

# 第106期:油田伴生气回注模拟方法及流程(GEM)

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伴生气回注是石油天然气开采产生的酸性气体的一项处理技术,既避免了环境污染和能源浪费,又能带来一定的经济效益。CMG 模拟伴生气回注技术有三种方式实现:单井方法、井组方法、CoFlow 方法。



本期以 gmflu001.dat 为例介绍前两种方式, GEM 模拟器自带算例路径: ...\CMG Templates\GEM\2022.10\TPL\flu。

该算例为凝析气藏循环注气模型,使用 9x9x4 笛卡尔网格,10 个流体组分,重力平衡 初始化,一注一采,前10年 75%的产出气进行回注,后 5 年衰竭开采。

生产井以最大产气量 STG 和最小井底流压作为约束条件, 注入井以最大注气量 STG 和最大井底流压作为约束条件。回注模拟需要注意的有两点:



- 生产井的类型为 CYCLPROD
- 注入井的流体定义为 CYCLING

这样就将两口井进行了关联。生产井的产气组成随时间变化,更新频率为每个时间步,即当前时间步注入流体组成为前一个时间步产出流体组成。

本期流程虽然篇幅较长,但流程并不复杂,熟悉之后,三分钟内即可完成。



### 一、井组方法

原模型中并未进行井组定义,因而,本节需要设置井组。在油气田开采过程中,当伴生 气量无法满足注气需求时,需注入一定量的补气,井组方法也可以进行相应的表征。

将gmflu001.dat拖入Builder图标, File→Save As, 另存为gmflu001\_1.dat。
 井组可实现回注比例的控制, 需注意的是, 井组控制和单井控制同时起作用, 执行最严格的控制条件。

2. 注入井的最大注气量STG可以不进行设定,或者设定为生产井的最大产

气量。以后者为例,点击左侧树视图Wells & Recurrent,双击Wells。



3. 在弹出的对话框中,点击INJ-Constraints,将其STG改为6200000 ft3/day。

修改数值时,单击数据框直接输入或粘贴数值,单位自动填充。OK退出。

Well Events										$\times$
displayed w	ells 2 of 2	1986-01-01	~	Well:	'INJ' at	1986-01-01	(0. 00 da	uy)		
Name / Date	Event	ID & Type	C	onstraint definition	previous date: <r< td=""><td>none&gt;</td><td></td><td></td><td></td><td></td></r<>	none>				
1986-01-01	WELL	Constraints	#	Constraint	Parameter		Lim	Value	Action	Freq
	constraints		* :	OPERATE	STG surface g	as rate	MAX	6200000 ft3/day	CONT	
1996-01-01	injected fluid		:	OPERATE	BHP bottom ho	le pressure	MAX	4000 psi	CONT	
PROD	ononin			select new 💌						
1986-01-01 WELL		Wellbore								

### **4. 双击Groups (0)** 创建井组。

ビ Wells & Recurrent	•
Separators Tubing Tables Groups (0) W Hydraulic Fra	; (0) cturing
Wells (2) Dates (6) Triggers (0) Well List (Ope	en/Shut)

5. 弹出的创建井组对话框中,可对井组名进行编辑。CMG中,可定义多级



井组,其中一级井组不能直接关联井,需点击左下角Add new group,继 续创建二级井组Group-2,并在第二个弹出对话框中点击OK,退出。

Definition			
Production	Name:	Group-1	
Injection	Parent group:	<none> this is a top-level group</none>	
Multipliers		The parent can be either top level group or a	
Monitoring		2nd level group with no wells attached.	
Apportionment		Attach Wells	
Cuido Potos	Please note.		
ourde kates	- defining the top- moment. To proci date.	-level group and no child group defined yet. No constraints can be defined at th eed with constraints, etc. you need to define at least one child group at the sele	e cted
ourue Aates	- defining the top- moment. To proce date.	-level group and no child group defined yet. No constraints can be defined at th eed with constraints, etc. you need to define at least one child group at the sele date: 1986-01-01	e cted

6. 点击树视图中的Groups(2),在弹出的对话框中选择Group-2,点击Attach Wells关联井,并在下一级的对话框中选择需要关联的两口注采井, OK。

