Time Series Analysis

1. Imputation using interpolation
2. Decomposition into trend, seasonalit, residuals using statsmodels.api library
3. Exponential Smoothing: Simple Exp Smoothing(SES),Double Exp Smoothing(DES), Tripple Exponential Smoothing(TES)
4. Converting non stationary TS to Stationary TS
5. Types of Models: AR(Auto Regression), MA(Moving Average), ARIMA, SARIMA

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

In [36]:
```
data=pd.read_excel(r"C:\Users\kanwar\Downloads\mobilesales.xlsx")
```

In [3]:
```
data.head()
```

Out[3]:

	DATE	Sales
0	2001-01-01	6519.0
1	2001-02-01	6654.0
2	2001-03-01	7332.0
3	2001-04-01	7332.0
4	2001-05-01	8240.0

In [4]:
```
data.tail()
```

Out[4]:

	DATE	Sales
212	2018-09-01	13838.0
213	2018-10-01	15351.0
214	2018-11-01	15615.0
215	2018-12-01	16941.0
216	2019-01-01	12160.0

In [5]:
```
data.dtypes
```

Out[5]:
```
DATE     datetime64[ns]
Sales           float64
dtype: object
```

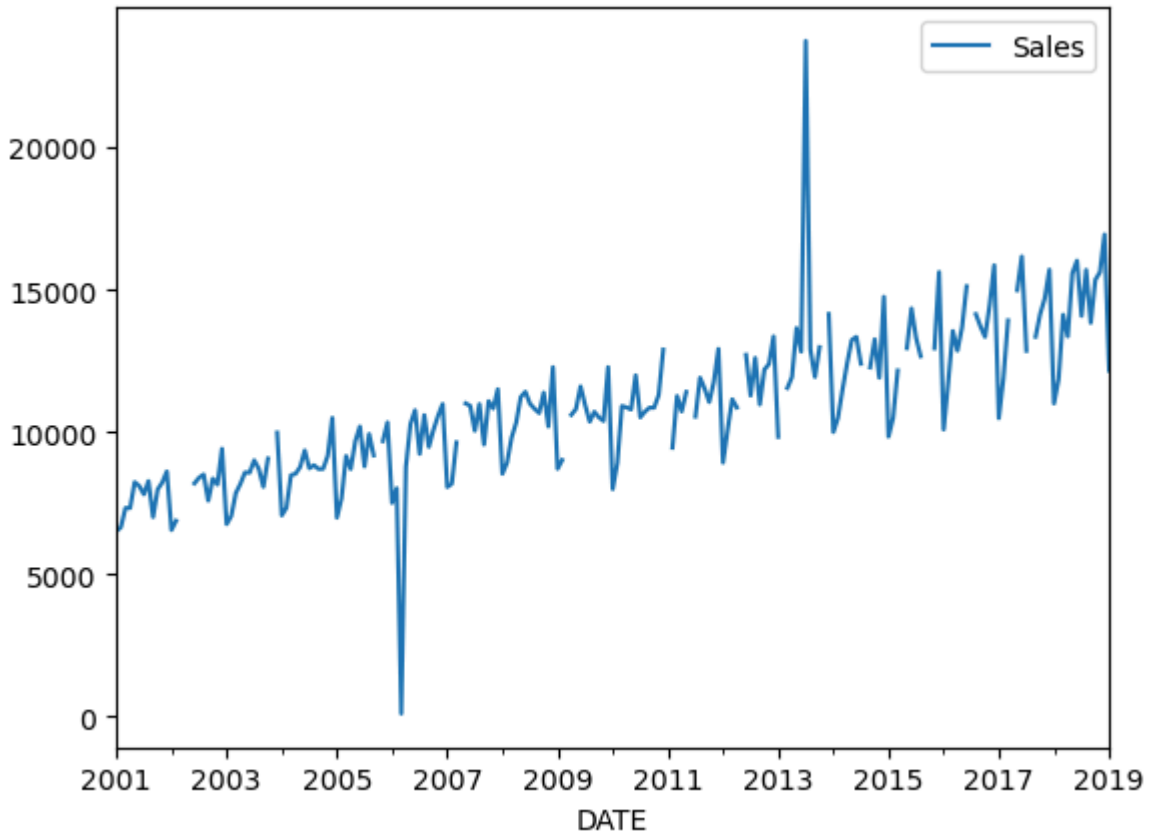
In [6]:
```
data.describe()
```

Out[6]:

	DATE	Sales
count	217	198.000000
mean	2009-12-31 04:25:26.267281152	10842.757576
min	2001-01-01 00:00:00	108.000000
25%	2005-07-01 00:00:00	8856.000000
50%	2010-01-01 00:00:00	10745.000000
75%	2014-07-01 00:00:00	12399.750000
max	2019-01-01 00:00:00	23740.000000
std	NaN	2605.006293

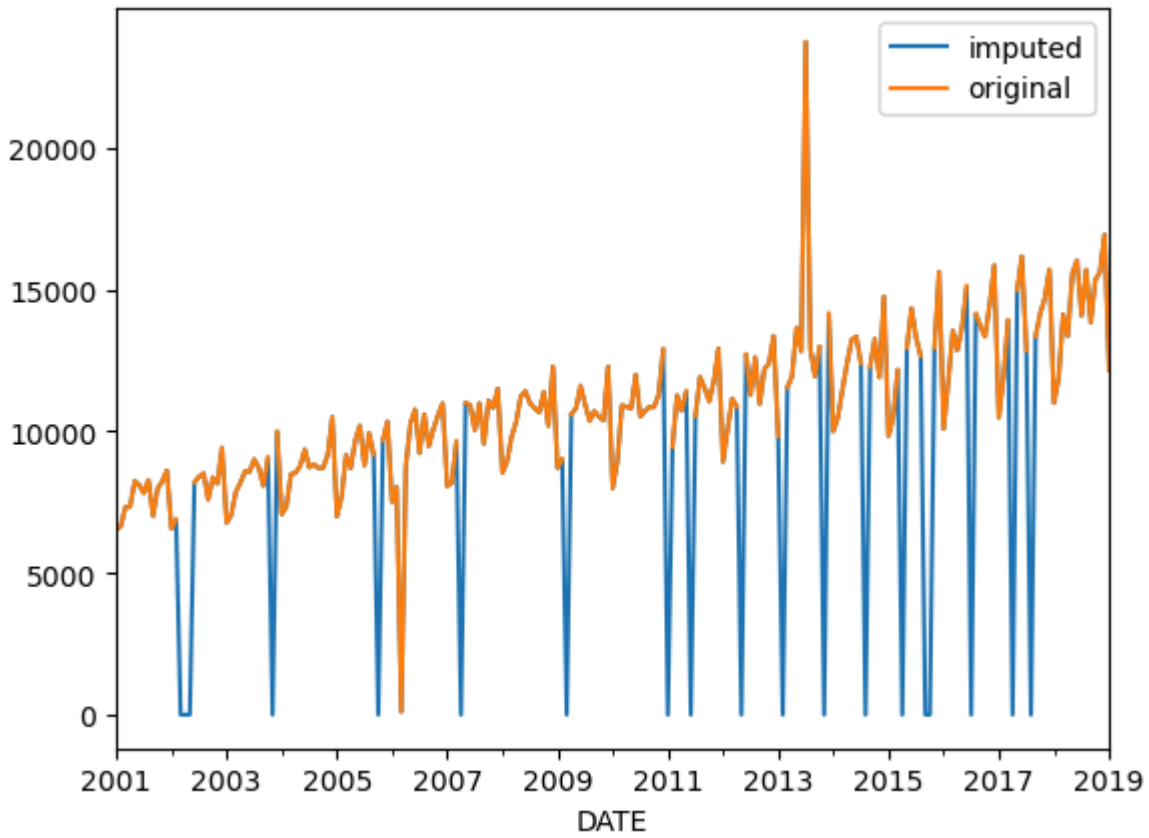
In [37]:
```
data.set_index('DATE',inplace=True)
```

In [38]:
```
data.plot();
```

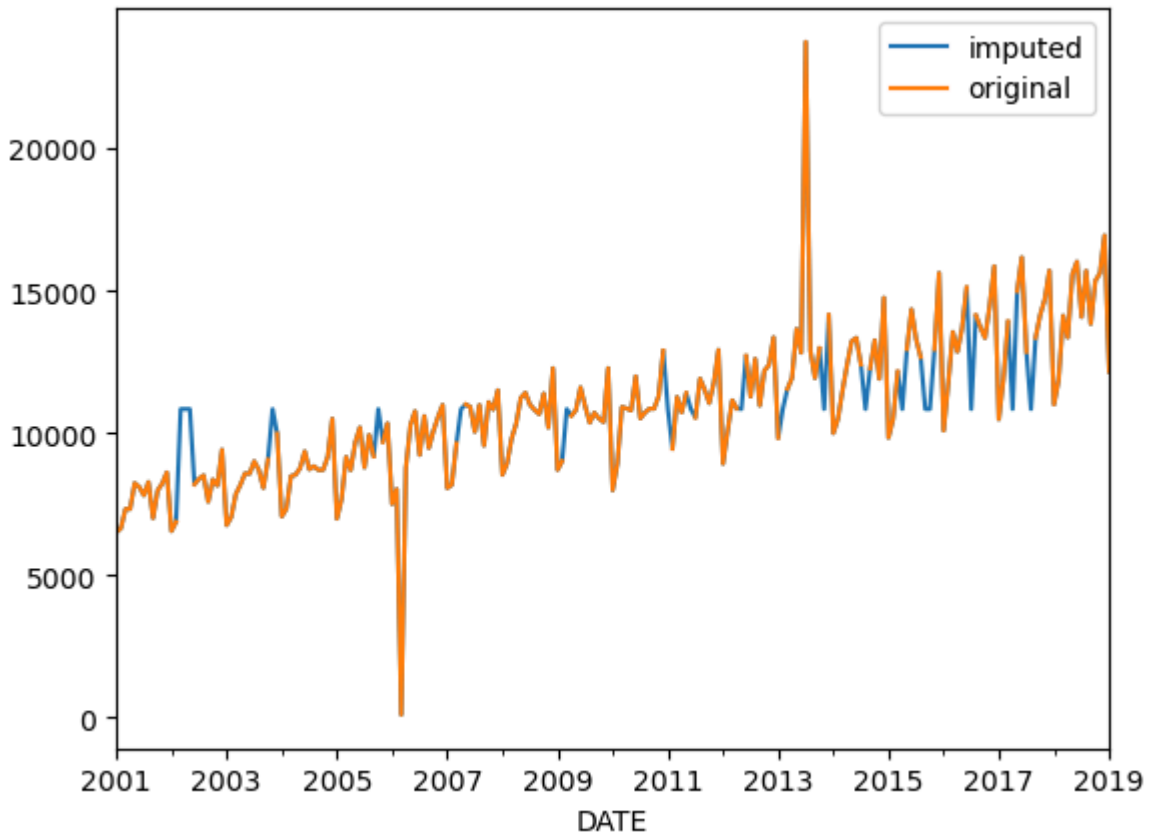


Imputation

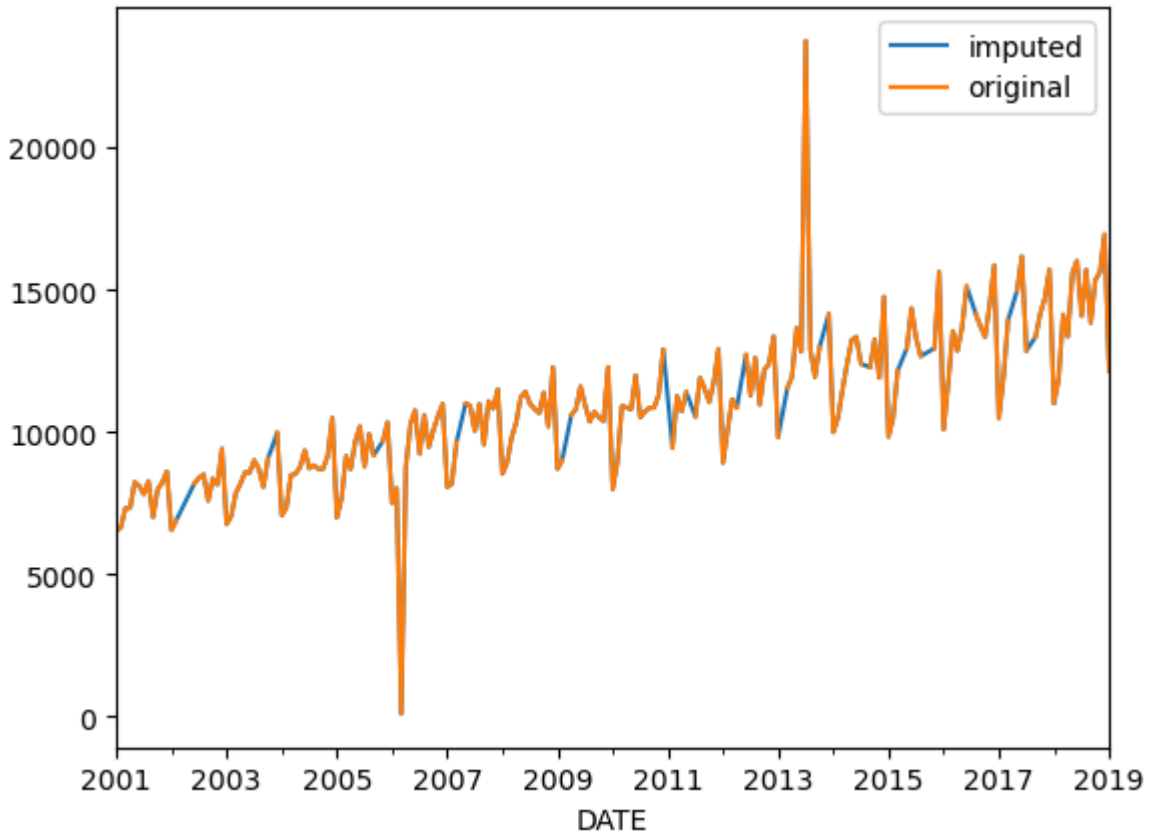
In [39]:
```
data['Sales'].fillna(0).plot(label='imputed')
data['Sales'].plot(label='original')
plt.legend();
```



In [40]:
```
data['Sales'].fillna(data['Sales'].mean()).plot(label="imputed")
data['Sales'].plot(label="original")

plt.legend()
plt.show()
```

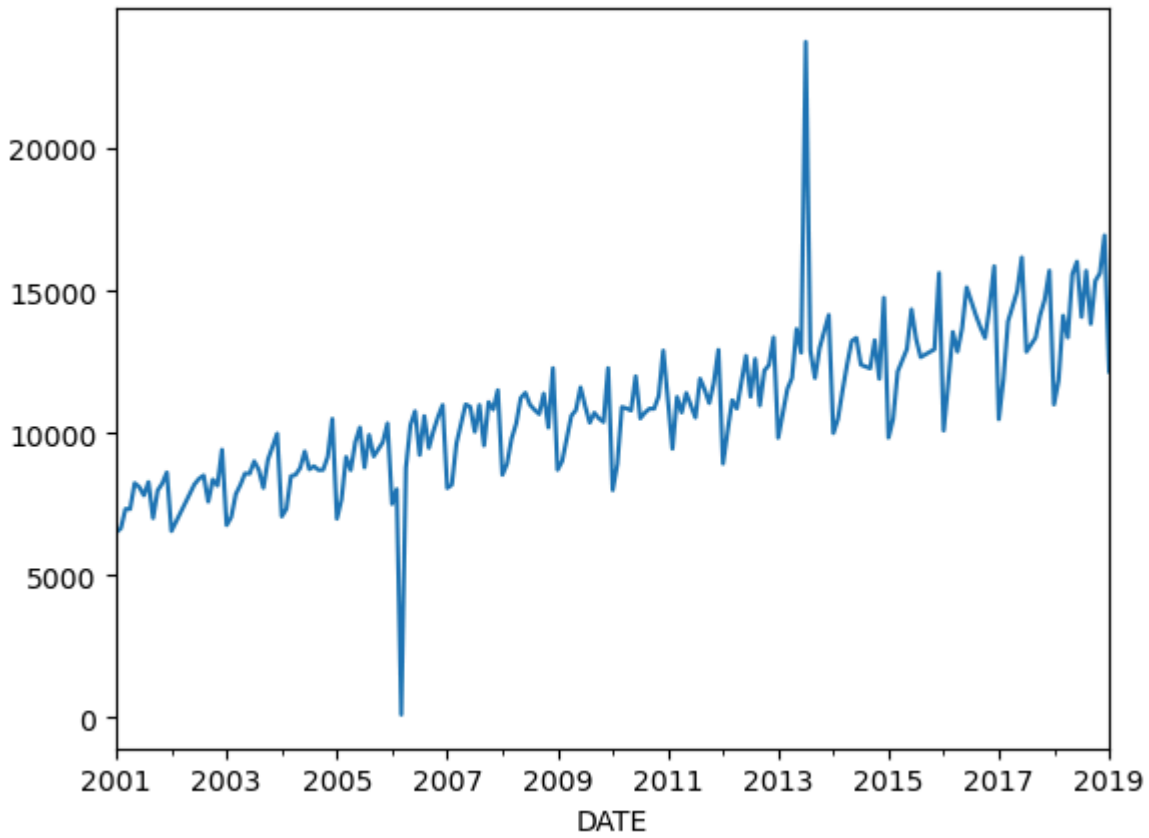


In [41]:
```
# linear interpolation

data.Sales.interpolate(method  = 'linear').plot(label='imputed')
data.Sales.plot(label='original')

plt.legend();
```



