Evaluation of Pipe-It's Optimizer

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Abstract

In this paper we will evaluate the use of PetroStreamz Pipe-It's Optimizer for mathematics, science and engineering students. We will start with simple Maximum/Minimum problems and then go over to more complicated functions.

Simple problems

Consider the following problem:

Find two nonnegative numbers whose sum is 9 and so that the product of one number and the square of the other number is a maximum.

Let the two nonnegative numbers be x and y. Then we have that $x + y = 9$. We need the product of one number and the square of the other to be a maximum. So we have the following function:

$$z = xy^2$$

We use the constraint to get an expression for x:

$$x = 9 - y$$

$$z = (9 - y)y^2$$

$$z = 9y^2 - y^3$$

We now differentiate and let the derivative equal zero to find the maximum.

$$z' = 18y - 3y^2$$

$$0 = 18y - 3y^2$$

$$y = 6$$

$$x = 9 - 6 = 3$$

So $x = 3$ and $y = 6$, gives the maximum z, which is $z = 3 \cdot 6^2 = 108$.

We can use the Optimizer to solve this problem easily. We add the variables(VAR) x and y. Then we add a constraint(CON), which is the sum $x + y = 9$. The Lower, Upper and Value of the constraint must be set to 9. Since the two numbers are nonnegative and their sum is 9, we set the Lower and Upper values for both of them to be 0 and 9, respectively. We leave the value for both x and y to be 0. Finally, we add an objective function(OBJ), xy^2. We use the IPOPT solver and run the optimizer. The Optimizer gives the following values:

```
x = 3.00015026620687
y = 5.99984973379313
z = 107.999999796784
```

Now obviously, because this is an optimizer and uses complex algorithms to compute the values, it will not give integer values, but the given values are very close to the exact values. But if we really want integer values, we can change the types of the variables and the objective function to "int" for integer in which case it will round off to the nearest integer.

Let's look at one other problem:

What angle between two edges of length 3 will result in an isosceles triangle with the largest area?

The angle turns out to be $\frac{\pi}{2}$ making the largest area 4.5. You should verify this by solving the problem. To solve this using the optimizer we add 2 variables, side1 and side2 and making the lower, upper and value to be equal to 3. Add another variable for the angle and let it be between 0 and $3.2(\pi < 3.2)$. The Optimizer operates in radians. Add an objective function and enter this function for the area: `(1/2)*sin(angle)*side1*side2`. Then we run the Optimizer once again and get the following values:

```
angle = 1.57133599066897
area = 4.49999934471655
```

Again we see that we are very very close to the exact values.
Conclusion: As shown above, the Optimizer is a great tool to solve simple maxima/minima problems that often appear in high school curricula and first year university courses.