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Original Research Article

VAPOUR COMPRESSION IMPROVES OF FAST COOLING AND ENERGY EFFICIENCY IN INDUSTRIAL REFRIGERATION SYSTEMS

Rohit Chauhan, Prof. Sachin Baraskar, Prof. Anil Verma

Department of Mechanical Engineering
Sri Satya Sai University of Technology & Medical Science (SSSUTMS) Sehore, India

Abstract: Modeling and analysis work was done on vapor compressor refrigeration system for enhance energy productivity. The system which were displayed in detail compressors have vitality use 6 to 9% lower than the units with horizontal scroll compressors and Air-cooled condensers have energy utilization 11% and auxiliary loop system have energy utilization 15%. Because of the natural concern of a global warming, endeavors have been made in supermarket [5] refrigeration industry to outline or create refrigeration system that work with less refrigerant charge and energy utilization. The "propelled" systems that have been utilized or created and have considerably less refrigerant charge than the parallel and minimal effort establishment, adaptability so as to arrange and rebuilding. Be that as it may, the independent system has some inborn weaknesses including high hardware cost and low effectiveness because of heat exchange.

Keywords- Energy efficiency, Heat transfer rate, Energy consumption and Compressors, Refrigeration system

Introduction: Refrigeration is a procedure in which work is done to move heat with one area then onto the next [1] crafted by heat transport is customarily determined by mechanical work, however can likewise be driven by heat, attraction, power, laser, or different means. Refrigeration has numerous applications including however not constrained to family coolers, mechanical coolers, cryogenics, [10] and aerating and cooling. Heat pumps may utilize the heat yield of the refrigeration procedure, and furthermore might be intended to be reversible, yet are generally like refrigeration units. Energy effectiveness under a particular activity condition. [9] The Cool Pack is particularly appropriate for store refrigeration investigation for which we have all around characterized segment execution and need to get the primary system qualities while dismissing a

For Correspondence:
rohit.chauhan1603@gmail.com
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few subtle elements. The energy proficiency under various working condition coordinates the refrigerant through a condenser and an evaporator of the refrigeration system. [2]

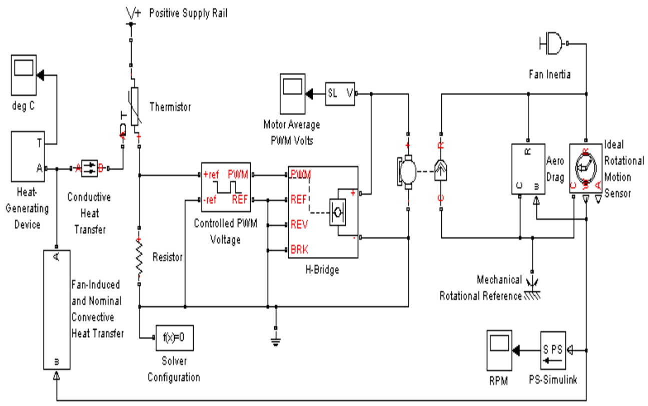


Fig.1. Block diagram energy saving refrigeration system

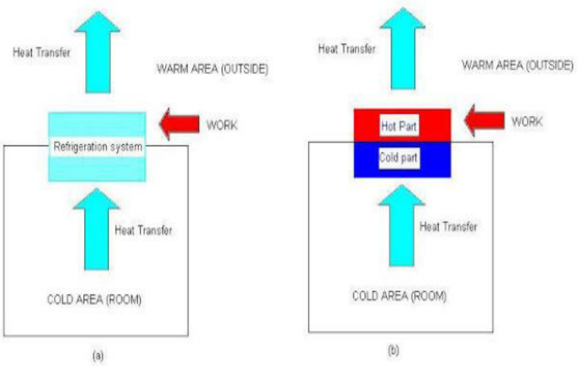


Fig.2. (a) Refrigeration system (b) Refrigeration system produces cold and hot part

