

A SIMPLE METHODOLOGY TO BENCHMARK & OPTIMIZE PLANT PERFORMANCE WITH EXAMPLE OF GRM (Gross profit) OF A PETROLEUM REFINERY

ABSTRACT

This paper, explains, how plant performance benchmarking can be easily and quickly done, daily, in few minutes. This is illustrated with an example of a petroleum refinery. The objective is to maximize GRM (the gross profit) of refinery, which has about 30 plants.

The proposed practice is as follows:

1. Use the following simple equation, to know, whether refinery profit TODAY, is as per benchmark, or lower. This will take one minute.

GRM= (0.19 * Refinery Throughput) + (0.8 * Distillate Yield) + (40 * (Ratio of Sales Revenue / Annual Crude Cost) + (0.0001 * Crude price /MMT) -107.95

2. If GRM is lower than expected, address relevant factor, i.e. Throughput or yield (by optimizing operating parameters). Remaining two factors in the equation are beyond operations control. Parameter optimization can be done, by spending not more than 2 minutes per day, last section of this paper explains "BENCHMARK™ ALERT service" (www.benchmark1.in) for the same. NO laboratory analysis/assays/feed analysis, is needed.

Many refineries already have established work processes and systems, to optimize the operating parameters every day. For such refineries, even that 2 minutes of extra work is not needed.

3. Thus, commercial excellence, i.e. maximum GRM, can be achieved, with available manpower, with few minutes of extra work every day. The paper shows extent of \$ GRM increase/benefits possible, by operating parameter optimization, alone.

SUMMARY

A very simple relationship, as an example, for a PARTICULAR Refinery, is found,

$$\text{GRM} = (0.19 * \text{Refinery Throughput}) + (0.8 * \text{Distillate Yield}) + (40 * (\text{Ratio of Sales Revenue} / \text{Annual Crude Cost})) + (0.0001 * \text{Crude price} / \text{MMT}) - 107.95$$

The relationship is quite accurate, coefficient of correlation being 0.92. In other words, this equation can explain 92% of variation in GRM, remaining 8% variation is due to factors, other than the 4 factors mentioned above. Also note the high negative fixed factor, - 107.95, which characterizes high fixed costs, and low profit margins, in case of petroleum refineries, which is of the order of magnitude 5%

The above equation is developed, for a particular refinery, using publicly published data (or very easily available data, in refinery). It takes one hour to perform this analysis, and generate such equation, for a refinery. Such an equation can be generated for any business.

Example calculation and analysis demonstrates relative importance of following 4 factors on GRM in a particular refinery. It can be noted that these 4 factors account for all the variation in refinery economics. 92% of variation in GRM (Gross Refinery Margin), is explained by these factors

1. Refinery Throughput
2. Distillate Yield
3. Market incentive/Cracks/pricing of petroleum products - in this analysis, a simple factor (Sales revenue/Crude cost), is used
4. Crude price per MMT (this factor is taken in analysis, to account for Brent variations)

Finally, this analysis is for a refining only company, NOT a refining and marketing company. The subject refinery has less than 50 retail outlets. Although, a similar exercise can be done for any company. Also, this analysis is REFINERY specific i.e., the same relationship will not hold good for any other refinery.

Another possible utility of such analysis is to know which of the above 4 factors is most impacting the GRM. Increase in GRM, due to parameter optimization, is also quantified.

It can be shown that out of above 4 factors, the percentage impact on GRM is as follows:

FACTOR	PERCENTAGE IMPACT ON GRM
Refinery Throughput	2.5 (Note- this is in "normal" throughput range, if throughput is abnormally low, this relationship will not hold)
Distillate Yield	54
Ratio of Sales Revenue / Annual Crude Cost	39.3 (This is market driven, not impacted by efficiency or throughput of refinery operations)
Crude price /MT	4.1 (Typically decided by crude purchase decisions)

BASIS

1. The data is taken from website published sources, for years 2014-2015 to 2022-2023
2. Data for year 2019-2020, is excluded as it was found abnormal. Annual report mentions - Q1 was impacted by "unprecedented water shortage and Q4 was impacted by Covid.