Group Events	;		— D X
		1986-01-01	✓ Ind level group 'Group-2' at 1986-01-01 (0.00 day)
Name / Date	Event	Definition	Group definition Previous date: <none></none>
1986-01-01 Group-2	GROUP	Production	Name: Group-2
1986-01-01	GROUP GCONI	Injection	Parent group: Group-1
		Multipliers	The parent can be either top level group or a
		Monitoring	
		Apportionment	Attach Wells
		Guide Rates	Well-Group Attachment — — — X
		Autodrill	Well Group: Group-2
		Recycling	Auto-Apply Changes Select Wells To Display. All By Filter
		Manifolds	NOTE: * the well definition event. Its date can not be modified.
		Options	P*         E.         Well         Date         Group           □**         1.         ☑         INJ         1986-0         Group-2
		Cycling Group	× 2 PROD 1986-0 Group-2
		Comments	
Sort by: ONam			

7. 设置回注比例。点击Injection,勾选GCONI复选框,依次选择Recycle,

### GAS,并设定回注比例0.9。

Group Events	5											$\times$
		1986-01-01	~	2	nd 1	evel group	'Grou	p-2'	at 1	1986-01-01	(0. 00	day)
Name / Date	Event	Definition	G	CONI aroup iniec	tion co	onstraints	F	revious d	late: <nor< td=""><td>1e&gt;</td><td></td><td> </td></nor<>	1e>		
Group-1	00000		<u> </u>									
1980-01-01	GROUP	Production	#	Туре		Parameter		Value/	Fractic	on Actio	n Ma	ake
1986-01-01	GROUP	Triestion	• :	RECYCLE		GAS gas pha	se	0.9	]			
	GCONI	Injection		select new	-							



8. 对应的关键字段:

GCONI 'Group-2' RECYCLE GAS 0.9 \*\*回注比例

9. 点击 🖩 保存,因模型较小,运算时间短,可在Builder点击菜单栏下 🎺 🕬

→**Run normal immediately**提交运行,结束后点击**Launch Results**打开后 处理模块。

С	) Validate (Run to ) Run to view initia	validate da	taset only) 1 one time step)			S	how/Hide Job	Status		
0	Run normal imm	ediately atch (Subrr	it to job scheduler	)			Display .OUT	file		
Run Abort Simulation Launch Results										
ile	D:\Users\WuXY\	CMG Temp	ates\GEM\2022.1	0\TPL\flu\ç	ymflu001	_2.log				
T T T T M S I I M D C E E	62w 61.00 otal numbe: otal numbe: otal numbe: aterial Bai olver/CPUs, mplicitnes: emory usage ate and tin PU second(: lapsed sec: nd of Simu:	1 r of ti r of Ne r of sc r of sc lance E /thread s, aver e, aver me at e s) used ond(s): lation:	5478 200 me steps: wton cycle lver itera me step cu lver failu rror; Weig s/nlv1ca/c age/peak/v nd of run: : Normal Te	s: tions: ts: res: hted b dir/dp m size rminat	y Orialanes	gMatIn /host:	-50.1 -50.1 62 94 59 0 0 Place+In AIMSOL/ 4.8135 45 MB/ 2023-Fei 0.875 1.279	j: 8/ %/ 14 47 MB b-23	3.79 1/ .814 / 48 11	2: 2: 69E 0/ 8 % MB :28
_	Item	Units	Value							
#	Total Pore Vol	RES FT3	1.11408E+09							
# 1 2			1 124655-09							
# 1 2 3	Total Hydrocar	RES FT3	1.13403L+00							
# 1 2 3 4	Total Hydrocar Original Oil in	RES FT3 STD BBL	3.38959E+06							

在后处理模块,可以查验一下注采量。

 点击Results界面左侧树视图Plots-Time Series,并在主窗口下方的曲线面 板依次选择Groups-\*.sr3-Group-1-INJ/PRO(使用Ctrl或Shift键)-Gas Rate SC-Add To New Plot。鼠标右键点击曲线,可更换颜色。





通过两条曲线对比可以看出注入量为采出量的 0.9, 实现了回注比例的设置。下面介绍, 伴生气回注的同时, 注入补气的实现方法。

11. 在Builder中,切换Wells & Recurrent,双击Groups (2)。点击Group-2-Recycling,依据下图设置补气最大注气量GMKMAXR和补气组成 GMKCOMP(以CH4为例)。