Refrigeration has a large affects industry, way of life, agriculture and settlement designs. Preserving sustenance goes back to the antiquated Roman and Chinese domains. Nonetheless, refrigeration technology has quickly developed in the most recent century, from ice gathering to temperature-controlled rail cars. [4] The presentation of refrigerated rail cars added toward the westbound extension of the United States, permitting settlement in territories that were not on primary transport channels, for example, streams, harbors, or valley trails. Settlements were likewise flying up in barren parts of the nation, loaded with new normal assets. These new settlement designs started the working of extensive urban communities which can flourish in regions that were generally thought to be unsustainable, for example, Houston, Texas and Las Vegas, Nevada. In most created nations, urban communities are vigorously needy upon refrigeration in general stores, [6] so as to get their nourishment for day by day utilization. The expansion in sustenance sources has prompted a bigger convergence of horticultural deals originating from a littler level of existing ranches. Homesteads today have a considerably bigger yield for each individual in contrast with the late 1800s. This has brought about new nourishment sources accessible to whole populaces, which has largy affected the sustenance of society.

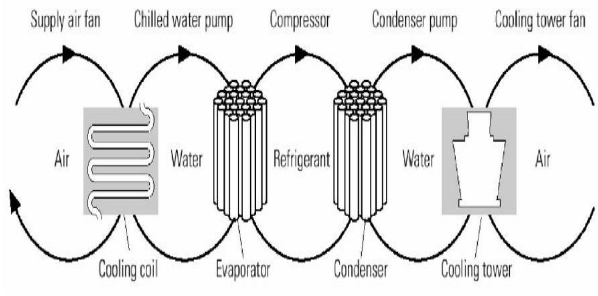


Fig.3. Heat Transfer Loop in Refrigeration System

There are several heat transfer loops in a refrigeration system as shown in Figure 2. Thermal energy moves from left to right as it is extracted from the space and expelled into the outdoors through five loops of heat transfer.

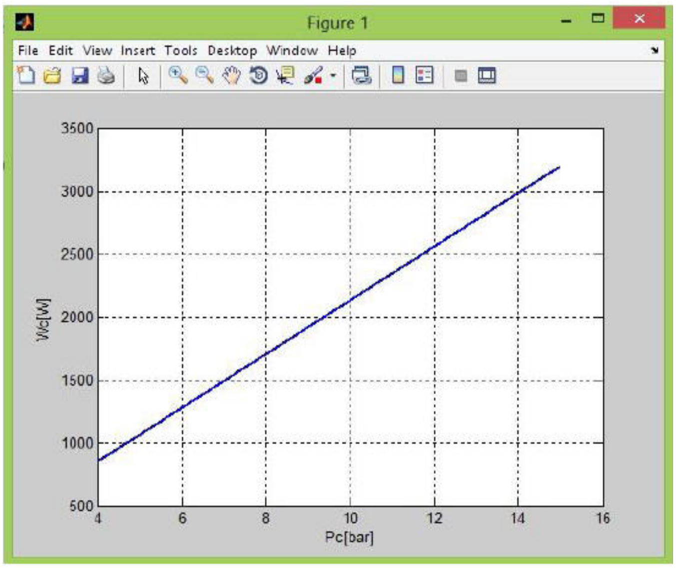


Fig.4. Compressor Power & Condenser Pressure

The optimization of condenser set points to minimize energy use requires a tradeoff between high compressor energy use at high head pressures and high condenser fan and [8] pump energy use to achieve low head pressures. Multi-speed fans and variable speed drive (VSD) fan controls only give significant energy use reductions compared with on/off control if[13] compressors operate highly unloaded and/or the condenser is grossly oversized. Oil separators, discharge and high pressure liquid lines, and expansion and other refrigerant control valves should be designed to operate satisfactorily across the full range of discharge pressures likely to be encountered if discharge pressure is floated. Most industrial refrigeration systems employ compressor discharge (head) pressure controls. Generally these controls modulate the condenser fans (for air-cooled or evaporative condensers) or water flow rates and cooling tower fans (for water-cooled condensers) to keep the head pressure within a specified range. Reducing fan speed or cooling water flow reduces the effective capacity of the condensers so that it equals the required heat rejection by maintaining a larger temperature difference between the refrigerant saturated condensation temperatures