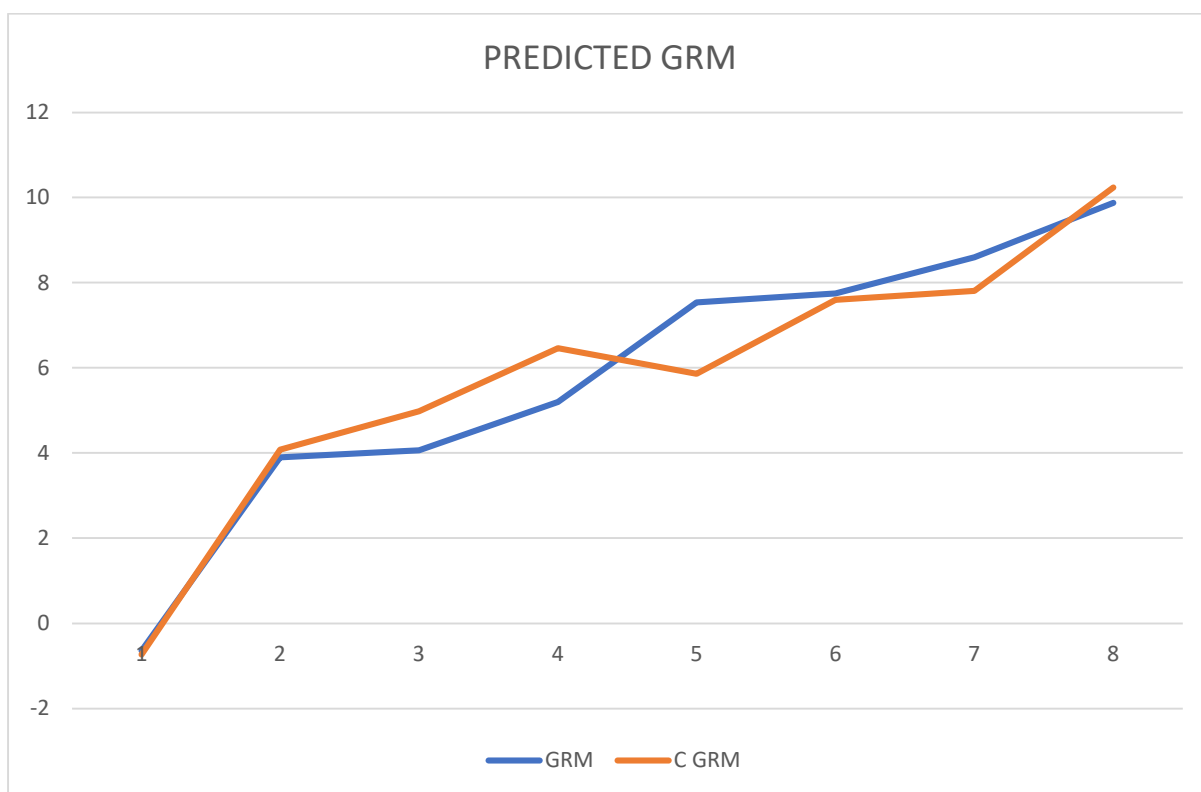
Following is the data

Year	GRM	Throughput MMT	Distillate Yield	Sales Revenue/Annual Crude cost	Crude price /MMT
2014-15	-0.64	14.6	72.31	1.032021	38120.55
2015-16	5.2	15.5	76.9	1.171533	21825.3
2016-17	7.75	16	77.3	1.186411	22753.72
2017-18	7.54	16.1	76.5	1.146535	26238.39

Year	GRM	Throughput MMT	Distillate Yield	Sales Revenue/Annual Crude cost	Crude price /MMT
2018-19	4.06	16.2	76.8	1.087299	35215.87
2020-21	3.9	11.5	78.09	1.095365	25326.22
2021-22	8.6	14.9	78.8	1.09882	42590.14
2022-23	9.88	17.11	77.9	1.117863	56886.99

RESULTS

Here is the comparison of actual GRM and GRM, predicted using the said relationship.



Following is same data, tabulated year-wise:

Year	GRM	Predicted GRM
2014-15	-0.64	-0.73199
2015-16	5.2	6.459788

Year	GRM	Predicted GRM
2016-17	7.75	7.599141
2017-18	7.54	5.86095
2018-19	4.06	4.982757
2020-21	3.9	4.074499
2021-22	8.6	7.806921
2022-23	9.88	10.23794

ANALYSIS

FACTOR	PERCENTAGE IMPACT ON GRM
Refinery Throughput	2.5 (Note- this is in "normal" throughput range, if throughput is abnormally low this relationship will not hold) Many refiners have told that in practice this is the MOST reported factor and has most of refinery challenges and efforts are consumed to achieve this in "normal throughput range"
Distillate Yield	54 This is achieved by knowing the "RIGHT" operating plant parameters, typically called OPTIMIZATION, and in practice decide by plant operator and thereafter maintaining these RIGHT factors on a minute-to-minute basis, which is typically done by APC

FACTOR	PERCENTAGE IMPACT ON GRM
Ratio of Sales Revenue / Annual Crude Cost	39.3 (This is market driven, not impacted by efficiency or throughput of refinery operations)
Crude price /MT	4.1 (Typically decided by crude purchase decisions by the planning department)

HOW MUCH GRM COULD BE IMPROVED, JUST BY OPERATING PARAMETER OPTIMIZATION?

