最大NPV的处理尺寸。其次，选择一项标准，即大自然将其强加于我们的设计中，以避免水力压裂扩展到含水砂中。如果我们在含水区域的底部设置一个5英尺长的垫片，那么断裂顶深度不应小于6,084英尺。

现在，我们可以使用“条件”选择“规模”，如果以前没有评估过经济学，则必须首先选择“经济分析”按钮。

步骤5：定义经济学

设计过程的下一步是定义处理成本和生产收入。首先，可以在“优化经济数据-F8”屏幕中定义水力压裂处理成本。此屏幕上所有条目的费用都已提供。选择“下一步”以前进至“油井生产-F6”屏幕的“生产约束”选项卡。要填充“生产约束”表，请将“总生产时间”设置为730天，将“最大HC速率”设置为10,000 bbl /天，将“最小压力”设置为500 psi，然后选择“设置表”按钮。对于高渗透率井，通常在相对较短的时间段（例如2年）内评估经济性。假设井筒不对非常大的水力压裂裂缝的生产响应施加显着限制，则可以将“最大HC速率”设置为相当高。选择下一步进入“优化控制-F10”屏幕。

该屏幕显示的表格几乎与以前的“治疗选择-F8”屏幕相同，但已添加了各种列以显示经济标准。选择运行模拟器按钮后，Fracpro将填充这些列中的值。在根据预测的生产响应根据定义的成本和收入计算了所有经济指标之后，使用经济准则选择NPV的大小，并针对225英尺的水力压裂裂缝长度选择最大NPV的处理方法。

现在，选择“处理选择”按钮以返回到“处理选择-F8”屏幕，以最终调节最有利的经济性水力压裂裂缝的一半长度，并避免含水区域的增长。

步骤6：创建最终处理设计

再次使用“使用条件选择尺寸”按钮，现在已经评估了经济性，Fracpro将选择水力压裂裂缝的一半长度，以兼顾经济和自然界施加的增长限制。这导致最佳的水力压裂裂缝半长为225英尺，因此我们假设的最佳经济性的水力压裂裂缝半长仍保持在含水区域以下。

所选的黄线表示在井筒处获得正确的支撑剂电导率所需的近似处理尺寸。最后一步是确定计划的其余部分，以在整个水力压裂长度上获得理想的电导率曲线。选择一个标准配置文件，并将最大错误设置为15％，并将迭代次数设置为15（或更少，取决于您的耐心）。通过选择该功能来获得Fracpronext合适的电导率剖面图，Fracpro会迭代以最佳方式获得适合理想时间表的支撑剂剖面图。现在，您已经创建了一个需要大约1000桶液体和250,000磅支撑剂的设计，这是时候使用“生成报告”查看您的工作了。

完成此操作后，选择“下一步”转到“处理时间表-F6”屏幕以检查设计处理阶段和总计。

现在，您还可以通过以下方式运行此计划的模型：转到“主屏幕-F2”屏幕，选择“断裂分析”，然后以该模式运行模型。