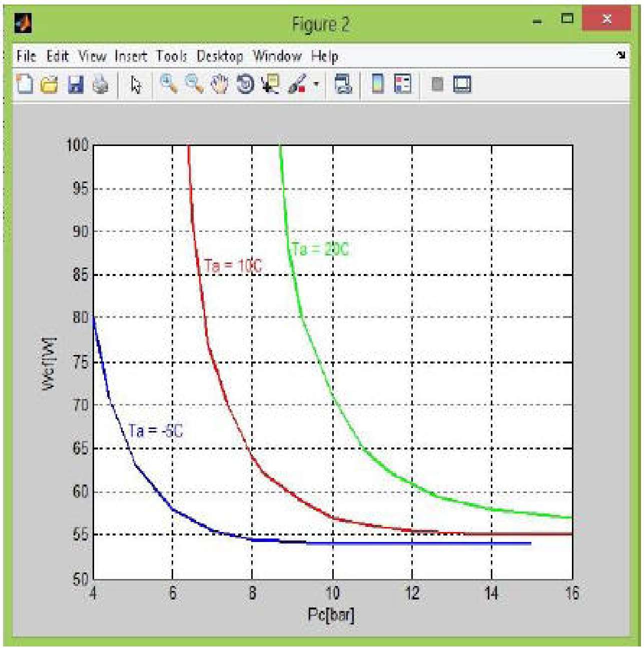


Fig.5. Condenser Fan power & Condenser Pressure

Experimental Work: The commonly referred to as the heart of the system, the compressor is a belt driven pump that is fastened to the engine. It is responsible for compressing and transferring refrigerant gas. [12] The A/C system is split into two sides, a high pressure side and a low pressure side; defined as discharge and suction. Since the compressor is basically a pump, it must have an intake side and a discharge side. The intake, or suction side, draws in refrigerant gas from the outlet of the evaporator. In some cases it does this via the accumulator. Once the refrigerant is drawn into the suction side, it is compressed and sent to the condenser, where it can then transfer the heat that is absorbed from the inside of the vehicle.

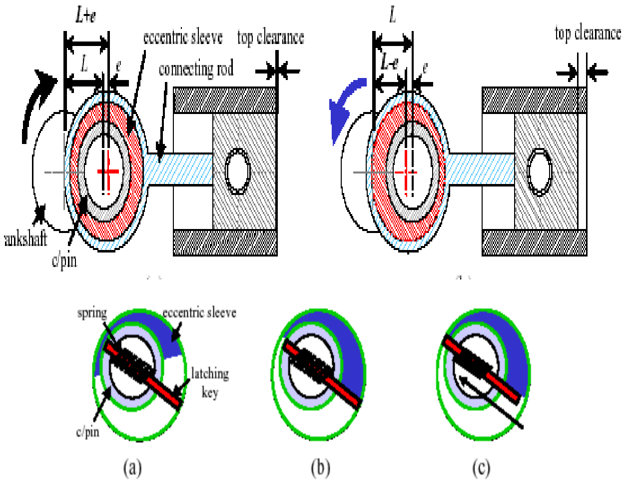


Fig.6 latching system of capacity modulation of compressor

OBSERVATION TABLE-I (At Control Temperature =0^0C)

SR. NO.	TIME (Min.)	VOLTAGE (V)	CURRENT(Amp.)		TEMPERETURE (°C)		POWER CONSUMPTION(Kwh)	
			WITHOUT PWM	WITH PWM	WITHOUT PWM	WITH PWM	WITHOUT PWM	WITH PWM
1	0	250	5	1.7	25	25		
2	5	250	2.5	1.4	22	20		
3	10	250	2.3	1.3	19	11		
4	15	250	2.2	1.2	17	0		
5	20	250	2.1	0	14			
6	25	250	2.1	0	11		0.0308	0.0255
7	30	250	2	0	8			
8	35	250	2	0	5			
9	40	250	1.9	0	4			
10	45	250	1.9	0	2			
11	50	250	1.8	0	0			

Observation Table-II (At Control Temperature = -5^0C)

SR. NO.	TIME (Min.)	VOLTAGE (V)	CURRENT(Amp.)		TEMPERETURE (°C)		POWER CONSUMPTION(Kwh)	
			WITHOUT PWM	WITH PWM	WITHOUT PWM	WITH PWM	WITHOUT PWM	WITH PWM
1	0	250	5	1.7	25	25		
2	5	250	2.5	1.4	22	20		
3	10	250	2.3	1.3	19	11		
4	15	250	2.2	1.2	17	0		
5	20	250	2.1	0	14	-5		
6	25	250	2.1		11			
7	30	250	2		8		0.044	0.0251
8	35	250	2		5			
9	40	250	1.9		4			
10	45	250	1.9		2			
11	50	250	1.8		0			
12	55	250	1.9		-2			
13	60	250	1.8		-4			
14	65	250	1.9		-5			