Group Events						×			
		1986-01-01	Top level g	group 'Group-1' a	t 1986-01-01 (0.00	day)			
Name / Date Group-1	Event	Definition			- (n.)		ke un ans comm	o sit	
1986-01-01 Group-2	GROUP	Production	Control options Gas recycling	Set	Type / Value Pr		ike-up gas comp	OSIL	
1986-01-01	GROUP	Injection	Group producing gas for	GPRODGROUP	Group-1	#	Compo	Fraction	
		Multipliers	Gas make-up target for	GMKUPTO	0 ft3/day	2	C2	0.0	
		Monitoring	Max make-up gas rate	GMKMAXR GRECYMAXR	500000 ft3/day	3	C3 C4	0.0	
		Apportionment	Max fuel consumption rate	GFUELMAXR	0 ft3/day	5	C5	0.0	
		Guide Rates	Max sales rate	GSALESMAXR	0 ft3/day	6	C6 C7-9	0.0	
		Autodrill	Fuel consumption fraction	GFUELFRAC	0	8	C10-11	0.0	
		Recycling	Make-up gas composition	GMKCOMP	1.0 0.0	9	C12-14 C15+	0.0	
		Recycling	Fuel component mask	GFUELMASK	0.0 0.0		Total:	1.0	
		Manifolds	Recycled gas component	GRECYMASK	0.0 0.0				
		Options	Sales component mask	GSALESMASK	0.0 0.0				
		Cycling Group	Water recycling						
		Comments	Group producing water f Water make-up target fo	WPRODGROUP WMKUPTO	Group-1 0 bb1/day				
		4							
Sort by: OName	e Tools •		Reset Page Auto-apply	OK Cancel	Apply Help	Nor	malize	ОК	Cancel

12. 对应的关键字段:

GCONI 'Group-2'											
RECYCLE	GAS	0.9	**回	注比值	列						
GMKCOMP	'Group-	2' 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
**设置注入	气摩尔组成										
GMKMAXR	'Group-	-2'	5e+	-05	**补	给气	注入量	圭			



13. OK退出, File→Save As, 另存为gmflu001\_2.dat。在Builder中直接运行。
14. 打开前面创建好的Results, 切换至Input-Data Sources, 点击主窗口上方的Add Files, 添加gmflu001\_2.sr3。

Enter Search Text	×	OPEN FILES				Add Files
Input     Data Sources     Well Associations	^	Name/Alias	File Name	Туре	Simulator	Path
General Preferences		gmflu001_1.sr3	gmflu001_2.sr3	SR3	GEM	D:\Users\WuXY\CMG Tem

15. 切换至Time Series-Gas Rate SC, Results已经为新模型自动创建曲线, 鼠



标右键点击曲线可更改线型。

16. 点击窗口顶部的 **园**按钮,即可保存为\*.results文件,可直接将其拖拽至 Results图标。

回注比例是控制伴生气回注的重要参数,原则上不能大于1。补气是在此基础上的注入 气,如果补气为CO2,需要事先在模型中添加对应组分。

GEM 井组中的 Recycling 功能较多,后续我们也将根据用户需求进行更多的分享。



## 二、单井方法

如果仅是简单的约束条件即可满足需求,推荐单井方法。如果注采井在整个过程中按照 设置的最大气量注采,也是实现了回注比例的设置,gmflu001.dat就是这样的方式。

17. 回注模型中,生产井类型CYCLPROD,注入井注入流体类型CYCLING,

其他与常规模型设置相同。

Well Events										
displayed w	rells 2 of 2	1986-01-01	~		Well: 'PROD	'at	1986-	01-01 (0. (	00 day)	
Name / Date	Event	ID & Tupo		all definition	Provious date: <	none>				
INJ		ib a type		actinition	Trevious dute.	-none-				
1986-01-01	WELL INJECTOR constraints	Constraints	Name		PROD				Edit	
1996-01-01	injected fluid 1996-01-01 SHUTIN									
PROD 1986-01-01	WELL	Wellbore	Type:	[	CYCLPROD	]		~		
	constraints	Injected Flui	d Group	:	Group-2			~ <sup>3</sup> of	rd or 2nd level group with no ther groups attached to it	
		Workover								
Wall Events										
displayed v	vells 2 of 2	1986-01-01		× 🔳	Well:	' INJ'	at	1986-01-	01 (0.00 day)	
Name / Date	Event					1				
INJ		1D & Ty	pe In	iected fluid <sup>.</sup>	CYCLING				~	
1986-01-01	WELL INJECTOR	Constrai	nts	,						
1996-01-01	injected fluid SHUTIN	Multipli	ers							
PROD 1986-01-01	WELL	Wellbox	e							
	PRODUCER constraints	Injected	Fluid							

## 18. 对应的关键字段:

*CYC	LPROD 1	**生产疗	井类型		
	*OPERATE	*MAX	*STG	6.2000E+6	
	*OPERATE	*MIN	*BHP	500.000	
*INJE	CTOR 2				
	*INCOMP	*CYCL	ING *	*注入流体设	置
	*OPERATE	*MAX	*STG	4.7000E+6	
	*OPERATE	*MAX	*BHP	4000.000	

19. Results中可查看注采气量曲线图。