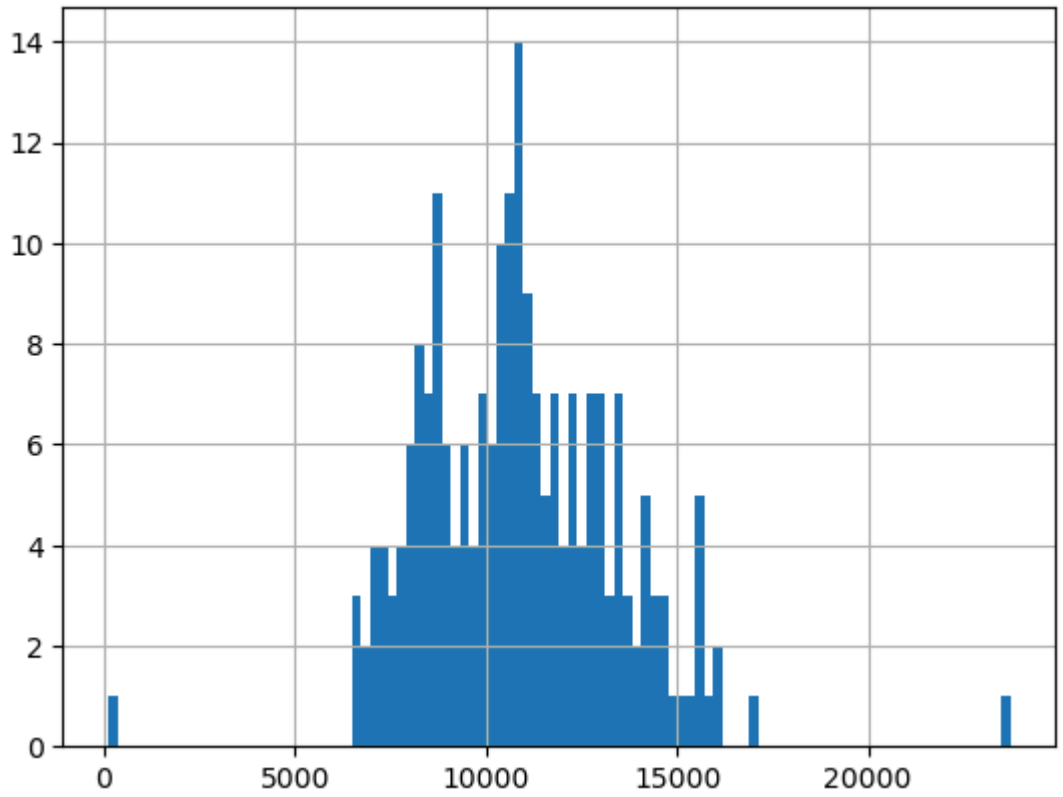
In [42]:
```
data.Sales = data.Sales.interpolate(method  = 'linear')
data.Sales.plot()
```

Out[42]: <Axes: xlabel='DATE'>

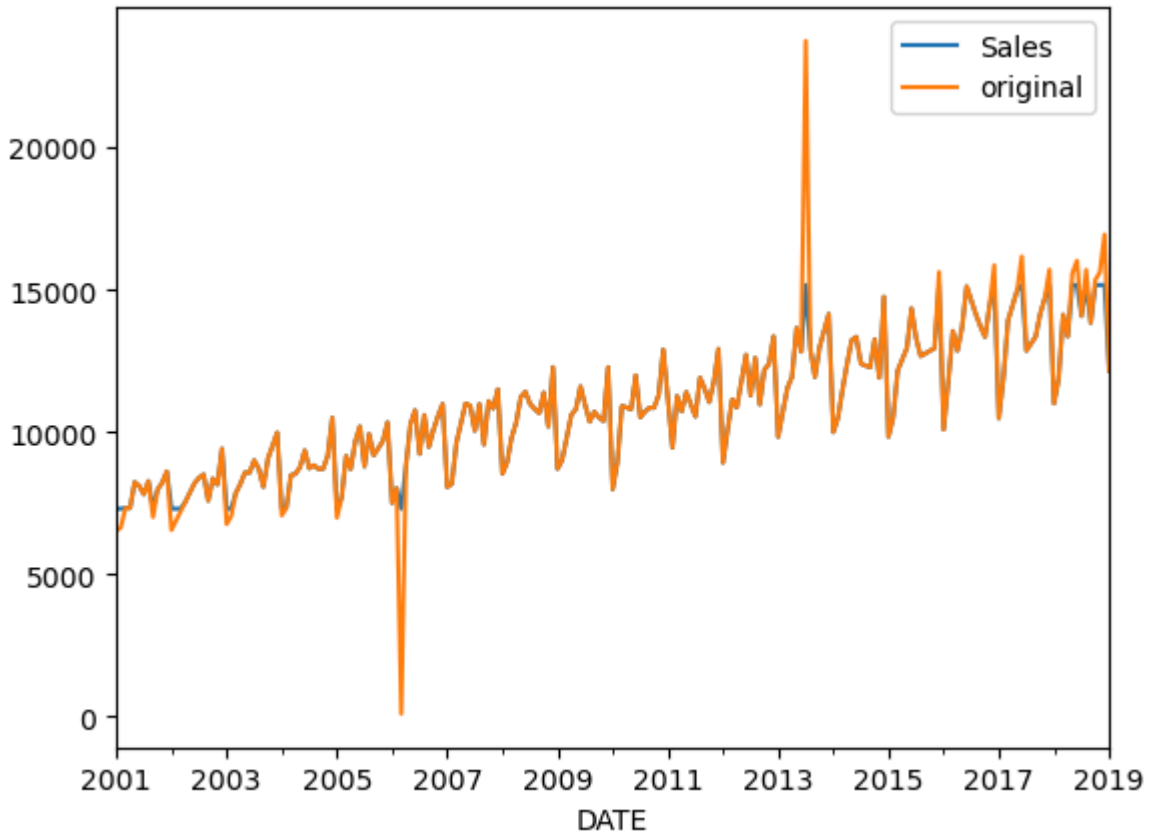


In [13]:
```
data.Sales.hist(bins=100).plot()
```

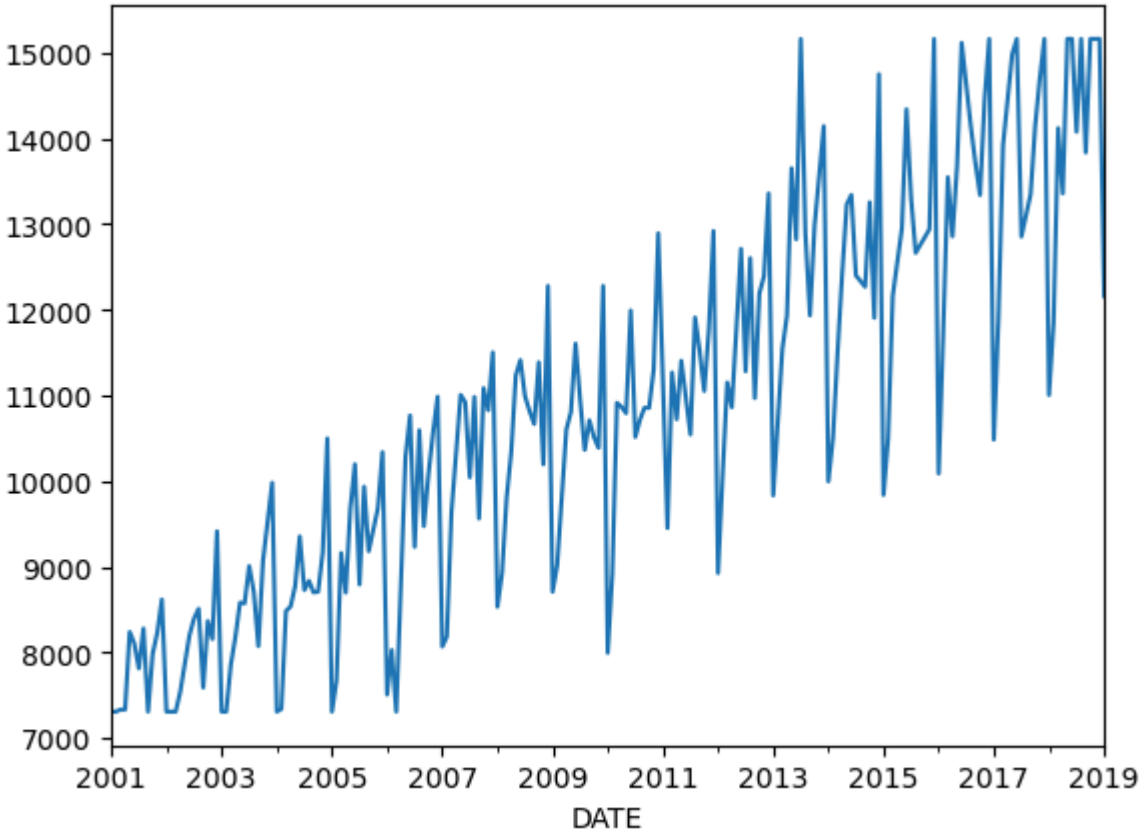
Out[13]:
```
[]
```



In [43]:
```
data.Sales.clip(upper=data.Sales.quantile(0.95),lower=data.Sales.quantile(0.05)).plot()
data['Sales'].plot(label="original")
plt.legend();
```

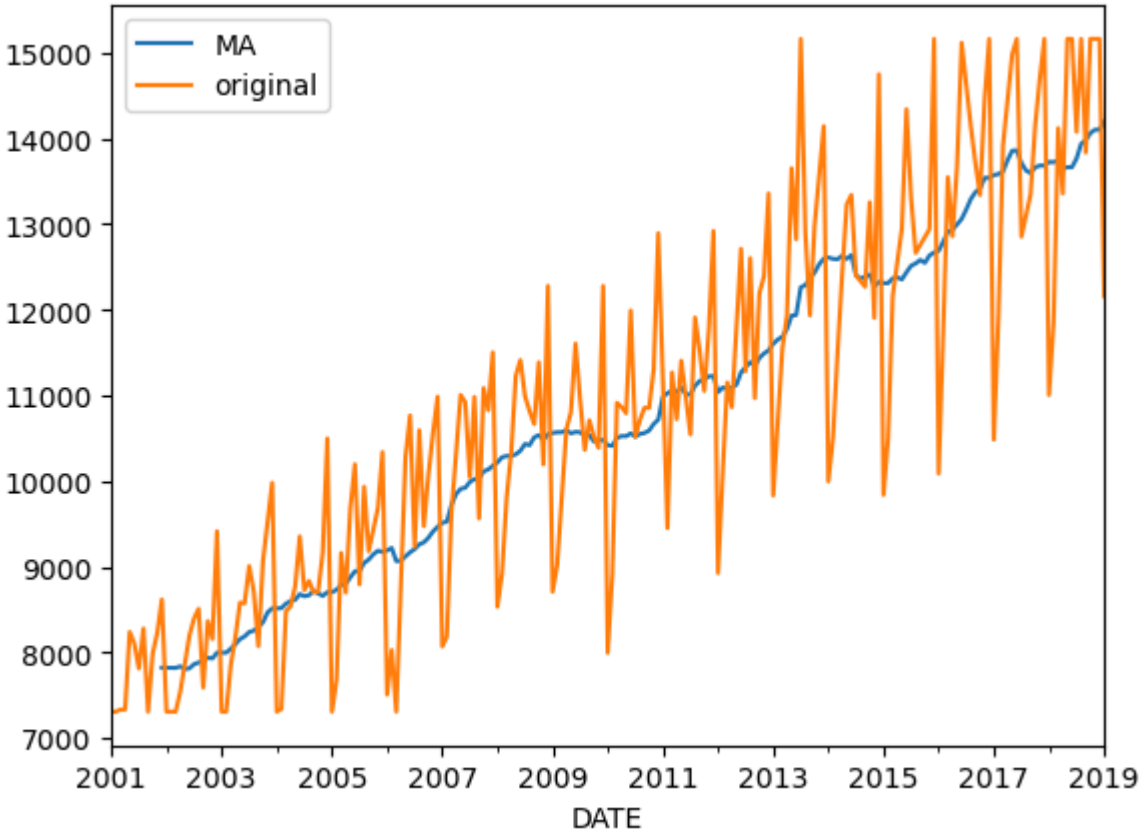


In [44]:
```
data.Sales.clip(upper=data.Sales.quantile(0.95),lower=data.Sales.quantile(0.05)).plot();
```



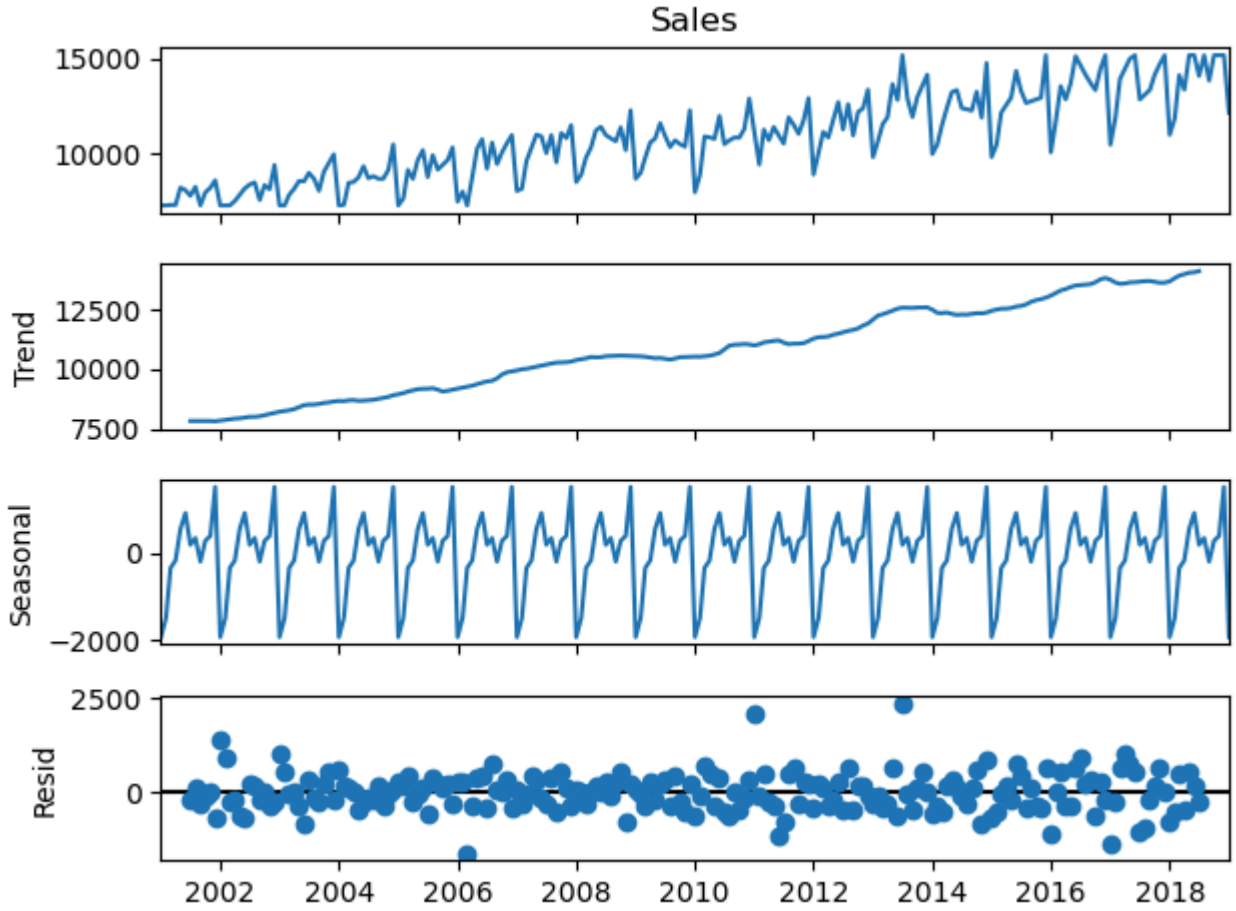
In [45]:
```
data.Sales=data.Sales.clip(upper=data.Sales.quantile(0.95),lower=data.Sales.quantile(0.05))
```

In [46]:
```
data.Sales.rolling(12).mean().plot(label='MA') ## Moving Average (MA) 12 months
data.Sales.plot(label='original')
plt.legend();
```

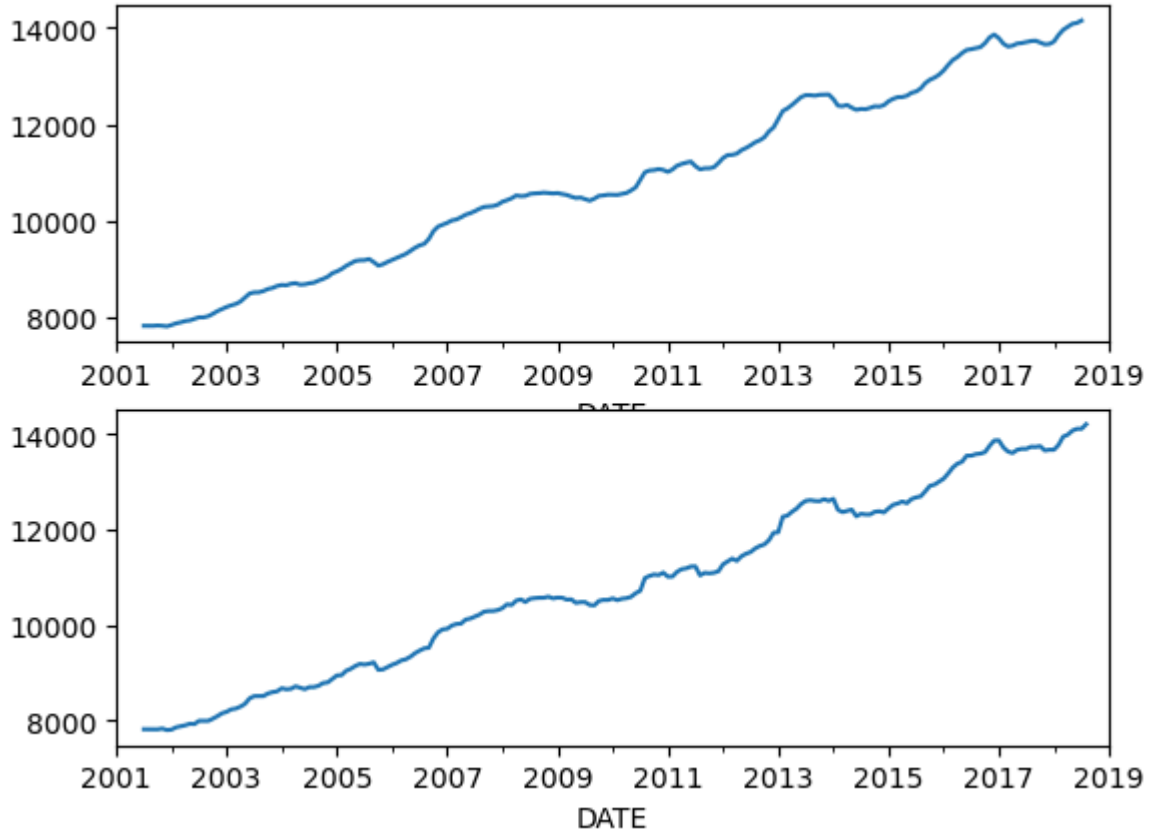


In [47]:
```
import statsmodels.api as sm
model=sm.tsa.seasonal_decompose(data.Sales)
```