Observation Table-III (At Control Temperature = -25^{0}C)

SR. NO.	TIME (Min.)	VOLTAGE (V)	CURRENT(Amp.)		TEMPERETURE (°C)		POWER CONSUMPTION(Kwh)	
			Without PWM	WITH PWM	WITHOUT PWM	WITH PWM	WITHOUT PWM	WITH PWM
1	0	250	5	1.7	25	25		
2	5	250	2.5	1.4	22	20		
3	10	250	2.3	1.3	19	11		
4	15	250	2.2	1.2	17	0		
5	20	250	2.1	0	14	-5		
6	25	250	2.1	0	11	-10	0.037	0.019
7	30	250	2	0	8	-14		
8	35	250	2	0	5	-18		
9	40	250	1.9	0	4	-20		
10	45	250	1.9	0	2	-23		
11	50	250	1.8	0	0	-25		

CALCULATIONS:-

(1) Comparison of saving in energy , money , time at control temperature at 0^{0}C

Saving in energy:-

Percentage reduction in power consumption

$$= \frac{0.030 - 0.021}{0.030} = 30\%$$

Saving in money:-

21.6 units costs at the rate of Rs.4 per unit = Rs. 86.4 (Without pwm)

15.12 units costs at the rate of Rs.4 per unit = Rs.60.4 (With pwm)

Percentage reduction in saving of money

$$= \frac{86.4 - 60.48}{86.4} = 30\%$$

Saving in time:-

Time consumption to achieve 0^{0}C= 50 Min. (Without pwm)

Time consumption to achieve 0^{0}C= 15Min. (With pwm)

(2) Comparison of saving in energy, money, time at control temperature at -5^{0}C

Saving in energy:-

Percentage reduction in power consumption

$$= \frac{0.044 - 0.0251}{0.044} = 43\%$$

Saving in money:-

31.68 units costs at the rate of Rs.4 per unit = Rs. 126 (Without pwm)

18.07 units costs at the rate of Rs.4 per unit = Rs. 72.28 (With pwm)

Percentage reduction in saving of money

$$= \frac{126.72 - 72.28}{126.72} = 43\%$$

Saving in time:- Time consumption to achieve -5^{0}C= 65 Min. (Without pwm)

Time consumption to achieve -5^{0}C= 20 Min. (With pwm)

(3)Comparison of saving in energy, money, time at control temperature -25^{0}C

Saving in energy:-

Percentage reduction in power consumption

$$= \frac{0.89 - 0.47}{0.89} = 47\%$$

Saving in money:-

Percentage reduction in saving of money

$$= \frac{106.4 - 56.4}{106.4} = 47\%$$

26.7 units costs at the rate of Rs.4 per unit = Rs. 106.4 (Without pwm)

14.1 units costs at the rate of Rs.4 per unit = Rs. 56.4 (With pwm)

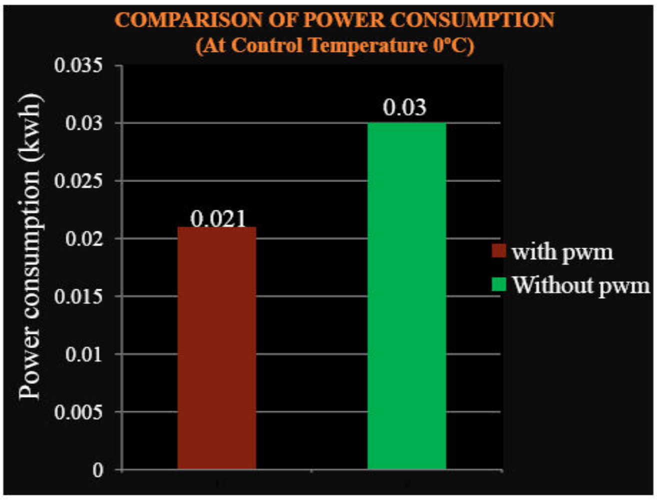
Saving in time:-

Time consumption to achieve -25^{0}C= 90 Min. (Without pwm)