Using the accurate GRM relationship, following order of magnitude can be easily calculated, for this particular refinery which is 300,000 bbl/day. This is assuming, that yield increase is at practically zero cost, hence GRM increase, translates into equivalent net profit increase of the particular refinery.

For possible yield increase of	Calculated possible GRM increase	Calculated possible <u>DAILY NET PROFIT</u> increase	Calculated possible <u>ANNUAL NET PROFIT</u> increase
0.1%	0.08 \$/bbl	0.024 M\$ Rs. 0.2 Cr	8 M\$ Rs. 66 Cr
0.5%	0.4 \$/bbl	0.12 M\$ Rs. 1 Cr	40 M\$ Rs. 330 Cr
1%	0.8 \$/bbl	0.24 M\$ Rs. 2 Cr	80 M\$ Rs. 660 Cr
1.5%	1.2 \$/bbl	0.36 M\$ Rs. 3 Cr	120 M\$ Rs. 990 Cr
2%	1.6 \$/bbl	0.48 M\$ Rs. 4 Cr	160M\$ Rs. 1320 Cr

In order to know “possible yield increase”, as in the table above, the difference of actual yield and EXPECTED yield is to be calculated for a particular year. This is assuming that optimization of all parameters will lead to actual yield being equal to EXPECTED yield. It is not possible for “man on street,” to know what was the EXPECTED yield of the crude, fed to the refinery. However, the refinery planning department may have record, so as to what was the EXPECTED yield in the particular refinery, of the crude purchased in a particular year. Such yield vectors form basis of refinery planning, using well-known tools, like PIMS/RPMS/Haverly/Aveva, and others.

HOW PARAMETER OPTIMIZATION CAN BE DONE WITHOUT SPENDING NOT MORE THAN 2 MINUTES PER DAY, USING “BENCHMARK™ ALERT SERVICE”

This section explains a specific offering of BENCHMARK www.benchmark1.in, and is like an advertisement. One may skip this section, without any academic loss.

This is how the “BENCHMARK™ ALERT service” works:

1. Plant engineer sends current plant data (no lab data needed) to benchmark by email. For example, a Crude Distillation plant may have 100 no values of important measured parameters like temperature, pressure, flow. NO laboratory analysis/assays/feed analysis, is needed.
2. In some time, plant engineer gets an email from BENCHMARK, saying following (example)
 - a. Your current distillate yield is 1% less than possible. Please keep following combination of temperature, pressure, flows, in the plant, to get the extra 1% yield
 - b. All important product qualities current, as well as optimal, are predicted
 - c. All ABNORMAL parameters, which can lead to accidents, breakdowns, process upsets, in some time, are pointed out

The above advise is based on an accurate process model, PROVED earlier.

Customer does not have to install any system, does not have to buy any hardware or software. Model is property of BENCHMARK, and NOT delivered to customer.

Customer pays for each use. For example, if this plant uses the "BENCHMARK™ ALERT service" 10 times in a year, customer will pay for

Usage of 10 times X PER USE PRICE (current PER USE PRICE is INR 30,000 +Taxes).
INR 30,000 is approximately US\$ 350

Thus, there is no money wastage on account of unutilized system/CAPEX, or money wastage on account of advance fixed annual fees paid.

CONCLUSION

Simple data analytics can be useful to know which factors impact the GRM most. Author is not expert in refining business, but purely based on this analysis, it can be said that for this particular refinery, the Plant Operating Parameter Optimization is the most important factor that decides actual GRM achieved, in "normal throughput range," and having bought the right crude.

AUTHOR



Samir Gijre, consultant at BENCHMARK, applies AI and strategy, to improve industrial processes, as well as to improve human happiness and efficiency.

Samir.Gijre@benchmark1.in

BENCHMARK provides pay per use service, which is - zero upfront cost, zero CAPEX, zero risk, zero maintenance cost, for PLANT OPERATING PARAMETER OPTIMIZATION, for petroleum refineries and other process/power plants. Typical benefits are 10 times the cost, benefits are realized on the same day, i.e., payback period is one day.

www.benchmark1.in