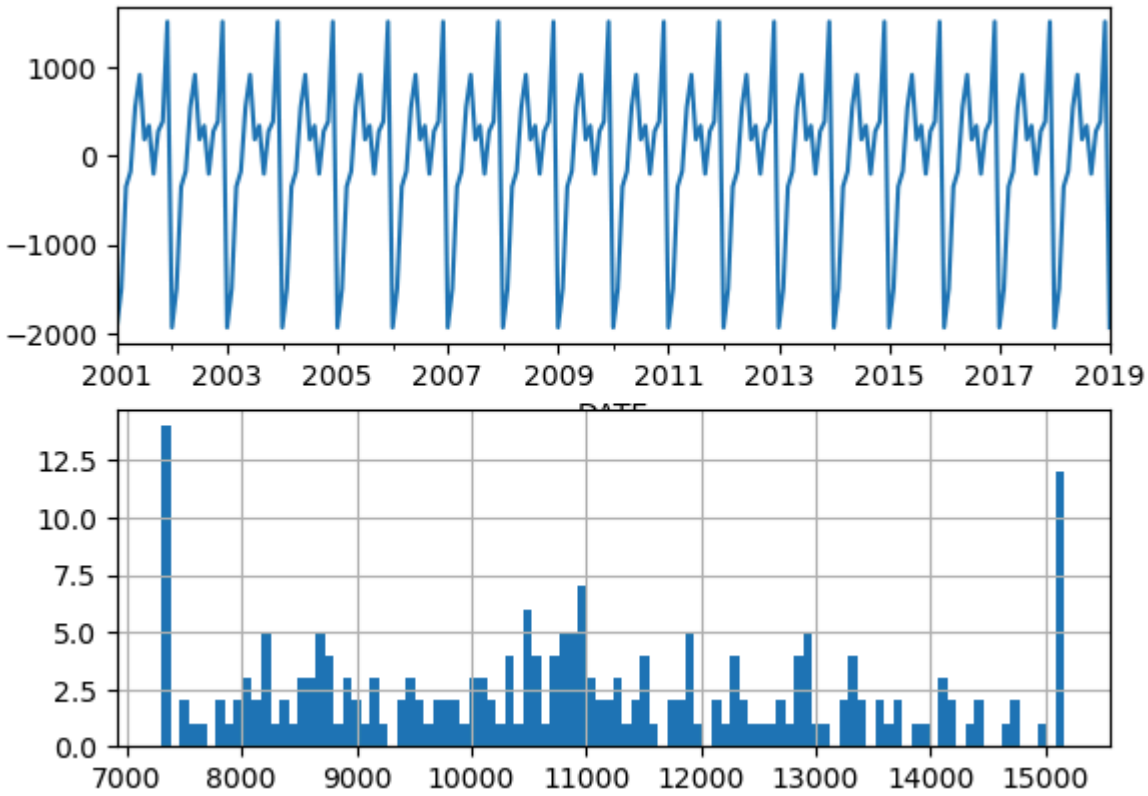
In [24]:
```
model.plot();
```



In [48]:
```
plt.subplot(2,1,1)
model.trend.plot()
plt.subplot(2,1,2)
data.Sales.rolling(12,center=True).mean().plot();
```



In [49]:
```
plt.subplot(2,1,1)
model.seasonal.plot()
plt.subplot(2,1,2)
data.Sales.hist(bins=100);
```



In [39]:
```
model.resid.mean()
```

Out[39]:
```
np.float64(-2.547773692809866)
```

In [53]:
```
train_max_date = data.index[-12]



train_x = data.loc[data.index < data.index[-12]].copy()
test_x = data.loc[data.index >= data.index[-12]].copy()
```

In [41]:
```
train_x.shape, test_x.shape
```

Out[41]:
```
((205, 1), (12, 1))
```

In [42]:
```
test_x
```

Out[42]:

DATE	Sales
2018-02-01	11852.0
2018-03-01	14123.0
2018-04-01	13360.0
2018-05-01	15164.6
2018-06-01	15164.6
2018-07-01	14080.0
2018-08-01	15164.6
2018-09-01	13838.0
2018-10-01	15164.6
2018-11-01	15164.6
2018-12-01	15164.6
2019-01-01	12160.0

In [50]:
```
from sklearn.metrics import (
    mean_squared_error as mse,
    mean_absolute_error as mae,
    mean_absolute_percentage_error as mape
)


# Creating a function to print values of all these metrics.
def performance(actual, predicted):
    print('MAE :', round(mae(actual, predicted), 3))
    print('RMSE :', round(mse(actual, predicted)**0.5, 3))
    print('MAPE:', round(mape(actual, predicted), 3))
```

In [44]:
```
train_x['Sales'].mean()
```

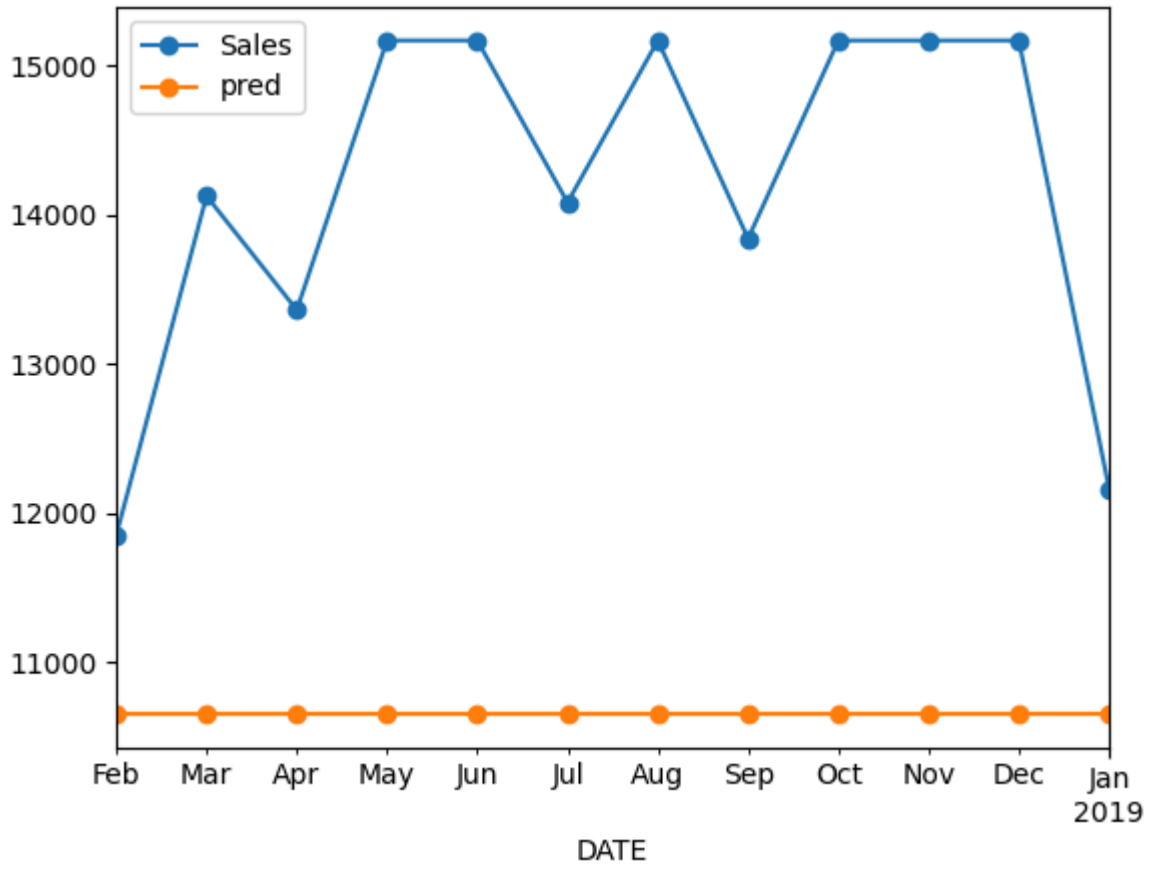
Out[44]:
```
np.float64(10659.16)
```

In [45]:
```
# Mean model
test_x['pred'] = train_x['Sales'].mean()
test_x.head()
```

Out[45]:

DATE	Sales	pred
2018-02-01	11852.0	10659.16
2018-03-01	14123.0	10659.16
2018-04-01	13360.0	10659.16
2018-05-01	15164.6	10659.16
2018-06-01	15164.6	10659.16

In [46]:
```
test_x.plot(style='-o');
```



In [47]:
```
performance(test_x['Sales'], test_x['pred'])
```

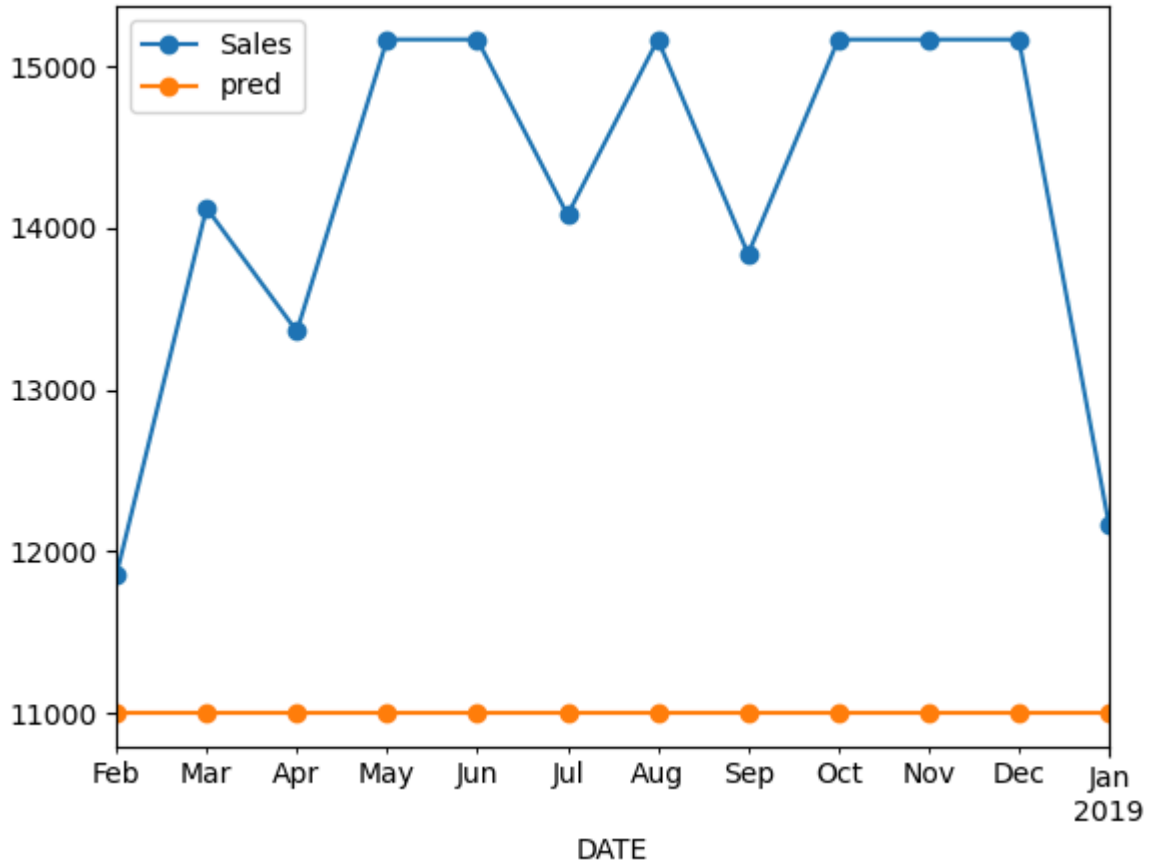
```
MAE : 3540.89
RMSE : 3725.69
MAPE: 0.244
```

In [50]:
```
## Naive Model: Prediction is the last value of the train data
```

In [54]:
```
test_x['pred'] = train_x['Sales'][-1]
```

```
C:\Users\kanwar\AppData\Local\Temp\ipykernel_28896\4166961390.py:1: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  test_x['pred'] = train_x['Sales'][-1]
```

In [55]:
```
test_x.plot(style='-o');
```



In [51]:
```
performance(test_x['Sales'], test_x['pred'])
```

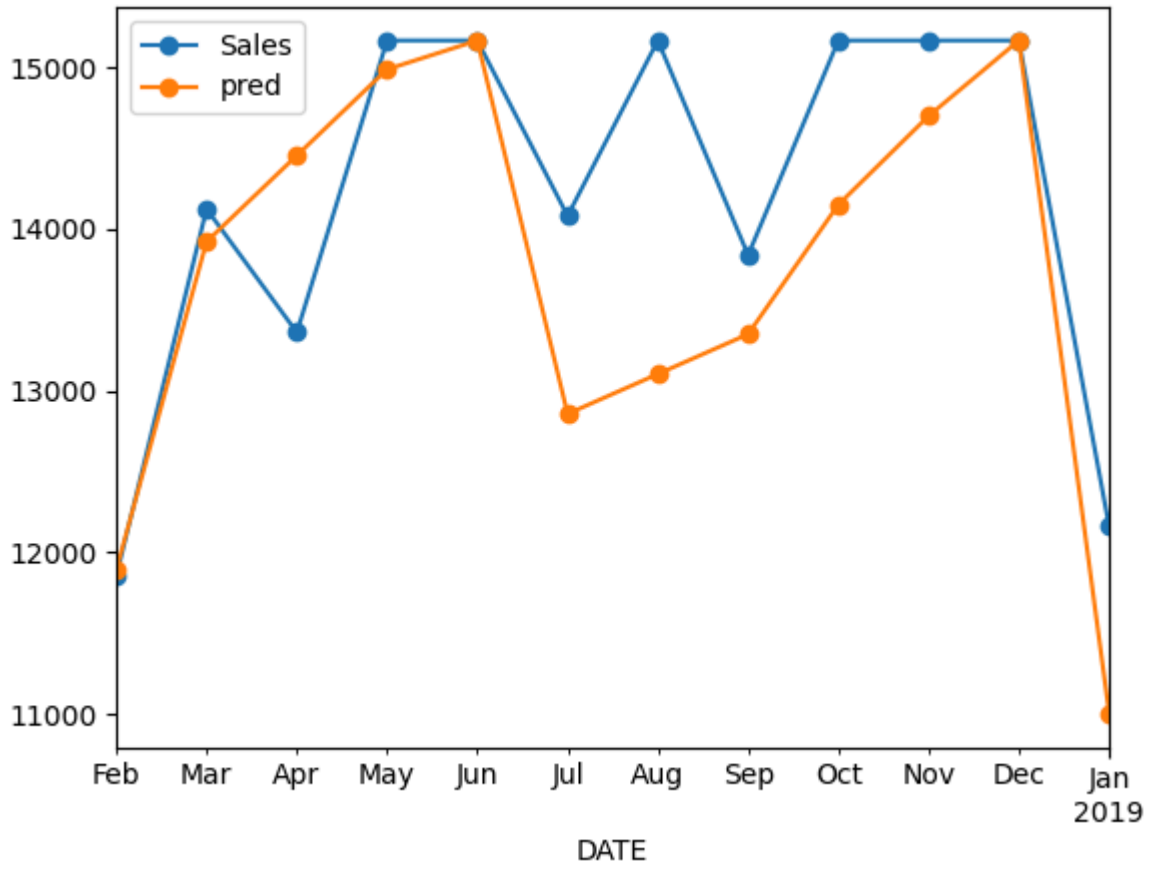
```
MAE : 3195.05
RMSE : 3398.707
MAPE: 0.219
```

In [56]:
```
# Seasonal Naive
pred = []

for i in test_x.index:
  pred.append(train_x.loc[i - pd.DateOffset(years=1)]['Sales'])

test_x['pred'] = pred
test_x.head()
```

Out[56]:

DATE	Sales	pred
2018-02-01	11852.0	11891.0
2018-03-01	14123.0	13921.0
2018-04-01	13360.0	14453.5
2018-05-01	15164.6	14986.0
2018-06-01	15164.6	15164.6

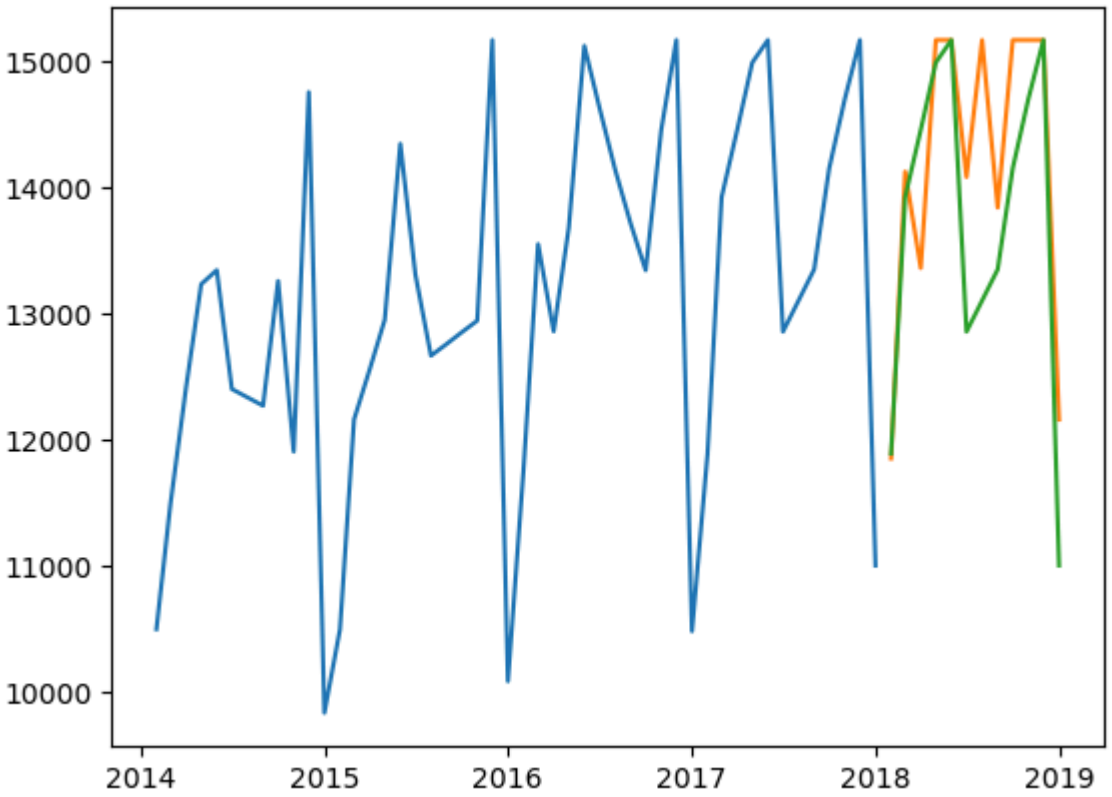
In [57]:
```
test_x.plot(style='-o');
```