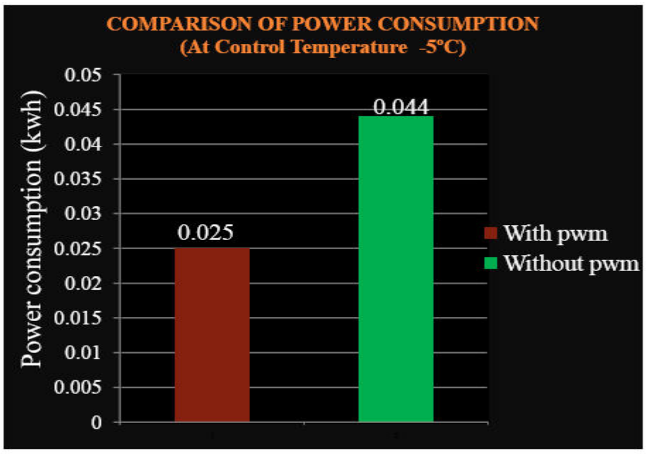
Time consumption to achieve -25^{0}C= 50 Min. (With pwm)

Results:-

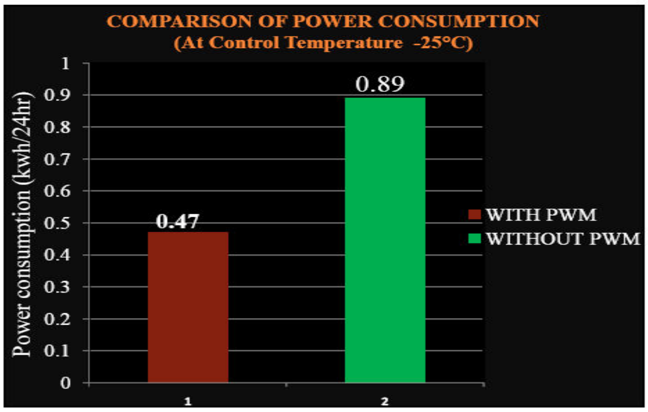
1. Comparison of power consumption with and without pulse width modulation technique at control temperature 0^0C.



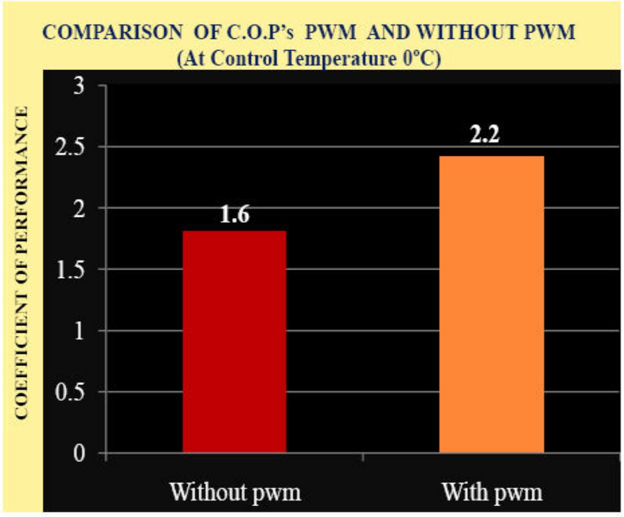
2. Comparison of power consumption with and without pulse width modulation technique at control temperature -5^0C.



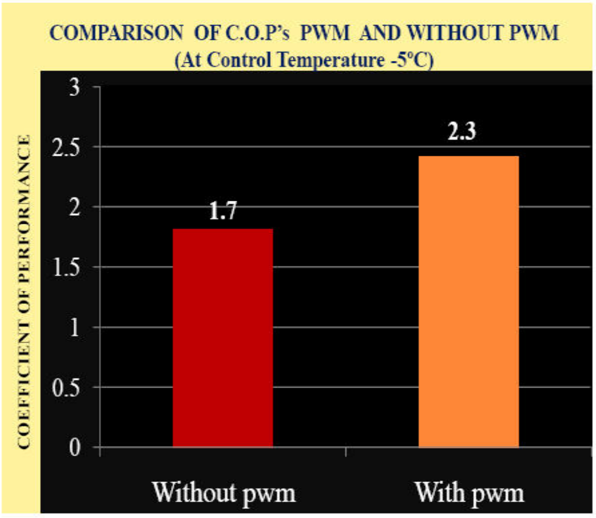
3. Comparison of power consumption with and without pulse width modulation technique at control temperature -25^0C.