In [54]:
```
performance(test_x['Sales'], test_x['pred'])
```

```
MAE : 660.367
RMSE : 905.569
MAPE: 0.047
```

In [55]:
```
plt.plot(train_x['Sales'][-48:], label='train')
plt.plot(test_x)
plt.plot();
```

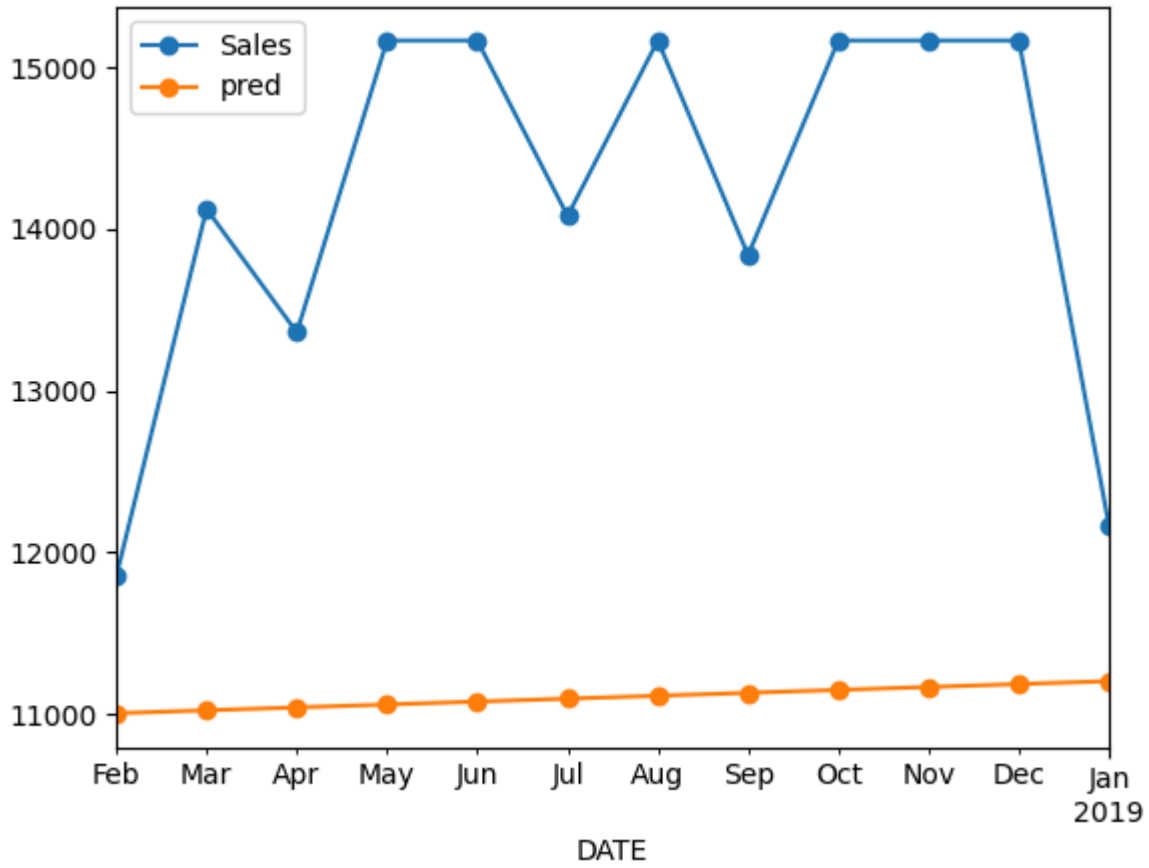


In [56]:

```
## Drift Method: Naive+Trend

# Get the slope
yt = train_x['Sales'][-1]

m = (yt - train_x['Sales'][0]) / len(train_x)

h = np.arange(0, 12)

test_x['pred'] = yt +  h*m
```

```
C:\Users\kanwar\AppData\Local\Temp\ipykernel_18508\1029698906.py:4: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  yt = train_x['Sales'][-1]
C:\Users\kanwar\AppData\Local\Temp\ipykernel_18508\1029698906.py:6: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  m = (yt - train_x['Sales'][0]) / len(train_x)
```

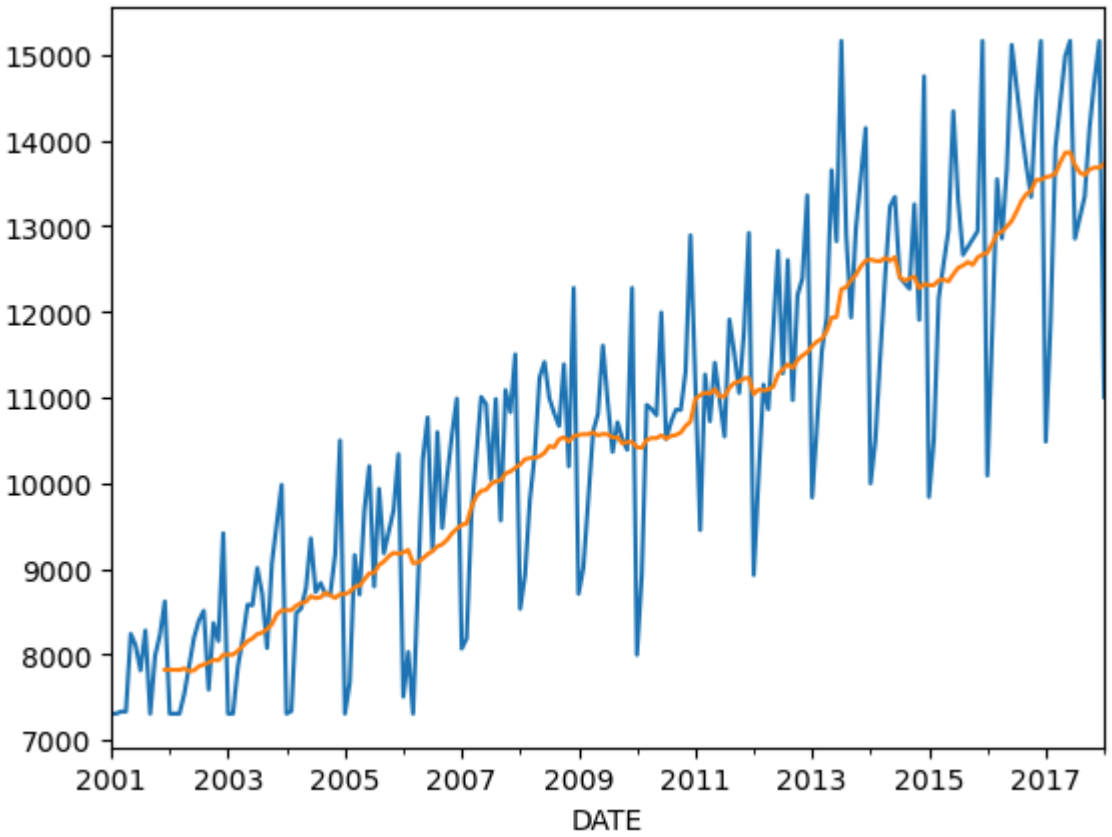
In [57]:
```
test_x.plot(style='-o');
```



In [58]:
```
performance(test_x['Sales'], test_x['pred'])
```

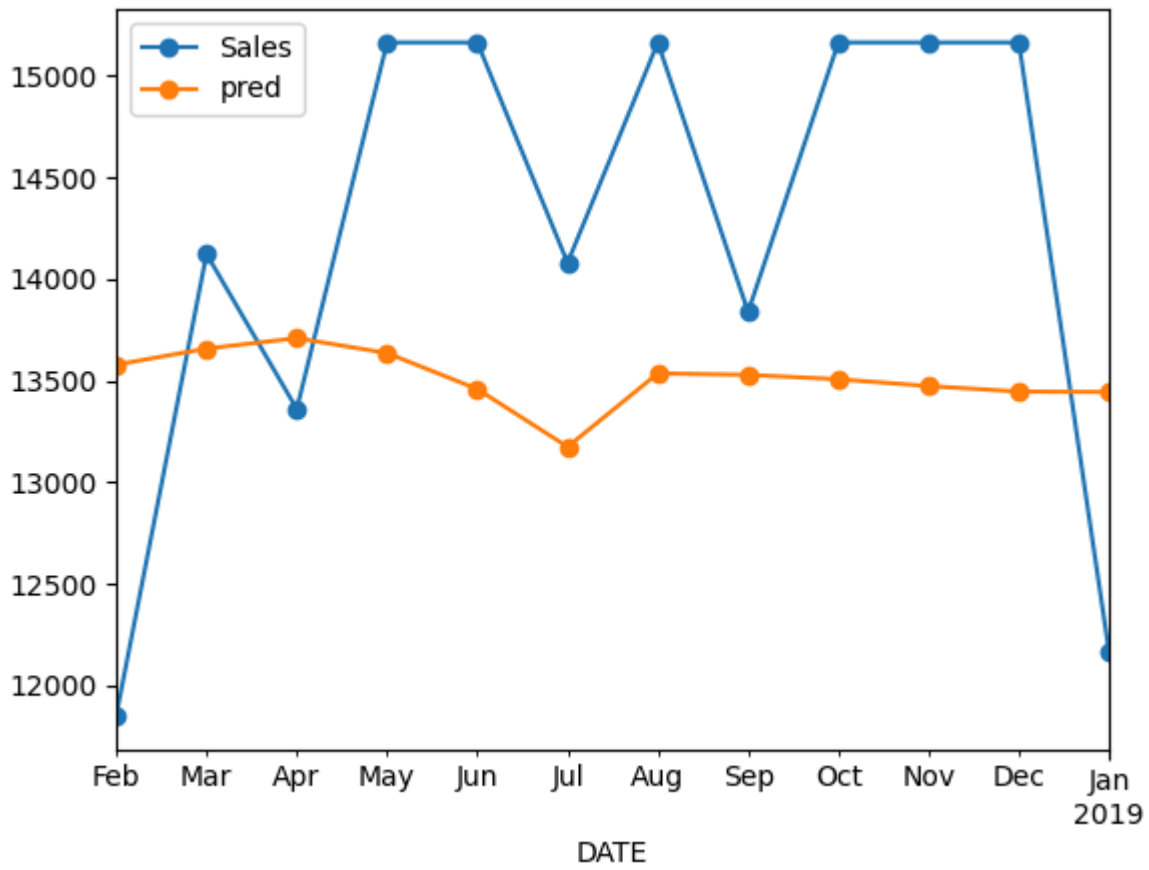
```
MAE : 3095.857
RMSE : 3301.099
MAPE: 0.212
```

In [59]:
```
train_x.Sales.plot();
train_x.Sales.rolling(12).mean().plot();
```



In [60]:
```
pred_ = train_x.Sales.copy().values

for i in range(12):
    pred_ = np.append(pred_, pred_[-6:].mean()) # MA(6) last 6 months avg.

test_x['pred'] = pred_[-12:] # predictions
```

In [61]:
```
test_x.plot(style='-o');
```



In [62]:
```
performance(test_x.Sales, test_x.pred);
```

```
MAE : 1247.799
RMSE : 1364.818
MAPE: 0.088
```

Exponential Smoothing Model:

1. Simple Exp Smoothing model
2. Double Exp Smoothing model

3. Tripple Exp Smoothing Model

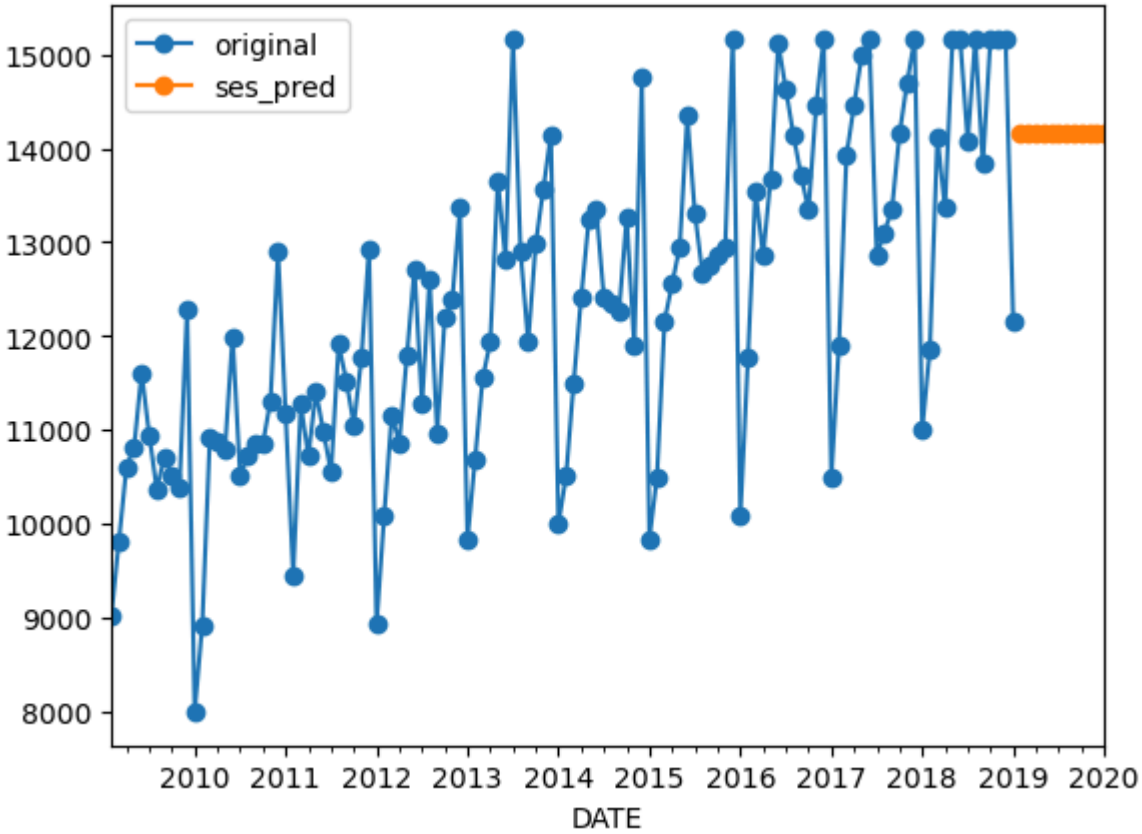
In [ ]:
```
## SESM : Naive+Rolling mean with weightage which reduce exponentially
```

In [63]:
```
model = sm.tsa.SimpleExpSmoothing(data.Sales).fit(smoothing_level=0.2) # alpha
pred = model.forecast(12) # pred for next 12 months.
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\pandas\util\_decorators.py:213: EstimationWarning: Model has no free parameters to
estimate. Set optimized=False to suppress this warning
  return func(*args, **kwargs)
```

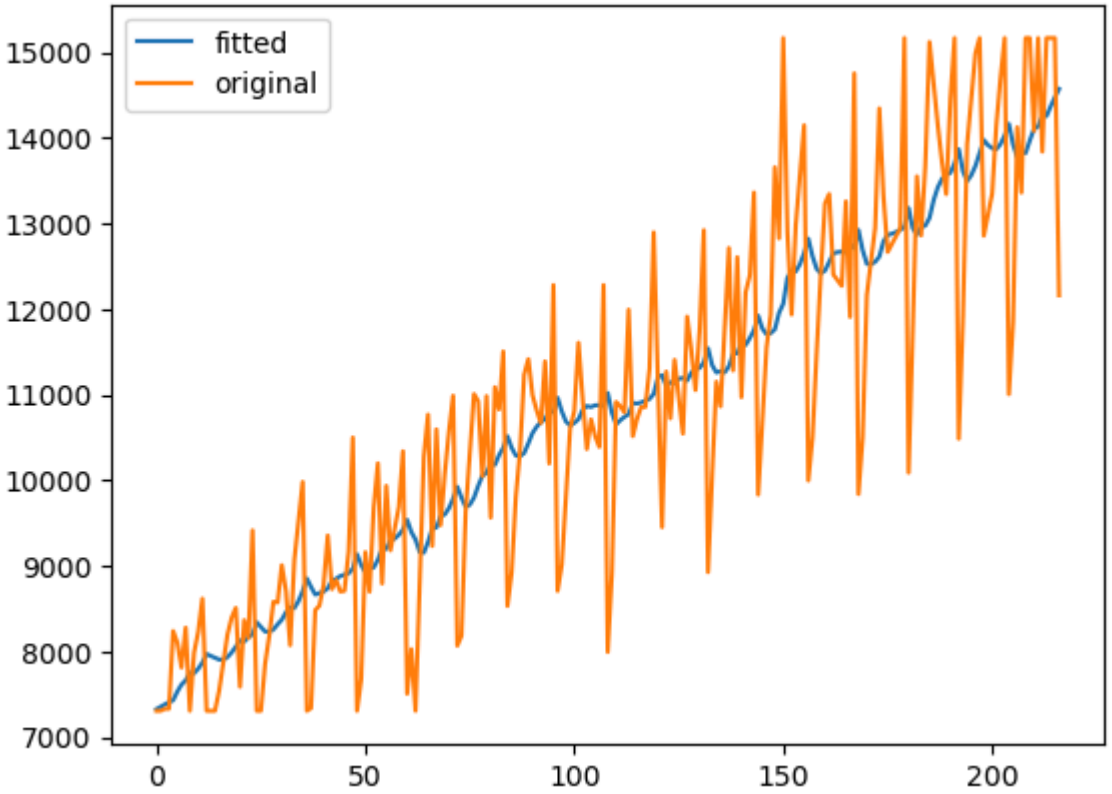
In [64]:
```
data.Sales[-120:].plot(label='original', style='-o')

pred.plot(label='ses_pred', style='-o')
plt.legend()
```

Out[64]:
```
<matplotlib.legend.Legend at 0x169038e5f90>
```



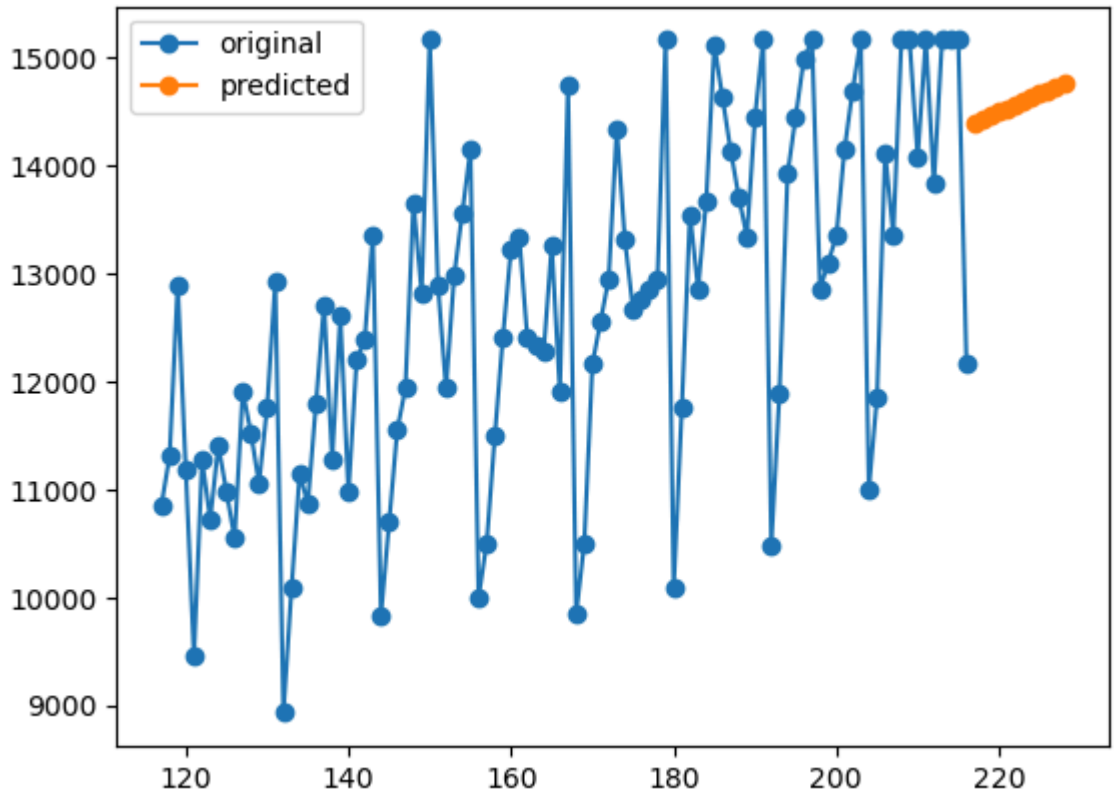
In [14]:
```
# just by adding trend -> DES
model = sm.tsa.ExponentialSmoothing(data.Sales, trend="add").fit(smoothing_trend=0.02);
model.fittedvalues.plot(label="fitted")
data.Sales.plot(label="original")

plt.legend();
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\holtwinters\model.py:918: ConvergenceWarning: Optimization failed t
o converge. Check mle_retvals.
  warnings.warn(
```



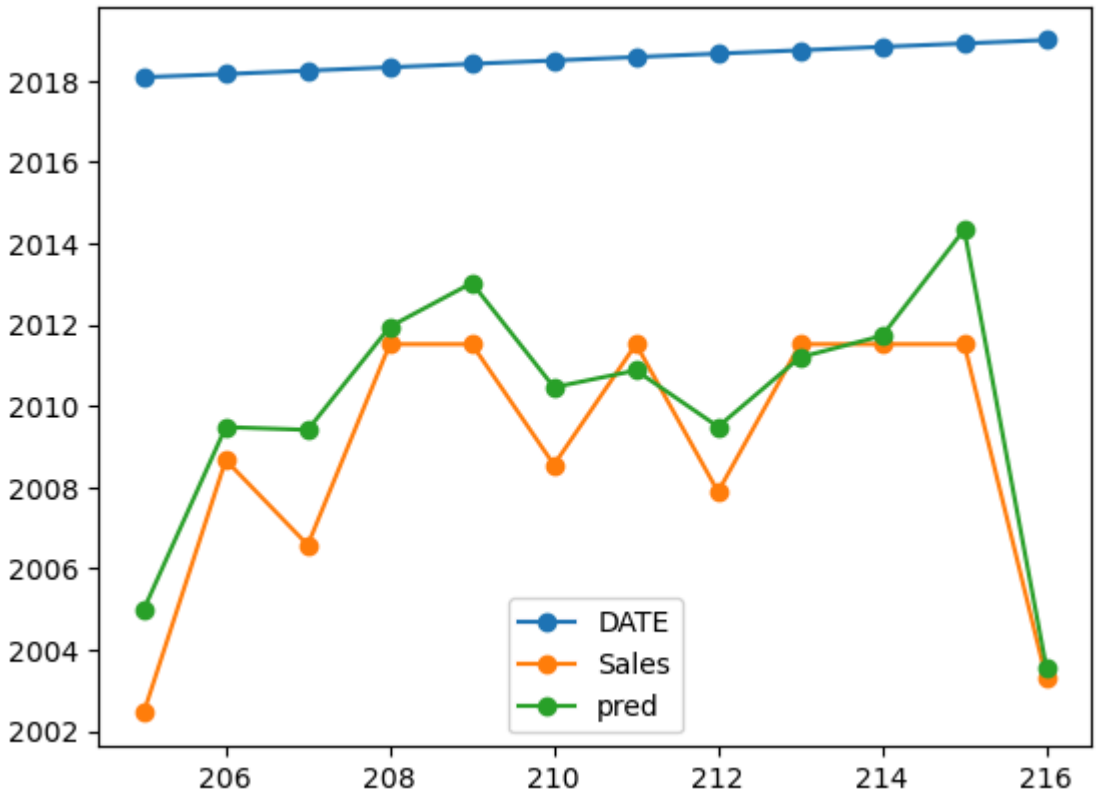
In [16]:
```
pred = model.forecast(12)
data.Sales.tail(100).plot(label="original", style='-o')
pred.plot(label="predicted", style='-o')
plt.legend()
```

Out[16]: <matplotlib.legend.Legend at 0x16800e64550>



In [52]:
```
test_x.plot(style='-o')

performance(test_x['Sales'], test_x['pred'])
```

```
MAE : 483.93
RMSE : 599.863
MAPE: 0.035
```

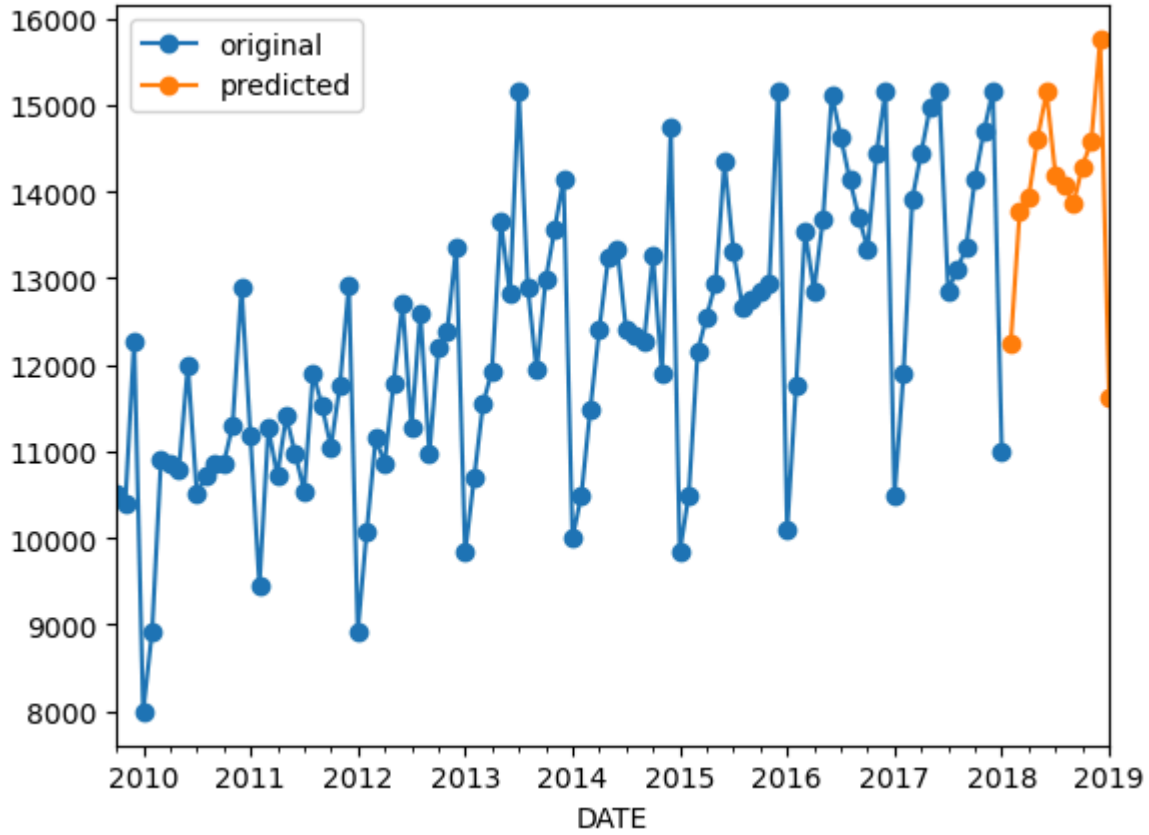


In [59]:
```
model = sm.tsa.ExponentialSmoothing(train_x.Sales, trend="add", seasonal = "add").fit();
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
```

In [61]:
```
pred = model.forecast(12)
train_x.Sales.tail(100).plot(label="original", style='-o')
pred.plot(label="predicted", style='-o')
plt.legend()
```

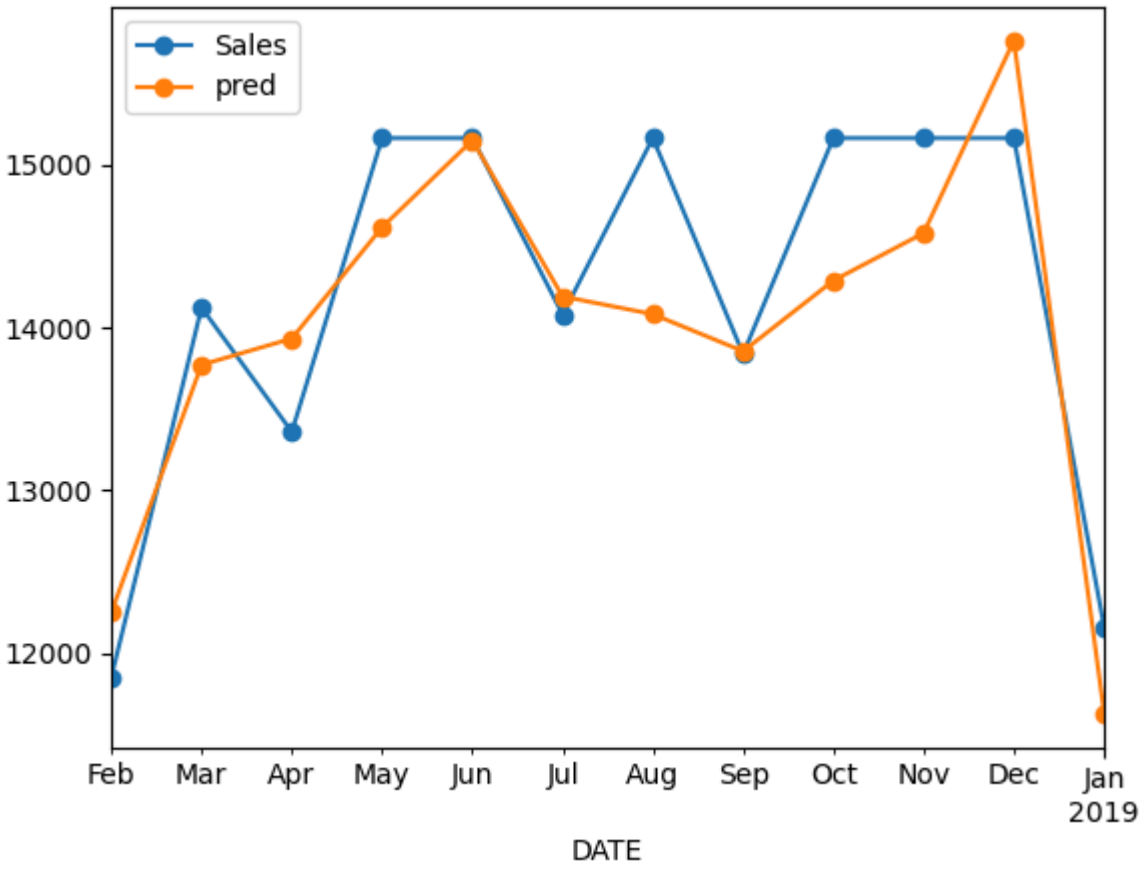
Out[61]:
```
<matplotlib.legend.Legend at 0x1680801b9d0>
```



In [62]:
```
test_x['pred']=pred.values
```

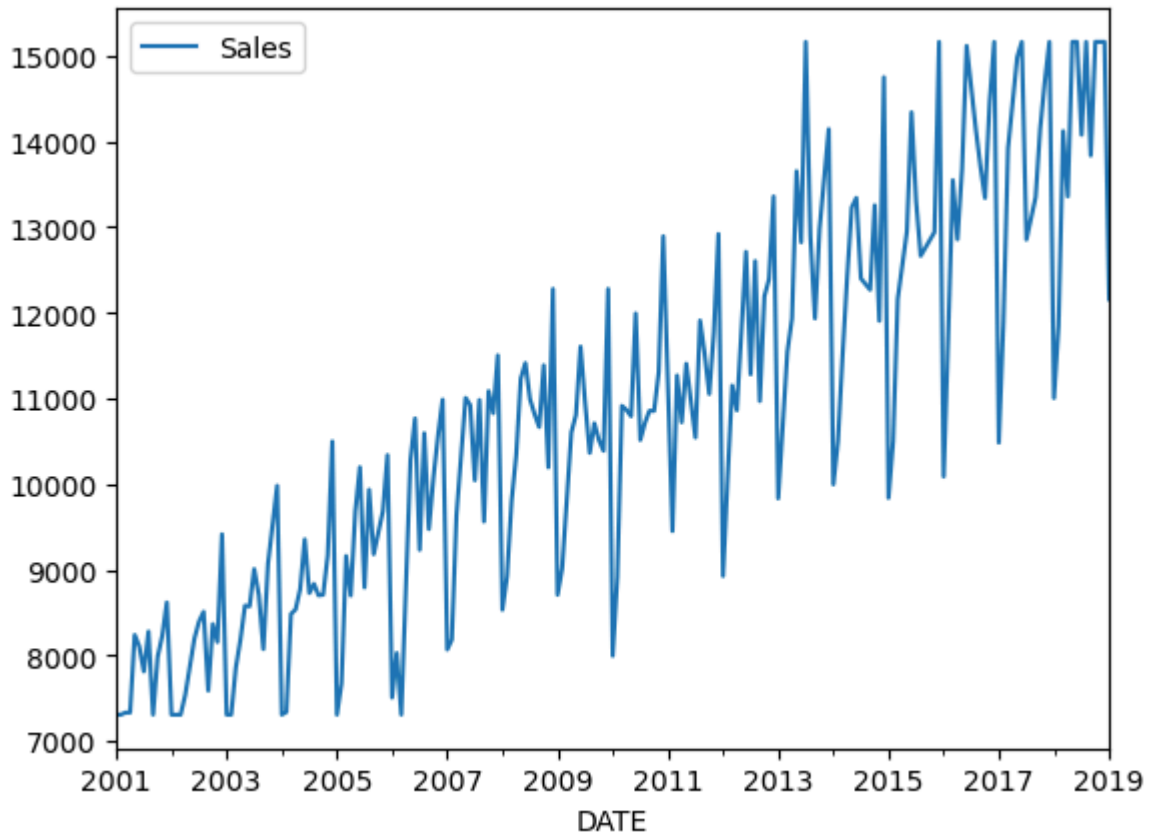
In [63]:
```
test_x.plot(style='-o')

performance(test_x['Sales'], test_x['pred'])
```

```
MAE : 473.509
RMSE : 565.711
MAPE: 0.033
```



In [64]:
```
## check if the time series is stationary:

def adf_test(data, significance_level=0.05):
    pvalue = sm.tsa.stattools.adfuller(data)[1]

    if pvalue <= significance_level:
        print('Sequence is stationary')
    else:
        print('Sequence is not stationary')
```