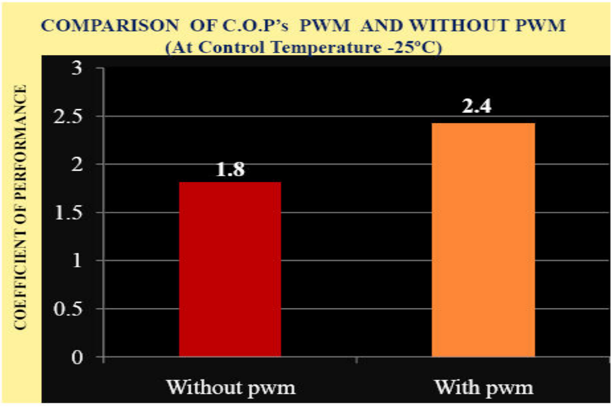
4. Comparison of coefficient of performance with and without pulse width modulation technique at control temperature 0^0C.



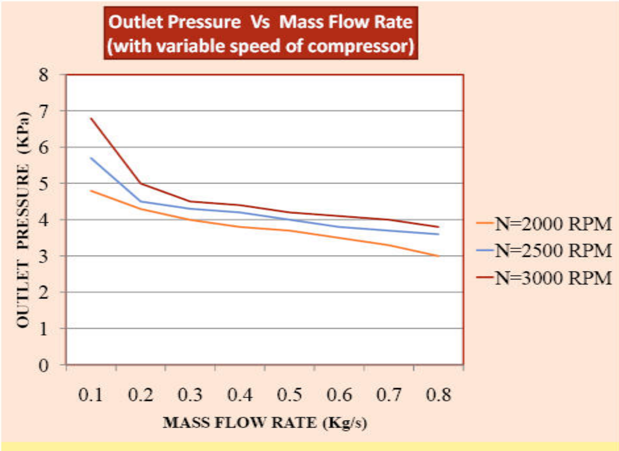
5. Comparison of coefficient of performance with and without pulse width modulation technique at control temperature -5^0C.



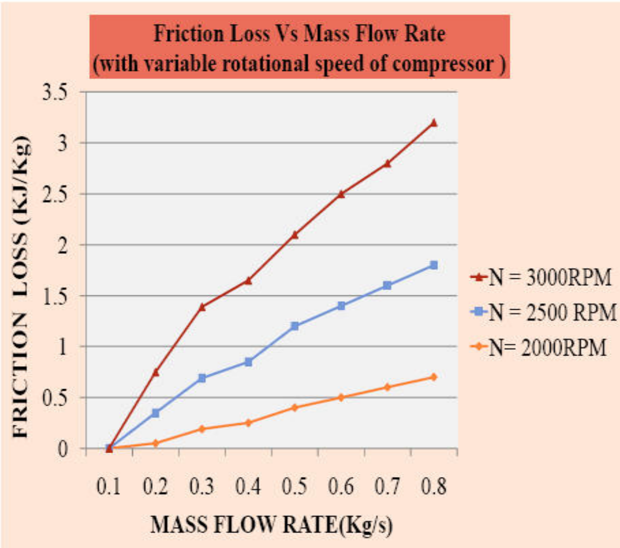
6. Comparison of coefficient of performance with and without pulse width modulation technique at control temperature -25^0C.



7. Outlet pressure versus mass flow rate with variable rotational speed of compressor (2000 RPM, 2500 RPM, 3000 RPM).



8. Friction loss versus mass flow rate with variable rotational speed of compressor (2000 RPM, 2500 RPM, 3000 RPM)



Conclusions: We have developed a novel experimental working model of V.C.R.S. with PWM method and applied it for air-conditioning and supermarket refrigeration system. This method is appropriate to be used by power management schemes for minimization of refrigeration loads. This method gives reduction in power consumption of operating system, saving in money and saving in time because of faster cooling rates. Existing and novel supermarket refrigeration systems were modeled and analyzed for their energy effectiveness, Based on modeling for representative supermarkets, distributed systems have energy usage 6 to 9% worse than the baseline.

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