In [66]:
```
data.plot();
```

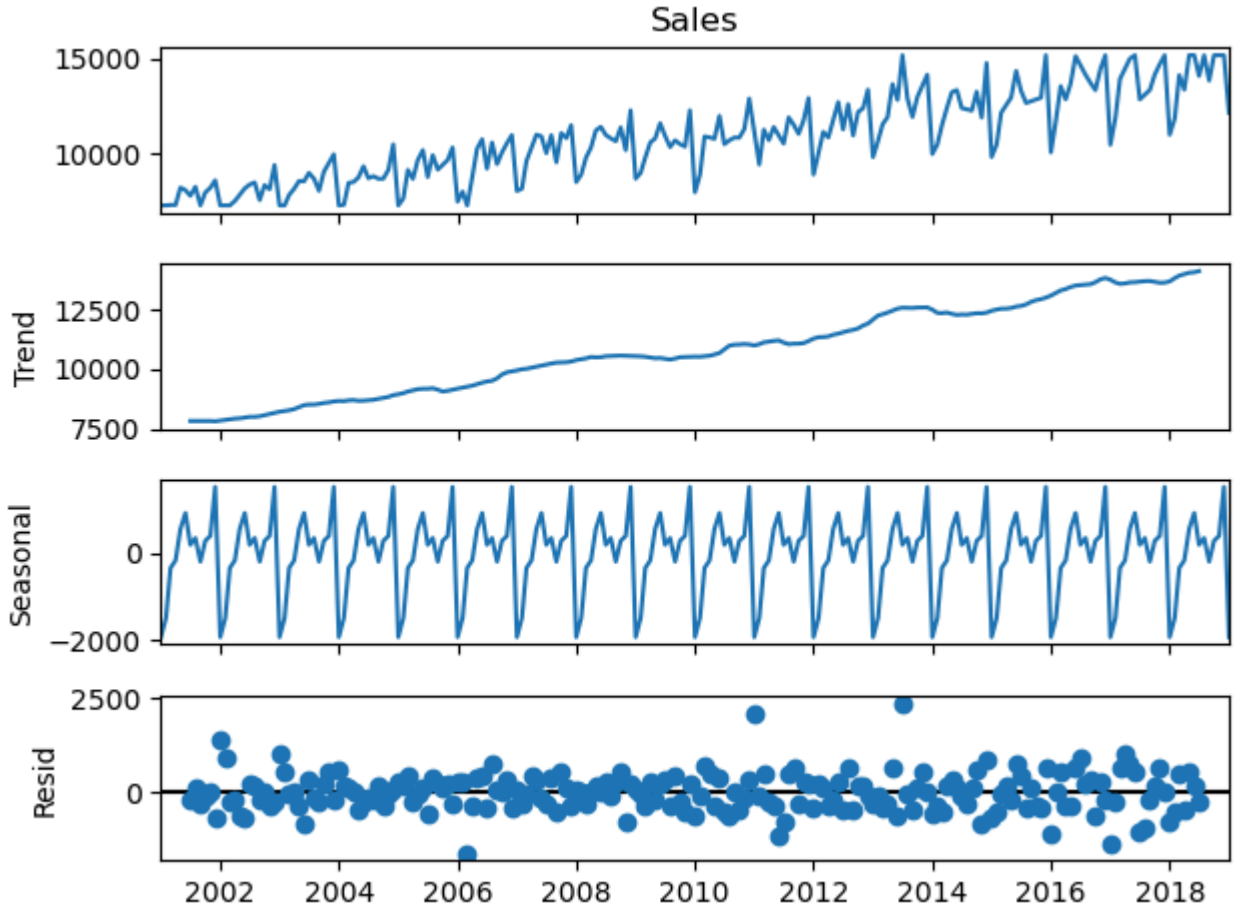


In [67]:
```
adf_test(data.Sales)
```

```
Sequence is not stationary
```

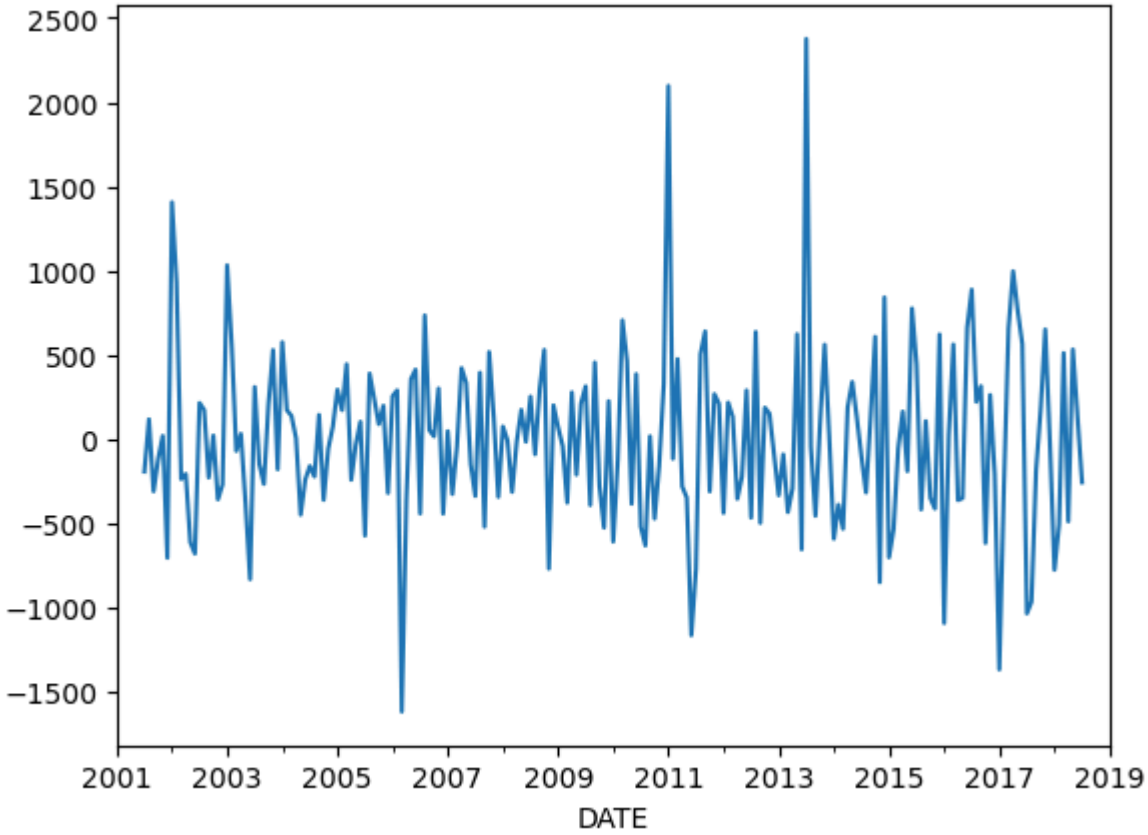
In [69]:
```
### Convert Non Stationary Time series to Stationary Time Series

model=sm.tsa.seasonal_decompose(data.Sales)
```

In [71]:
```
model.plot();
```



In [75]:
```
model.resid.plot()
```

Out[75]:
```
<Axes: xlabel='DATE'>
```



Conversion of Non Stationary to Stationary using Residual

Menthod1: Decomposition

y(t)=b(t)+s(t)+e(t)

Remove nulls from e(t) which has no trend and sesonality which makes it a stationary time series.

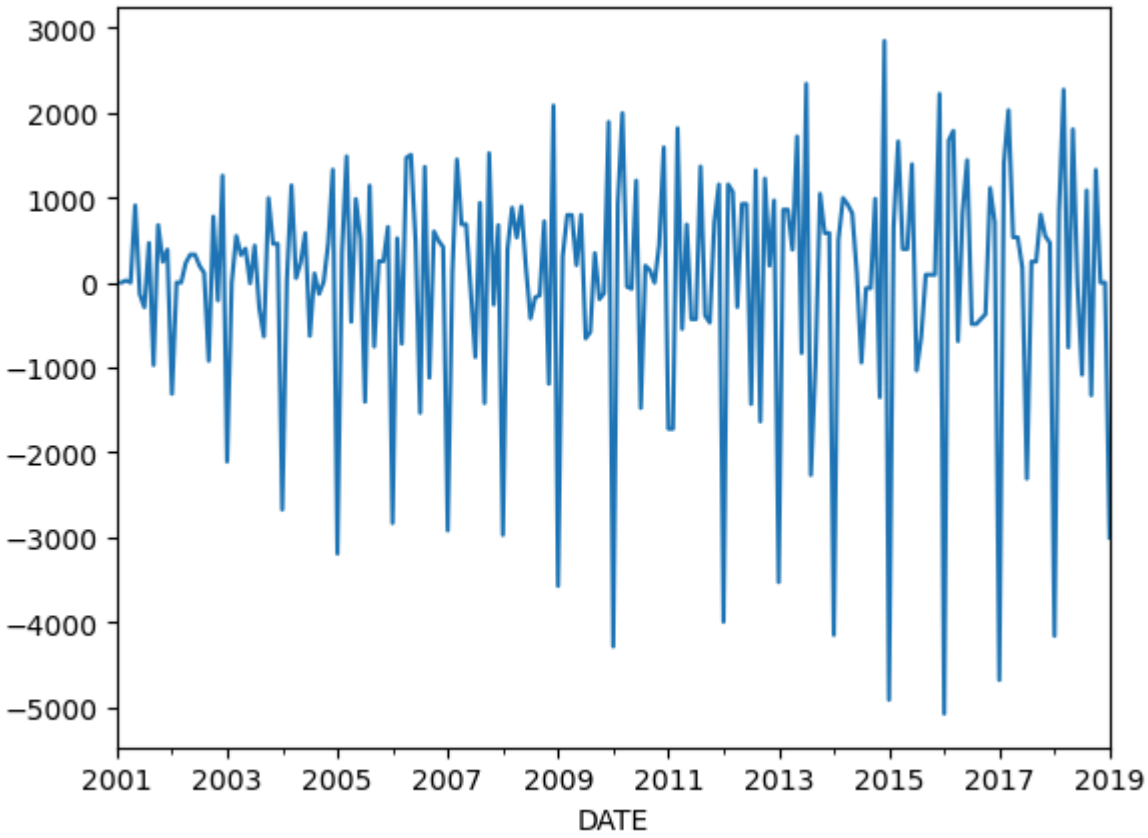
e(t)=y(t)-b(t)-s(t)

Method2: Differentiation

In [77]:
```
adf_test(model.resid.dropna())
```

```
Sequence is stationary
```

In [82]:
```
## Differentiation
data.Sales.diff(1).plot();
```



In [84]:
```
adf_test(data.Sales.diff(1).dropna())
```

```
Sequence is stationary
```

In [85]:
```
## If this is non stationary then we can do double differentiation i.e make it more smoother
```

Auto correlation

In [89]:
```
data.Sales.shift(1).head()
```

Out[89]:
```
DATE
2001-01-01       NaN
2001-02-01    7307.8
2001-03-01    7307.8
2001-04-01    7332.0
2001-05-01    7332.0
Name: Sales, dtype: float64
```

In [91]:
```
## check auto correlation with lag=12
lag=12
np.corrcoef(data.Sales[lag:],data.Sales.shift(lag)[lag:])[0][1]
```

Out[91]:
```
np.float64(0.9419098493883264)
```

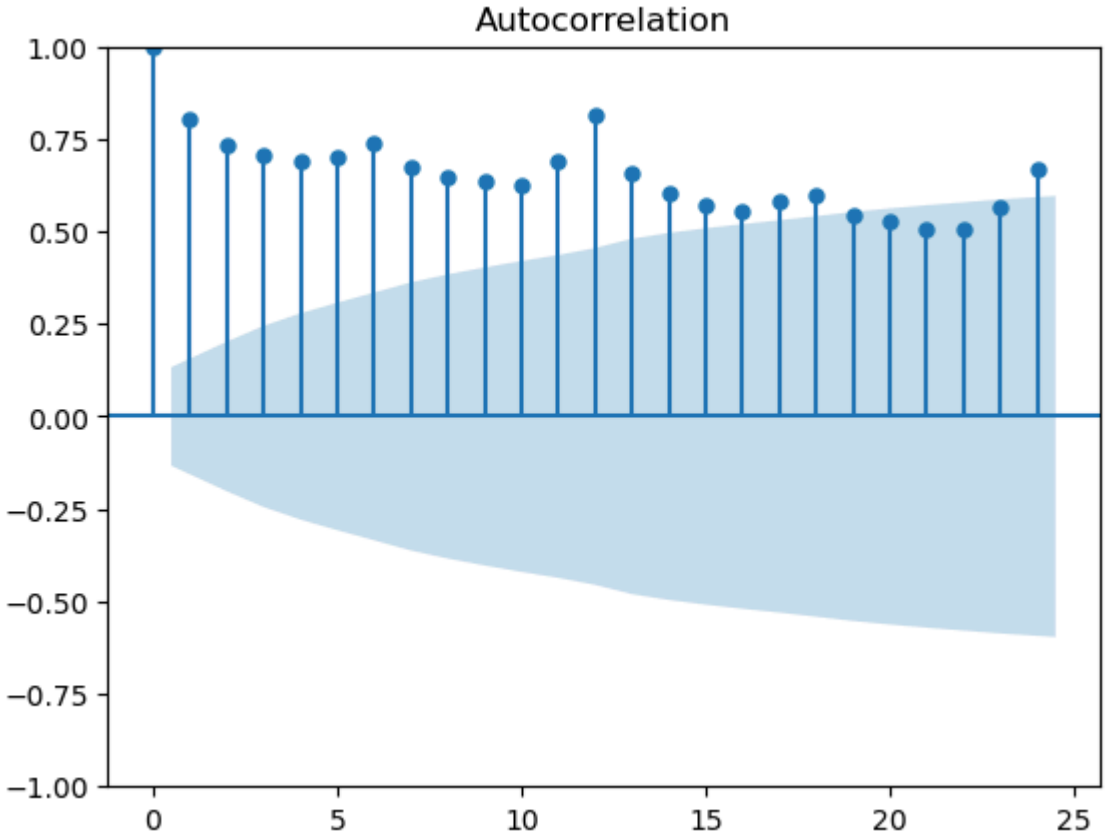
In [92]:
```
## check auto correlation with lag=12
lag=6
np.corrcoef(data.Sales[lag:],data.Sales.shift(lag)[lag:])[0][1]
```

Out[92]:
```
np.float64(0.7966090507569205)
```

In [93]:
```
## There is high correlation with 12 lag i.e because there is seasonality of 12 months
```

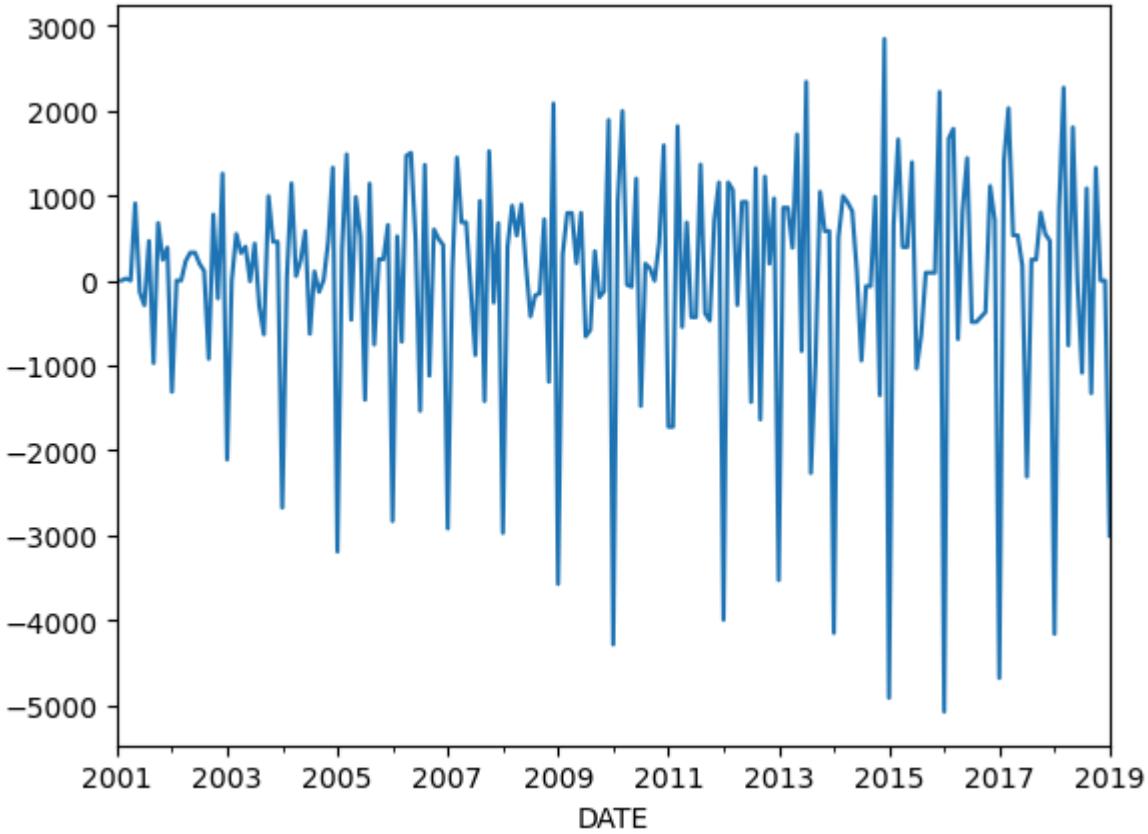
In [94]:
```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
```

In [95]:
```
plot_acf(data.Sales);
```

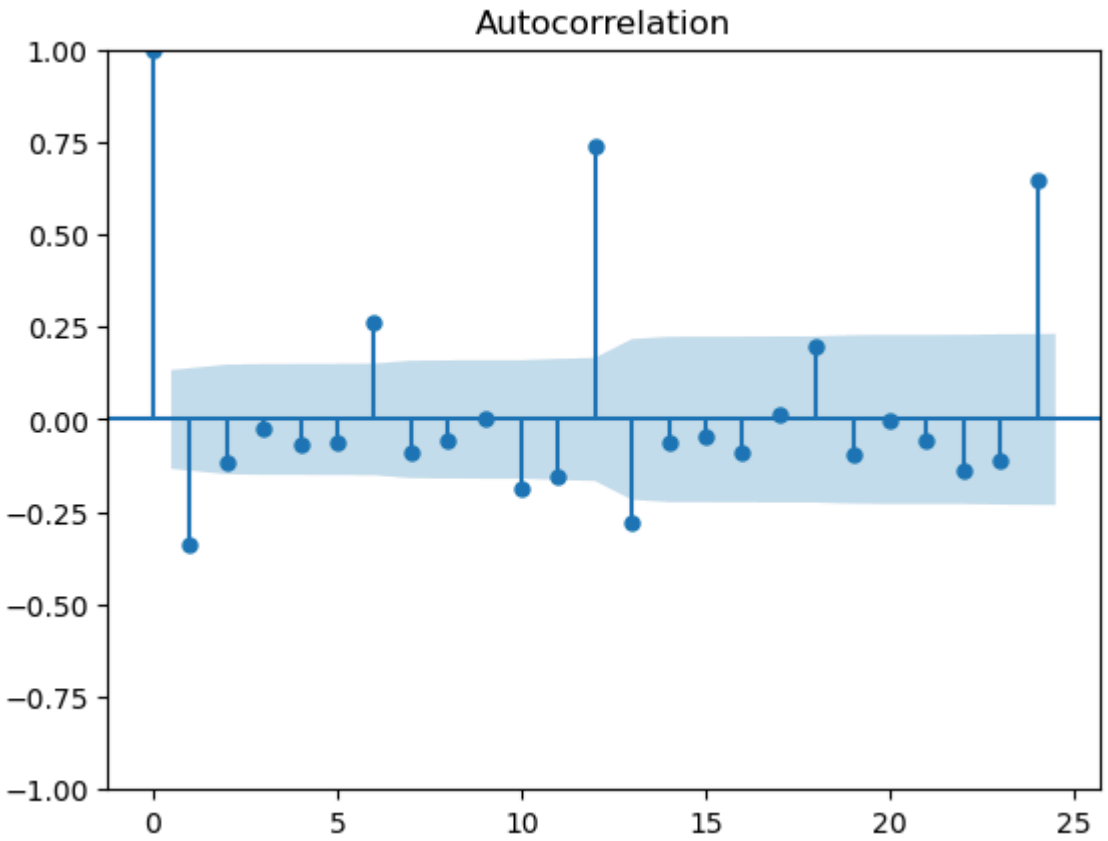


In [96]:
```
data.Sales.diff(1).plot()
```

Out[96]:
```
<Axes: xlabel='DATE'>
```



In [99]:
```
## Differentiation removes the trend from the data
plot_acf(data.Sales.diff().dropna());
```



Highest correlation is visible with lag value=12

Note here the correlation is also negative because the differentation values are negative as well which is unlike the original data

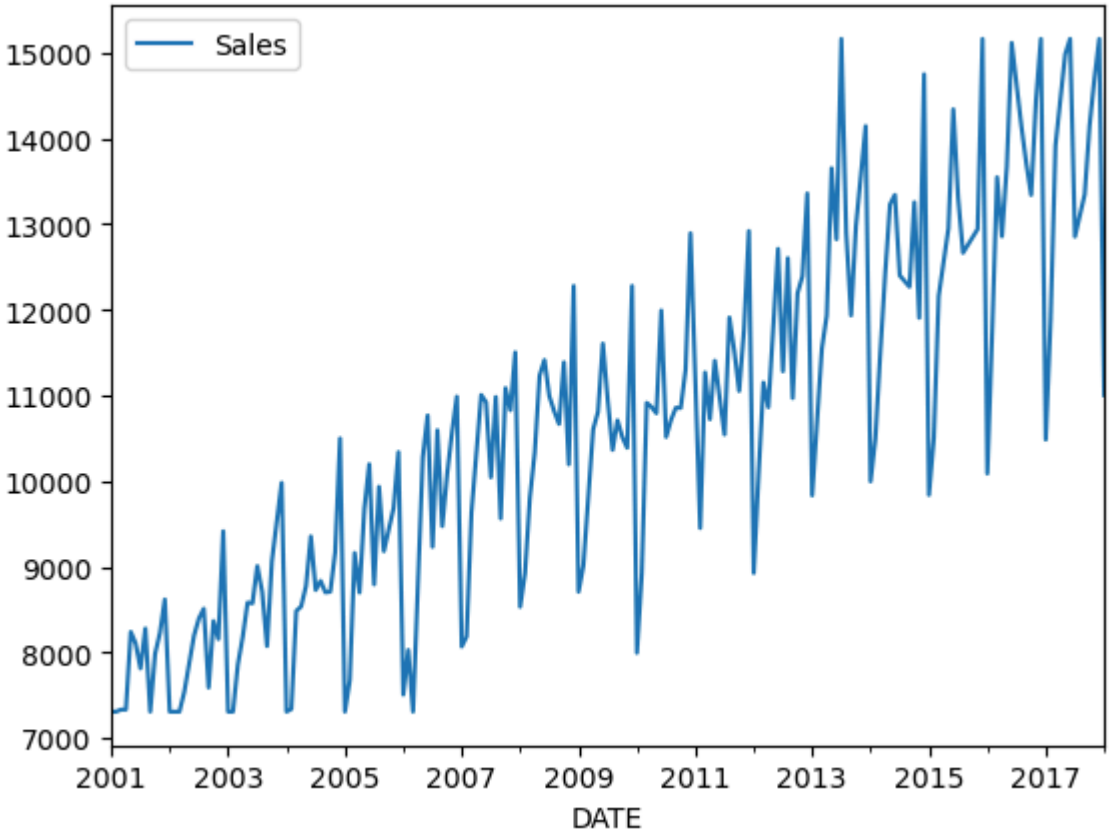
In [100…

```
## Lecture:4
```

ARIMA:

In [101…

```
train_x.plot();
```

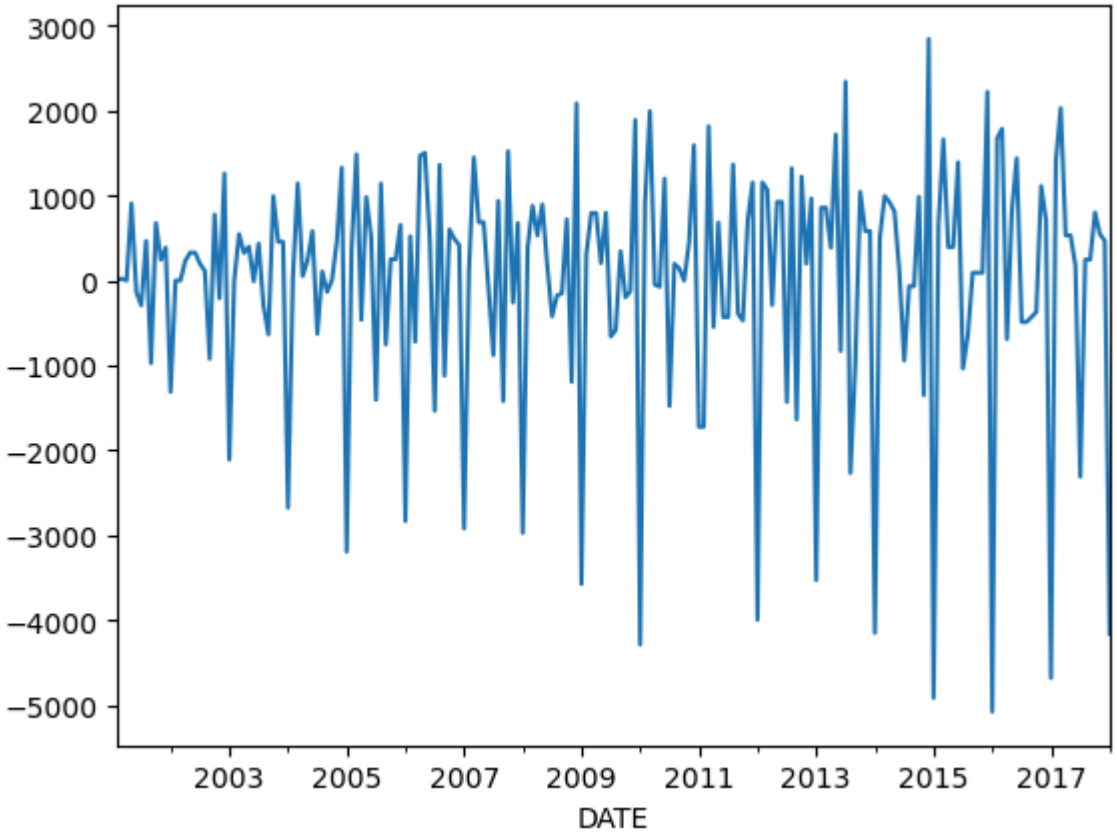


In [102…
```
train_x_st = train_x.copy()

train_x_st.Sales = train_x_st.Sales.diff(1)
train_x_st.dropna(inplace=True)
```

In [103…
```
adf_test(train_x_st.Sales)
```

```
Sequence is stationary
```

In [104…
```
train_x_st.Sales.plot();
```



In [105…
```
from statsmodels.tsa.statespace.sarimax import SARIMAX # supermodel
```

In [106…
```
# order = (p, d, q)
model = SARIMAX(train_x_st.Sales, order = (3,0,0) ) # AR(3)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
```

In [107…
```
test_x.head(10)
```

Out[107…

DATE	Sales	pred
2018-02-01	11852.0	1806.871390
2018-03-01	14123.0	512.621534
2018-04-01	13360.0	-6.529820
2018-05-01	15164.6	-582.530925
2018-06-01	15164.6	183.503533
2018-07-01	14080.0	122.694532
2018-08-01	15164.6	-1.070891
2018-09-01	13838.0	-84.884694
2018-10-01	15164.6	16.220618
2018-11-01	15164.6	23.212393

Why negative sales??

Because the model is trained with differences/differentiated data, hence post processing is required to check performance to compare the prediction and actual value

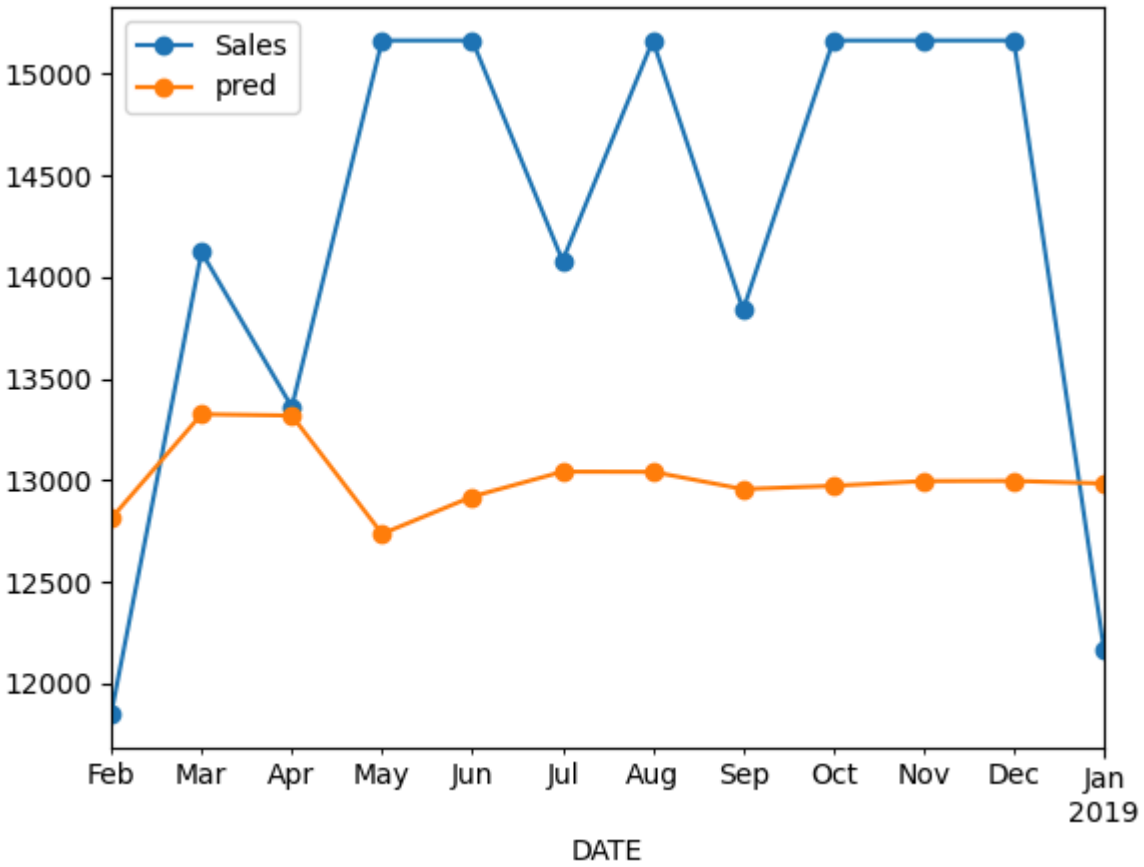
In [109…
```
# order = (p, d, q)
model = SARIMAX(train_x_st.Sales, order = (3,0,0) ) # AR(3)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)

# post processing
test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\AppData\Local\Temp\ipykernel_28896\2208145763.py:7: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()
```

In [110…

```
test_x.plot(style='-o')

performance(test_x['Sales'], test_x['pred'])
```

```
MAE : 1489.515
RMSE : 1677.498
MAPE: 0.102
```

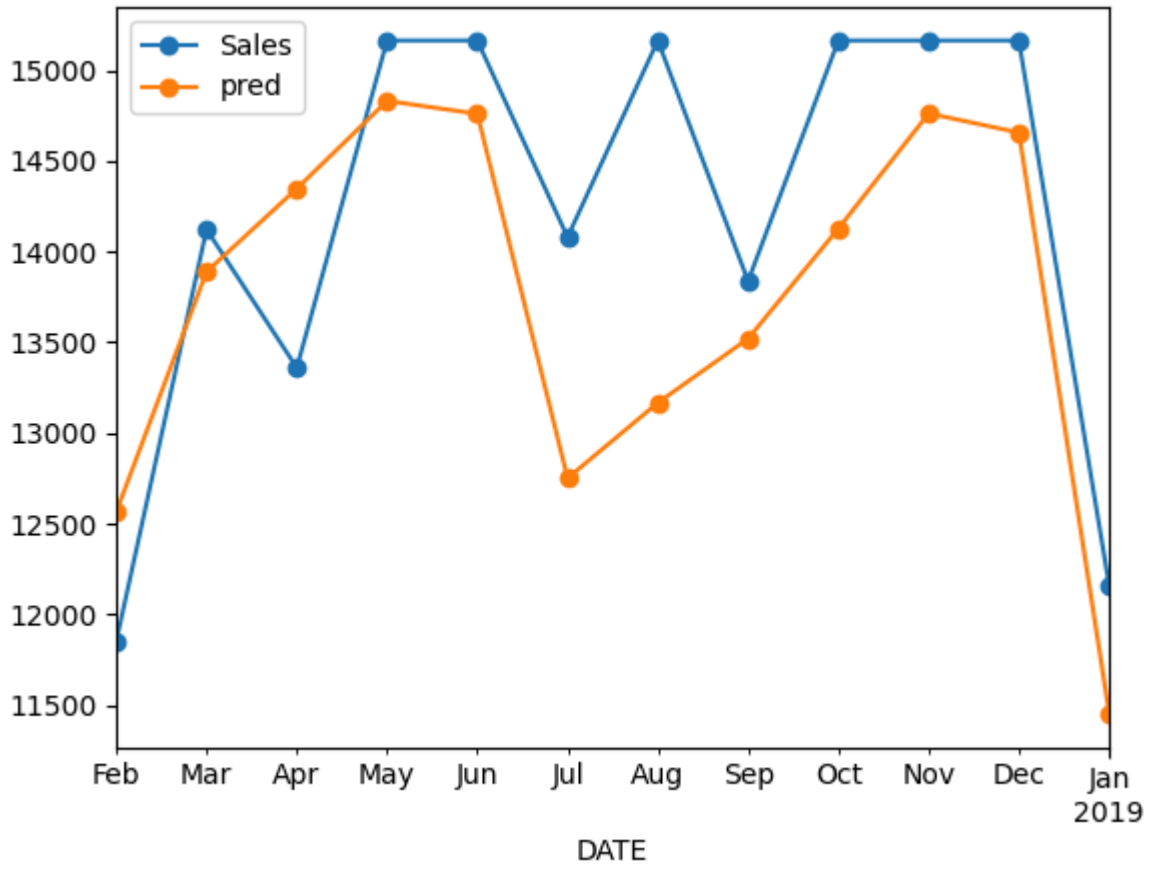


In [111…

```
# order = (p, d, q)
model = SARIMAX(train_x_st.Sales, order = (12,0,0) ) # AR(12)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)

# post processing
test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()


test_x.plot(style='-o')

performance(test_x['Sales'], test_x['pred'])
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\AppData\Local\Temp\ipykernel_28896\2927954615.py:7: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()
```

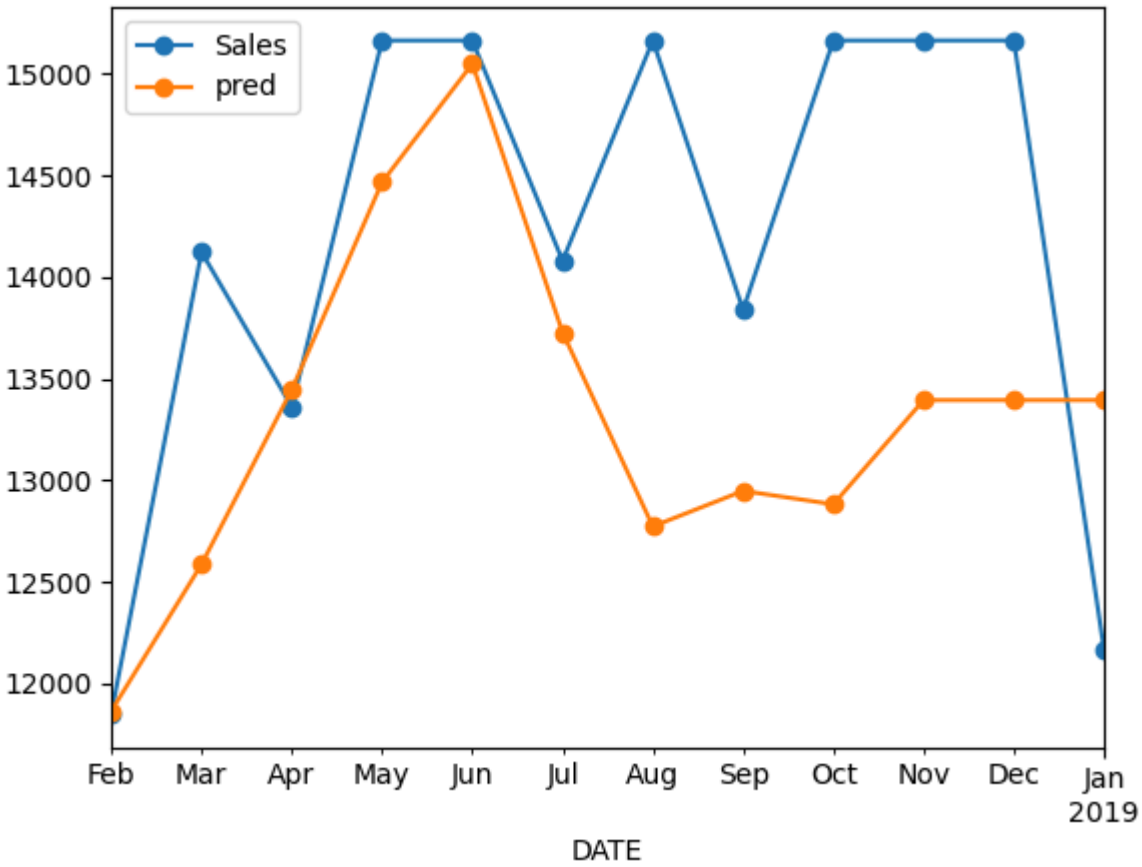
```
MAE : 747.487
RMSE : 897.502
MAPE: 0.053
```



In [112…

```
# order = (p, d, q)
model = SARIMAX(train_x_st.Sales, order = (0,0,10) ) # MA(10)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)

# post processing
test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()


test_x.plot(style='-o')

performance(test_x['Sales'], test_x['pred'])
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
C:\Users\kanwar\AppData\Local\Temp\ipykernel_28896\3566005573.py:7: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()
MAE : 1095.166
RMSE : 1369.994
MAPE: 0.075
```

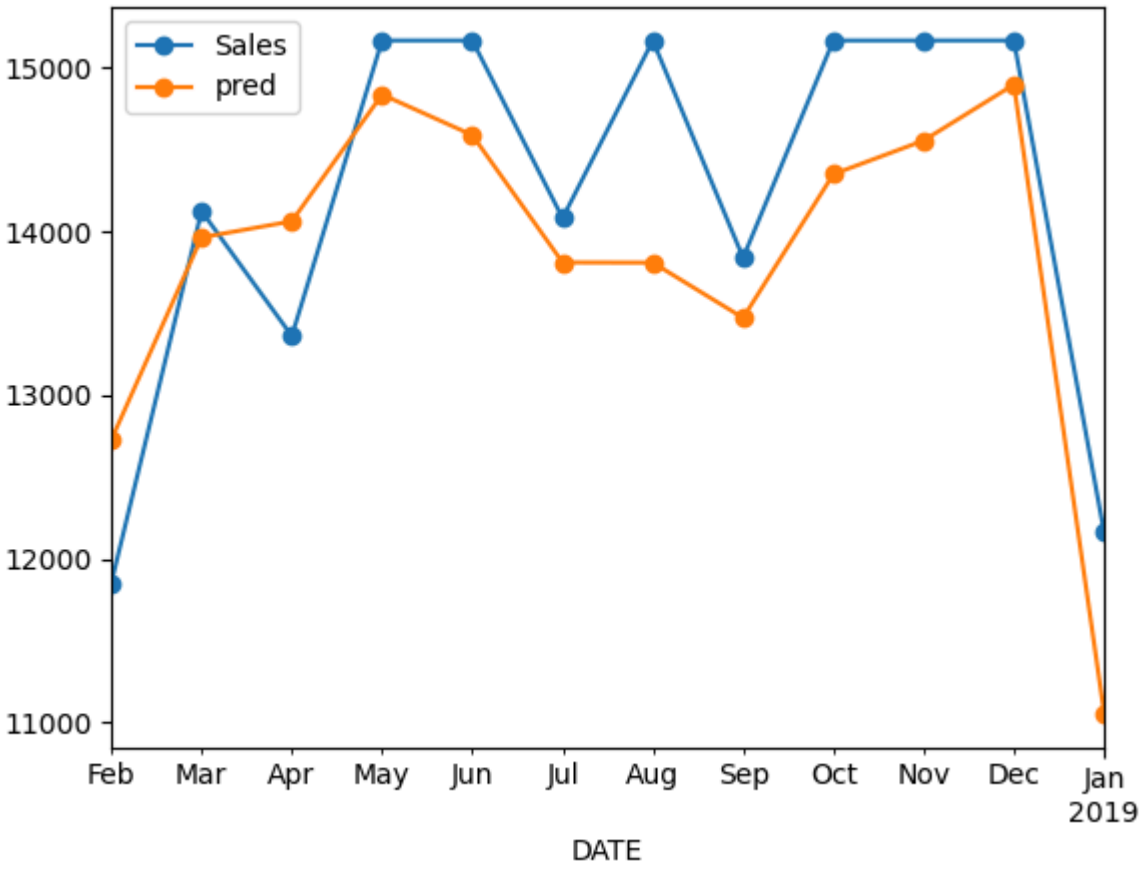


In [113…

```
# order = (p, d, q)
model = SARIMAX(train_x_st.Sales, order = (12,0,12) ) # ARMA(12,12)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)

# post processing
test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()


test_x.plot(style='-o')

performance(test_x['Sales'], test_x['pred'])
```

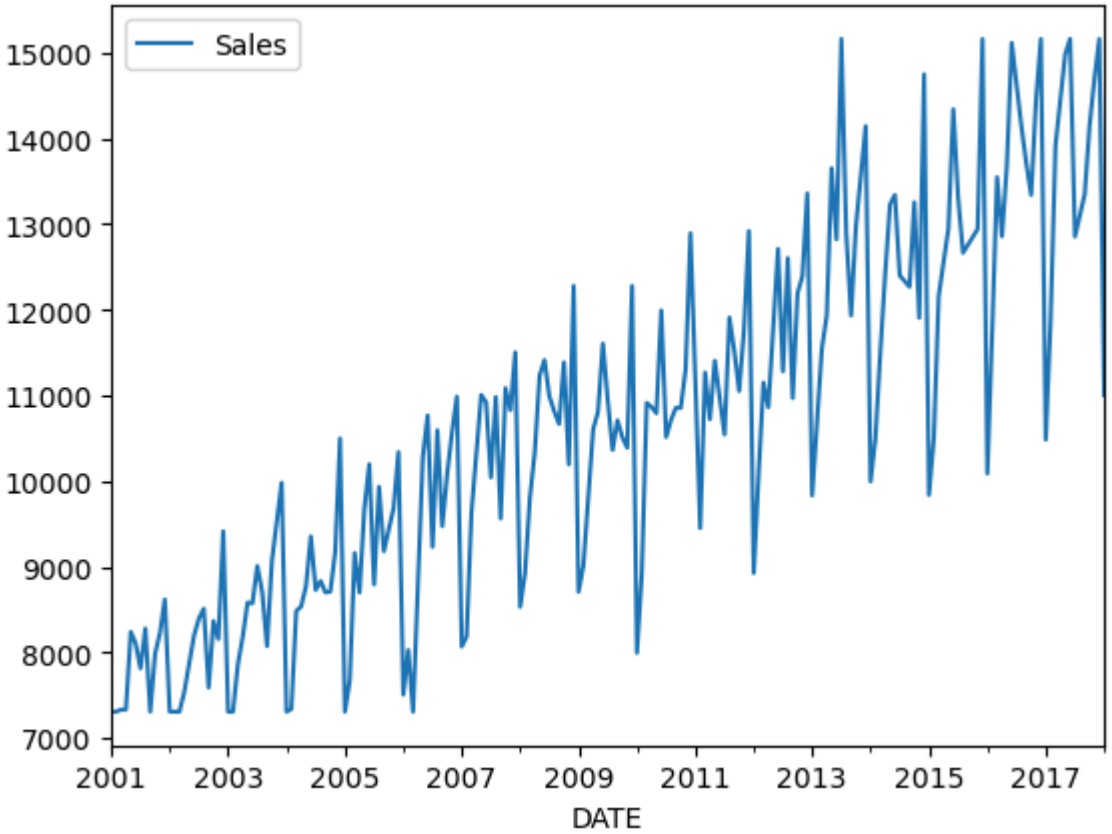
```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\statespace\sarimax.py:966: UserWarning: Non-stationary starting aut
oregressive parameters found. Using zeros as starting parameters.
  warn('Non-stationary starting autoregressive parameters'
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\statespace\sarimax.py:978: UserWarning: Non-invertible starting MA
parameters found. Using zeros as starting parameters.
  warn('Non-invertible starting MA parameters found.'
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
C:\Users\kanwar\AppData\Local\Temp\ipykernel_28896\2884599505.py:7: FutureWarning: Series.__getitem__ treating keys as position
s is deprecated. In a future version, integer keys will always be treated as labels (consistent with DataFrame behavior). To ac
cess a value by position, use `ser.iloc[pos]`
  test_x['pred'] = train_x.Sales[-1] + test_x['pred'].cumsum()
```

```
MAE : 619.802
RMSE : 713.085
MAPE: 0.045
```



In [115…

```
train_x.plot();
```



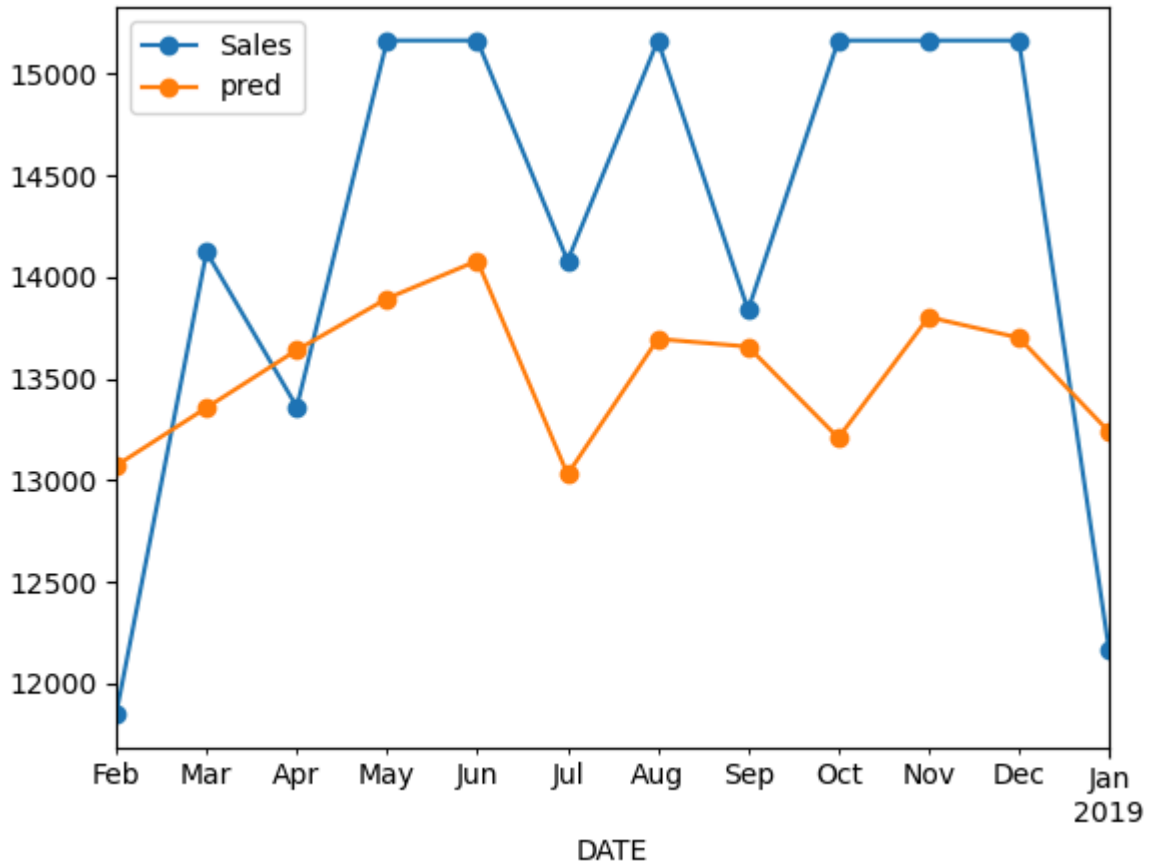
In [116…

```
## ARIMA: I for integration hence it handles post processing and preprocessing, AR+I+MA
```

In [120…

```
# order = (p, d, q)
model = SARIMAX(train_x.Sales, order = (5,1,3) ) # ARIMA(5, 1, 3) #5 previous values , 3 previous errors and 1 differentiation
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)


test_x.plot(style='-o')
performance(test_x['Sales'], test_x['pred'])
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
MAE : 1098.554
RMSE : 1198.155
MAPE: 0.077
```

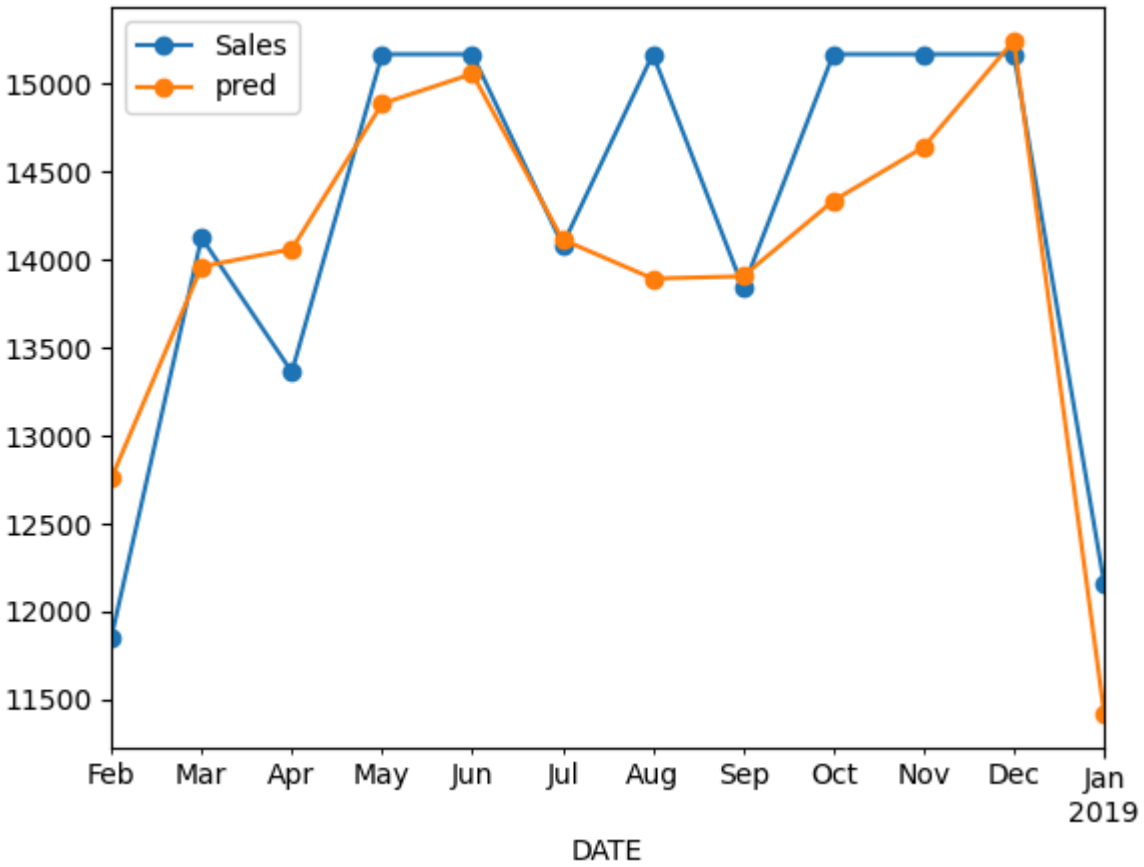


In [121…

```python
# (p, d, q)
model = SARIMAX(train_x.Sales, order = (15, 1, 12)) # ARIMA(5, 1, 5)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)
```

```
test_x.plot(style='-o')
performance(test_x['Sales'], test_x['pred'])
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\statespace\sarimax.py:966: UserWarning: Non-stationary starting aut
oregressive parameters found. Using zeros as starting parameters.
  warn('Non-stationary starting autoregressive parameters'
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\statespace\sarimax.py:978: UserWarning: Non-invertible starting MA
parameters found. Using zeros as starting parameters.
  warn('Non-invertible starting MA parameters found.'
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
MAE : 475.359
RMSE : 617.215
MAPE: 0.034
```



In [122…

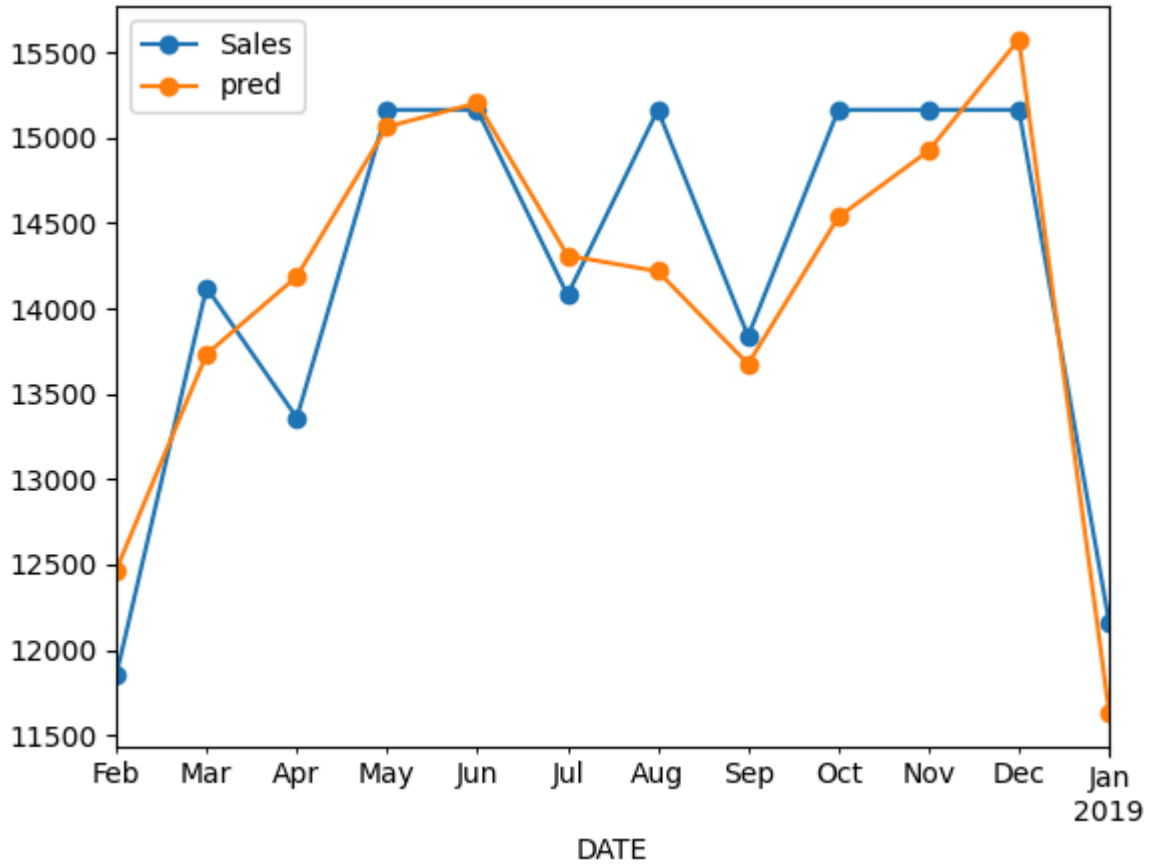
```
## SARIMA: Seasonal ARIMA, seasonality+AR+I+MA
```

In [123…

```
# order = (p, d, q), seaonal_order= P,D,Q,S----12 is seaonality, 12 months seasonality
model = SARIMAX(train_x.Sales, order = (5,1,3), seasonal_order=(1,1,1,12)) # SARIMA(5, 1, 3)
model = model.fit(disp = False)
test_x['pred'] = model.forecast(steps=12)


test_x.plot(style='-o')
performance(test_x['Sales'], test_x['pred'])
```

```
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was p
rovided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
C:\Users\kanwar\anaconda3\Lib\site-packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood optimization
failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
```

MAE : 426.811
RMSE : 508.667
MAPE: 0.031



In [ ]: